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Efecto de los programas de suplementación de hierro sobre la anemia infantil en la región de Puno (Perú)

Effect of iron supplementation programs on childhood anemia in the Puno region (Perú)

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RESUMEN

Objetivo: Evaluar el efecto de los programas presupuestarios Programa Articulado Nutricional (PAN) y Productos Específicos para el Desarrollo Infantil Temprano (PEDIT) en la anemia infantil, mediante una evaluación integral de los productos ofrecidos por los programas y una evaluación específica de la suplementación con hierro en niños de 6 a 35 meses en la región de Puno.

Materiales y métodos: Estudio de tipo longitudinal y transversal. Se utilizó el método de cointegración de Engle-Granger y el modelo Logit para niños de 6 a 35 meses en la región de Puno. La muestra longitudinal comprende observaciones de 12 años (2012-2023) y la transversal incluye 1.934 observaciones de los años 2021, 2022 y 2023. Los datos secundarios se obtuvieron del Portal de Transparencia del Ministerio de Economía y Finanzas (MEF) y del Instituto Nacional de Estadística e Informática (INEI).

Resultados: La tasa de anemia en la región de Puno en el año 2012 fue del 73,7% y se redujo al 70,4% en el año 2023. Según la evaluación integral, la anemia infantil disminuye en 0,163% a largo plazo y en 0,147% a corto plazo como efecto del aumento del gasto público en los programas presupuestarios. La evaluación específica, según el modelo Logit, muestra que la probabilidad de anemia disminuye en 0,3% con el consumo de hierro en gotas, en un 0,2% con jarabe, y en un 0,1% con micronutrientes.

Conclusiones: A pesar de las intervenciones de los programas presupuestarios PAN y PEDIT en el marco del Presupuesto por Resultados, la prevalencia de la anemia infantil sigue siendo alta en la región de Puno. Aunque estos programas muestran efectos positivos en la disminución de la anemia, no han sido lo suficientemente efectivos para lograr una reducción significativa. Es necesario revisar y mejorar las estrategias de implementación de los programas, así como explorar nuevas alternativas de suplementación.

PALABRAS CLAVE

Desarrollo infantil, hierro, micronutrientes, salud infantil, salud pública.

ABSTRACT

Objective: To evaluate the effect of the budgetary programs Articulated Nutritional Program (PAN) and Specific Products for Early Childhood Development (PEDIT) on childhood anemia, through a comprehensive evaluation of the products offered by the programs and a specific evaluation of iron supplementation in children aged 6 to 35 months in the Puno region.

Materials and methods: Longitudinal and cross-sectional study. The Engle-Granger cointegration method and the Logit

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model were used for children aged 6 to 35 months in the Puno region. The longitudinal sample includes observations from 12 years (2012-2023) and the cross-sectional sample includes 1,934 observations from the years 2021, 2022 and 2023. Secondary data were obtained from the Transparency Portal of the Ministry of Economy and Finance and the Demographic and Family Health Survey (ENDES).

Results: The anemia rate in the Puno region in 2012 was 73.7% and was reduced to 70.4% in 2023. According to the comprehensive assessment, childhood anemia decreases by 0.163% in the long term and 0.147% in the short term as an effect of increased public spending on budgetary programs. The specific evaluation, according to the Logit model, shows that the probability of anemia decreases by 0.3% with the consumption of iron drops, by 0.2% with syrup, and by 0.1% with micronutrients.

Conclusions: Despite the interventions of the PAN and PEDIT budget programs under the Budget for Results framework, the prevalence of childhood anemia remains high in the Puno region. Although these programs show positive effects in reducing anemia, they have not been effective enough to achieve a significant reduction. It is necessary to review and improve program implementation strategies, as well as to explore new supplementation alternatives.

KEYWORDS

Child development, iron, micronutrients, child health, public health.

LISTA DE ABREVIATURAS

ENDES: Encuesta Demográfica y de Salud Familiar.

INEI: Instituto Nacional de Estadística e Informática.

PpR: Presupuesto por Resultados.

PAN: Programa Articulado Nutricional.

PEDIT: Productos Específicos para el Desarrollo Infantil Temprano.

MEF: Ministerio de Economía y Finanzas.

INTRODUCCIÓN

La anemia es un problema de salud pública en el Perú y afecta a los niños entre 6 y 35 meses de edad[1]. La anemia por deficiencia de hierro es la más común en los niños[2,3]. Se caracteriza por una reducción en los niveles de hemoglobina en la sangre[4]. Esto disminuye la oxigenación de los tejidos y afecta el crecimiento y desarrollo, particularmente en el cerebro[5].

La anemia infantil tiene como consecuencia principal la desnutrición crónica, que afecta al 13.1% de niños menores de 5 años[6]. Además, repercute en el desarrollo cognitivo, psicomotor, social y emocional de los niños, e impone un costo considerable al país[7,8]. Las consecuencias más graves de la anemia incluyen la muerte y la discapacidad, tanto de manera directa como indirecta[9]. Desde el punto de vista económico, la anemia no solo incrementa los costos de atención médica, sino que también perjudica el desarrollo social y económico del país, estimándose que le cuesta a la sociedad peruana alrededor de 2.777 millones de soles, lo que representa el 0,62% del PBI[10].

La anemia infantil sigue siendo un problema significativo en la sierra peruana[11]. La prevalencia de la anemia está relacionada con la disminución en el consumo de alimentos tradicionales y el aumento en la dependencia de alimentos del mercado, que suelen ser menos nutritivos y ricos en carbohidratos[12].

A nivel del sistema de salud pública en Perú, se han implementado diversas acciones para mejorar la cobertura y calidad de la atención, especialmente a través de la atención primaria y la entrega de suplementos de hierro en programas para prevenir y tratar la anemia[13]. Entre los años 2018 y 2022, el Presupuesto Institucional de Apertura (PIA) para reducir la prevalencia de la anemia aumentó en 462 millones de soles[14].

En la región de Puno, el gasto público destinado a reducir la desnutrición crónica infantil y la anemia alcanzó los 136.7 millones de soles en 2023, con un aumento del 7,9% en los últimos cinco años[15]. A pesar de ello, la prevalencia de anemia en niños de 6 a 35 meses de edad se mantuvo en un promedio del 69,5%[16].

La suplementación con hierro, tanto diaria como semanal, ha demostrado ser una intervención eficaz para reducir la prevalencia de anemia en niños[17]. En Perú, los micronutrientes conocidos como "chispitas" han mejorado la condición de los niños tras el consumo de entre 80 y 100 sobres[18]. Sin embargo, su efectividad depende de una buena adherencia al tratamiento[19].

Diversos estudios han identificado factores asociados a la anemia, como los aspectos sociodemográficos, el consumo de proteínas y hierro, la adherencia al tratamiento, la vacunación completa, el peso al nacer, la ablactación temprana, el consumo de frutas y verduras y la lactancia materna[3,8,20].

A pesar de las intervenciones de las políticas públicas en salud y del incremento presupuestario destinado a los programas PAN y PEDIT mediante el Presupuesto por Resultados (PpR) para combatir la anemia, no existen estudios que evalúen de manera integral y específica los efectos de estos programas en la anemia infantil, tanto a nivel nacional como en la región de Puno. Por ello, es crucial evaluar el logro de los objetivos establecidos por estas políticas públicas.

Cabe señalar que los programas presupuestarios 0001: Programa Articulado Nutricional (PAN) y 1001: Productos

Específicos para el Desarrollo Infantil Temprano (PEDIT), han sido los principales instrumentos del gasto público para reducir la desnutrición crónica y la anemia en el país[14,21].

Por tanto, el objetivo de esta investigación es evaluar el efecto de los programas presupuestarios Programa Articulado Nutricional (PAN) y Productos Específicos para el Desarrollo Infantil Temprano (PEDIT) en la anemia infantil, mediante una evaluación integral de los productos ofrecidos por los programas y una evaluación específica de la suplementación con hierro en niños de 6 a 35 meses en la región de Puno.

MATERIALES Y MÉTODOS

Metodología

Se llevó a cabo una combinación de estudio longitudinal y transversal. El diseño longitudinal permitió analizar la evolución de la anemia infantil en niños de 6 a 35 meses entre los años 2012 y 2023, proporcionando evidencia sobre los cambios derivados del efecto integral de los productos ofrecidos por los programas presupuestarios PAN y PEDIT. Por otra parte, el diseño transversal evaluó específicamente el efecto de la suplementación con hierro y otros factores asociados durante los años 2021, 2022 y 2023 en la anemia infantil. Esta combinación metodológica permitió un análisis integral y robusto de las intervenciones dirigidas a combatir la anemia infantil en la región de Puno.

Población y muestra

Para la muestra longitudinal, se recopilaron 12 observaciones correspondientes a los años 2012 a 2023. La población de estudio incluye a niños de 6 a 35 meses de edad de la región Puno. La información secundaria fue obtenida del Portal de Transparencia Económica del Ministerio de Economía y Finanzas (MEF) y del Instituto Nacional de Estadística e Informática (INEI).

Para la muestra transversal, se obtuvieron 1.934 observaciones correspondientes a los años 2021, 2022 y 2023, también para niños de 6 a 35 meses de la región Puno. Esta información secundaria proviene de la Encuesta Demográfica y de Salud Familiar (ENDES) proporcionada por el INEI, utilizando los siguientes módulos: módulo de características del hogar (código 1629), módulo de lactancia y peso al nacer (código 1633), módulo de suplementación con hierro y salud (código 1634) y módulo de anemia (código 1638). Para determinar el tamaño de la muestra, se aplicaron filtros utilizando las variables de identificación. Asimismo, para la variable de anemia, se consideraron los valores ajustados por altura.

Análisis estadístico

Para la gestión de base de datos y el análisis de la regresión por Mínimos Cuadrados Ordinarios y Logit, se utilizó el software Stata 16.0.

Para evaluar el efecto del gasto público de manera integral (considerando todos los productos del programa presupuestario) de los programas presupuestarios PAN y PEDIT en la anemia infantil, se utilizó el método de cointegración propuesto por Engle-Granger. El primer paso fue verificar si las series eran estacionarias en primeras diferencias de orden I(1), utilizando la prueba de Dickey Fuller Aumentada (ADF). El segundo paso consistió en estimar la relación de largo plazo mediante Mínimos Cuadrados Ordinarios (MCO). El tercer paso fue comprobar si los residuos de la estimación del modelo a largo plazo eran estacionarios de orden I(0). Al cumplirse esta condición, las series de anemia y gasto público se consideraron integradas, lo que implica que existe una relación de largo plazo entre ambas, y se procedió a estimar la relación a corto plazo.

Modelo de largo plazo

$$\text{Anemia}_t = \alpha + \beta \cdot \text{Gasto Público}_t + \varepsilon_t \qquad (1)$$

Donde: *Anemia* representa la tasa de anemia en la región de Puno en el año *t*; *Gasto Público*$_t$ es el nivel de gasto público en millones de soles en la región Puno correspondiente a los programas presupuestarios 0001 (PAN) y 1001 (PEDIT); ε_t es el término de corrección de errores, que típicamente es el residuo de la relación de cointegración de largo plazo.

Modelo de corto plazo

Para plantear el modelo de corto plazo, primero se obtiene la predicción de ε_t en la ecuación (1). Luego, este residuo se incluye en el modelo de corto plazo como un término de corrección de error para ajustar la desviación del desequilibrio a largo plazo.

$$\Delta\text{Anemia}_t = \alpha_0 + \alpha_1\Delta\text{Gasto Público}_t + \lambda(\varepsilon_{t-1}) + \mu_t \qquad (2)$$

Donde: Δ representa las primeras diferencias de las series; Δ*Anemia*$_t$ es el cambio en la anemia de un año al siguiente (corto plazo); Δ*Gasto Público*$_t$ es el cambio del gasto público de un año al siguiente (corto plazo); λ es el coeficiente de corrección de errores, que mide la velocidad de ajuste de las desviaciones de largo plazo; ε_{t-1} son los residuos del modelo de largo plazo en el periodo anterior (que representan el desequilibrio entre la tasa de anemia y gasto público en *t–1* y μ_t es el término de error.

Modelo de la suplementación con hierro en la anemia infantil

Para evaluar específicamente el efecto de la suplementación con hierro en la anemia infantil, se utilizó el modelo Logit. Asimismo, dado que los datos corresponden a los tres años 2021 a 2023, en el modelo Logit se incorporó la variable de control "año", lo cual permitió capturar las diferencias entre los años y evitar sesgos.

Los puntos de corte para el diagnóstico del nivel de anemia y su clasificación en niños y niñas de 6 a 35 meses de edad son los siguientes: anemia severa <7,0 g/dl; anemia moderada: 7,0-9,9 g/dl; anemia leve: 10,0-10,9 g/dl; y sin anemia: ≥ 11,0 g/dl[22].

En el modelo, la variable dependiente (Y_i) es dicotómica y expresa la condición de anemia infantil, con valores entre 0 y 1 (1 = con anemia, es decir, ≤ 10,9 g/dl; y 0 = sin anemia, es decir, ≥ 11,0 g/dl). En el Logit, las probabilidades están determinadas por la variable dicotómica no observable (Y_i).

$$Y_i = \delta' X_i + \varepsilon_i \qquad (3)$$

$$\Pr(Y_i = 1 \mid X_i) = \frac{e^{\delta' X_i}}{1 + e^{\delta' X_i}} = \Lambda(\delta' X_i) \qquad (4)$$

Donde, $\Lambda(\boldsymbol{\delta' X_i})$ es la función de distribución logística y ***Pr*** denota la probabilidad de la condición de anemia. Por tanto, la probabilidad es la siguiente:

$$\Pr(Y_i = 1) = \frac{e^{\delta_0 + \delta_1 HJarabe + \delta_2 HGotas + \delta_3 Micronutrientes + \delta_4 Z_i + \varepsilon_i}}{1 + e^{\delta_0 + \delta_1 HJarabe + \delta_2 HGotas + \delta_3 Micronutrientes + \delta_4 Z_i + \varepsilon_i}} \qquad (5)$$

Asimismo, *HJarabe* es suplementación con hierro en jarabe y se expresa por la cantidad de consumo en frascos; *HGotas* es la suplementación con hierro en gotas y se expresa por la cantidad de consumo en frascos; *Micronutrientes* es la suplementación con hierro en polvo mediante micronutrientes (Chispitas, Estrellitas o Nutromix) y se expresa por la cantidad de consumo en sobres; Z_i son variables de control o factores asociados a la anemia infantil, como el nivel educativo de la madre, la lactancia materna durante los primeros 6 meses, el peso del niño o niña al nacer, la cantidad de controles de crecimiento, la edad del niño o niña en meses, el área de residencia (=1 rural, 0=urbano); la región (=1 Puno, 0=otras regiones) y el año.

$$\frac{\partial E\,[yI\ x]}{\partial E} = \Lambda(\delta'\ X)\,[1 - \Lambda(\delta\hat{}'\ X)] \qquad (6)$$

La ecuación (6) expresa el efecto marginal de la estimación del modelo Logit. Esto indica el cambio en la variable anemia provocado por un cambio unitario en el consumo de hierro en jarabe, gotas, micronutrientes y las variables de control.

Aspectos éticos

La investigación no implicó ningún tipo de riesgo, ya que se utilizaron bases de datos secundarias del ENDES, disponibles en la web del Instituto Nacional de Estadística e Informática (https://proyectos.inei.gob.pe/microdatos/), las cuales son parte de la Plataforma Nacional de Datos Abiertos del Perú. Por ende, no fue necesaria la aprobación y conformidad por un comité de ética.

RESULTADOS Y DISCUSIÓN

En la región de Puno, el porcentaje promedio de anemia en niños y niñas de 6 a 35 meses de edad durante los años 2021, 2022 y 2023 fue del 69,3%. En la figura 1 se presentan los puntos de corte según los gramos de hemoglobina por decilitro de sangre: la anemia leve (10,0-10,9 g/dl) representó el 36%, la anemia moderada (7,0-9,9 g/dl) el 32%, la anemia severa (<7,0 g/dl) el 1,3% y sin anemia (≥ 11,0) el 30,7%. En los últimos tres años, la tasa de anemia infantil se ha mantenido como la más alta en comparación con otras regiones. En 2023, la prevalencia de anemia alcanzó el 70,4%, superando el promedio nacional en 27,3 puntos porcentuales.

En la figura 2, se puede apreciar que el gasto público de los programas presupuestarios 0001 (PAN) y 1001 (PEDIT) desde el año 2012 hasta el año 2023 aumentó en 57,4 millones de soles. Mientras tanto, la tasa de anemia en los 12 años disminuyó en 3,3%. A partir del año 2016, se observa una tendencia creciente en el gasto público y una disminución en la tasa de anemia.

Los resultados de la tabla 1 muestran el efecto del gasto público de los programas presupuestarios 0001 (PAN) y 1001 (PEDIT) en la anemia infantil. Estos programas entregan diversos productos para el tratamiento y prevención de la anemia infantil. El modelo a largo plazo indica que, cuando el gasto público de estos programas aumenta, la anemia disminuye. Específicamente, si el gasto público incrementa en un millón de soles, el porcentaje de anemia infantil disminuye en 0,163 puntos porcentuales a largo plazo.

En cambio, los resultados del modelo a corto plazo, según la regresión del Modelo de Corrección de Errores (MCE), indican que, ante un aumento de un millón de soles en el gasto público, el porcentaje de anemia infantil disminuye en 0,147 pun-

Tabla 1. Resultados de la regresión del modelo a largo plazo y corto plazo

Variable	Modelo a largo plazo (1)	Modelo a corto plazo (Modelo de Corrección de Errores) (2)
Gasto Público$_t$ del PAN y PEDIT	-0,163*** (-5,24)	
Δ *Gasto Publico$_t$*		-0,147* (-2,14)
Mecanismo de Corección del Error (ε_{t-1})		-0,321*** (-4,46)
Constante	90,516*** (26,64)	0,201 (0,26)
N	12	11
r2	0,733	0,749

t statistics in parentheses.
* p<0.10, ** p<0.05, *** p<0.01.

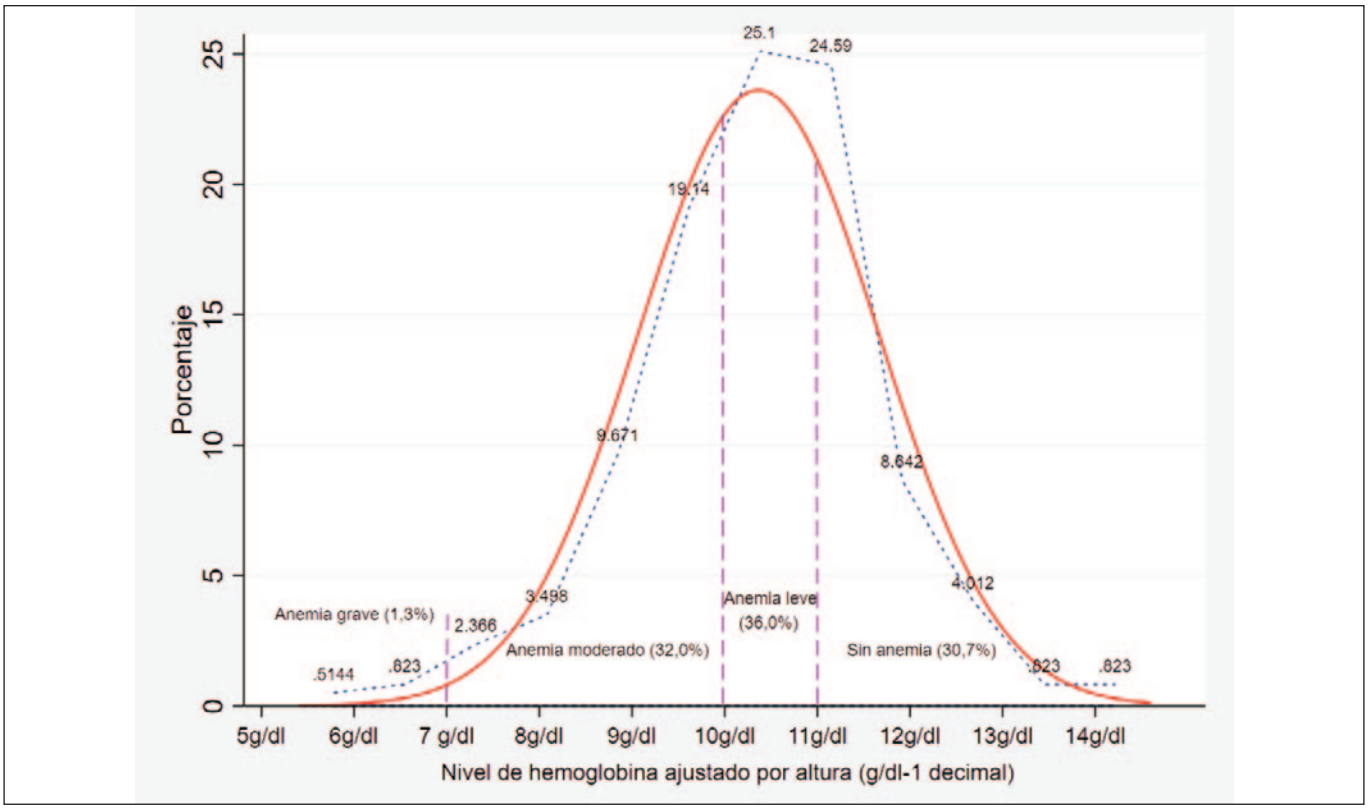

Figura 1. Distribución de los puntos de corte del nivel de anemia infantil y su clasificación en la región de Puno

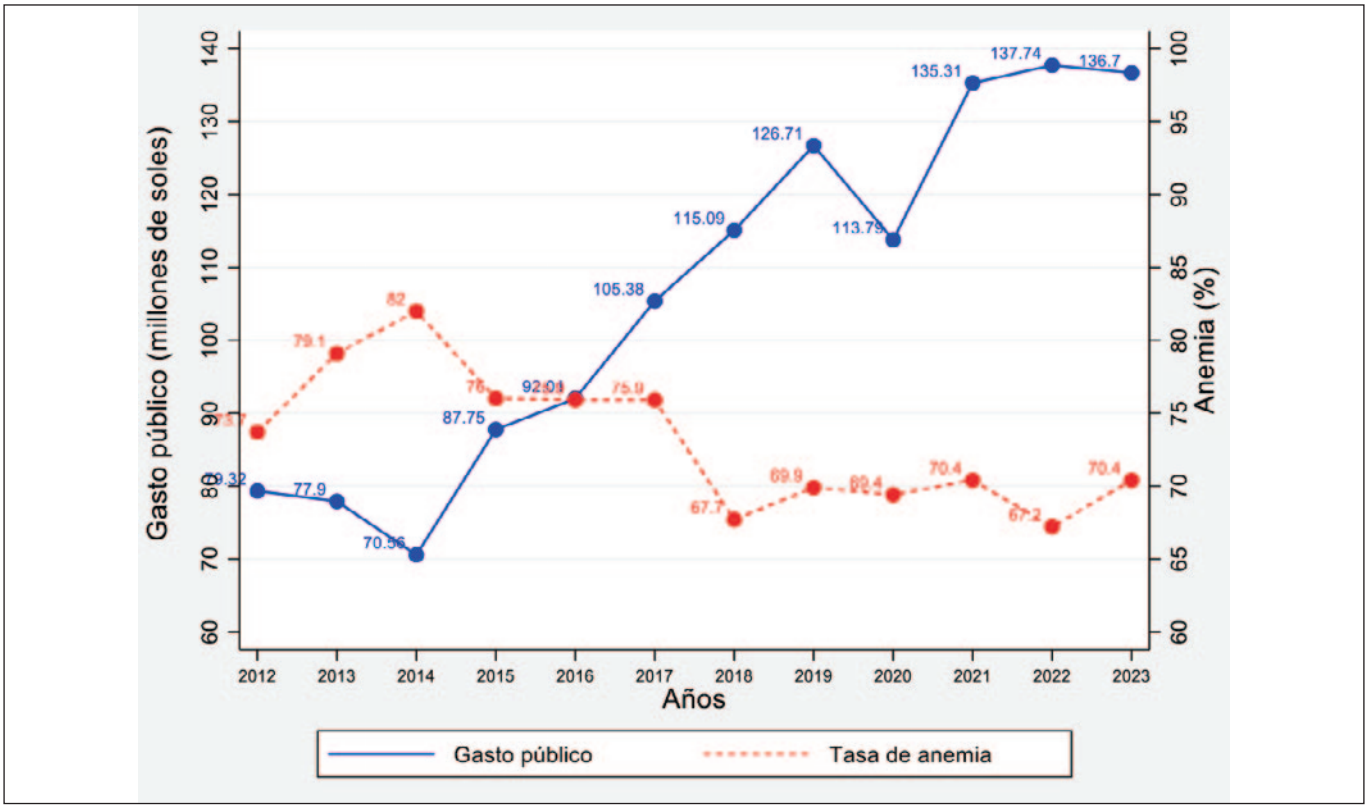

Figura 2. Evolución del gasto público de los programas presupuestarios 0001 (PAN) y 1001 (PEDIT) y la tasa de anemia en la región de Puno

tos porcentuales en el corto plazo. Además, la desviación de la anemia infantil respecto a su nivel de equilibrio a largo plazo se corrige anualmente en aproximadamente un 32%.

La tabla 2 presenta los resultados del efecto de la suplementación con hierro en la anemia infantil. Las estimaciones de los parámetros muestran que la suplementación con hierro, en sus diversas formas, se asocia con una reducción en la prevalencia de la anemia infantil en la región de Puno.

Tabla 2. Resultado de la estimación del modelo Logit y efecto marginal

Nivel de anemia (1 con anemia, 0 sin anemia)	(1) Modelo Logit	(2) Efecto marginal
Probabilidad si Pr(y=1)*		0,693
Suplementación con hierro en jarabe	-0,008* (-1,71)	-0,002
Suplementación con hierro en gotas	-0,017** (-2,33)	-0,003
Suplementación con hierro en polvo (Micronutrientes)	-0,003*** (-5,54)	-0,001
Lactancia materna durante los primeros 6 meses	-0,312*** (13,50)	-0,062
Peso del niño o niña al nacer	-0,024 (-1,16)	-0,005
Cantidad de controles de crecimiento	-0,001 (-0,73)	0,000
Nivel educativo de la madre	-0,171*** (-9,21)	-0,034
Edad en meses del niño o niña	-0,065*** (-47,45)	-0,013
Área de residencia (=1 rural)	0,301*** (11,59)	0,060
Año		
- 2022	0,159*** (5,88)	0,032
- 2023	0,196*** (6,98)	0,039
_cons	0,890*** (9,21)	
N	1,934	

"z" estadístico dentro de paréntesis.
*** p<0,01 nivel de significancia al 1%, ** p<0,05 nivel de significancia al 5%, * p>0,10 nivel de significancia al 10%
∂y/∂x: es el efecto marginal del modelo Logit.
Pr: Predicción de probabilidades del modelo Logit.

En los resultados de la tabla 1 columna 2 muestran los efectos marginales del modelo Logit en las tres diferentes formas de suplementación con hierro sobre la probabilidad de anemia en los programas presupuestarios PAN y PEDIT, se evidencian variaciones en los parámetros estimados y en nivel de significancia estadística de cada intervención.

La suplementación con hierro en jarabe muestra un efecto marginal de -0,002, lo que significa una reducción de 0,2 puntos porcentuales en la probabilidad de anemia infantil por cada frasco adicional consumido. Por otro lado, la suplementación con hierro en gotas presenta un efecto marginal más pronunciado de -0,003, lo que significa una reducción de 0,3 puntos porcentuales en la probabilidad de anemia por cada frasco adicional consumido.

Sin embargo, la suplementación con micronutrientes en sobres tiene un efecto marginal de -0,001, lo que indica una disminución de 0,1 puntos porcentuales en la probabilidad de anemia infantil por cada sobre adicional consumido. Aunque el efecto es menor en comparación con las otras formas se suplementación, pero es altamente significativo.

En cuanto a las variables de control o factores asociados a la anemia infantil, en primer lugar, la lactancia materna durante los primeros 6 meses de edad disminuye la probabilidad de la anemia en 6,2%. En segundo lugar, el nivel educativo de la madre se asocia con una reducción significativa en la probabilidad de anemia infantil en menos 3,4%.

Por otro lado, en cuanto al área de residencia, se evidencia que la probabilidad de anemia aumenta en un 6%, cuando los niños viven en zonas rurales.

Del gráfico 3, se observa que la mediana de la probabilidad de anemia infantil es del 78% cuando la madre tiene nivel educativo de primaria y reside en el área rural. Sin embargo, esta probabilidad disminuye a un 63% cuando la madre tiene posee un nivel educativo superior y vive en una zona urbana.

De la variable edad, se observa que a medida aumenta la edad del niño o niña en meses, la probabilidad de anemia disminuye en un 1,3%.

Finalmente, la variable de control "año" se encontró una tendencia temporal, donde la probabilidad de la anemia aumenta en los años 2022 y 2023 mientras las variables peso del niño al nacer y cantidad de controles de crecimiento no resultaron ser significativas en el modelo Logit.

DISCUSIÓN

Durante el período de estudio, la anemia afectó al 69% de los niños entre 6 y 35 meses de edad, de los cuales la anemia leve representó el 36%, la anemia moderada el 32% y la anemia severa el 1,3%. A pesar de los esfuerzos realizados

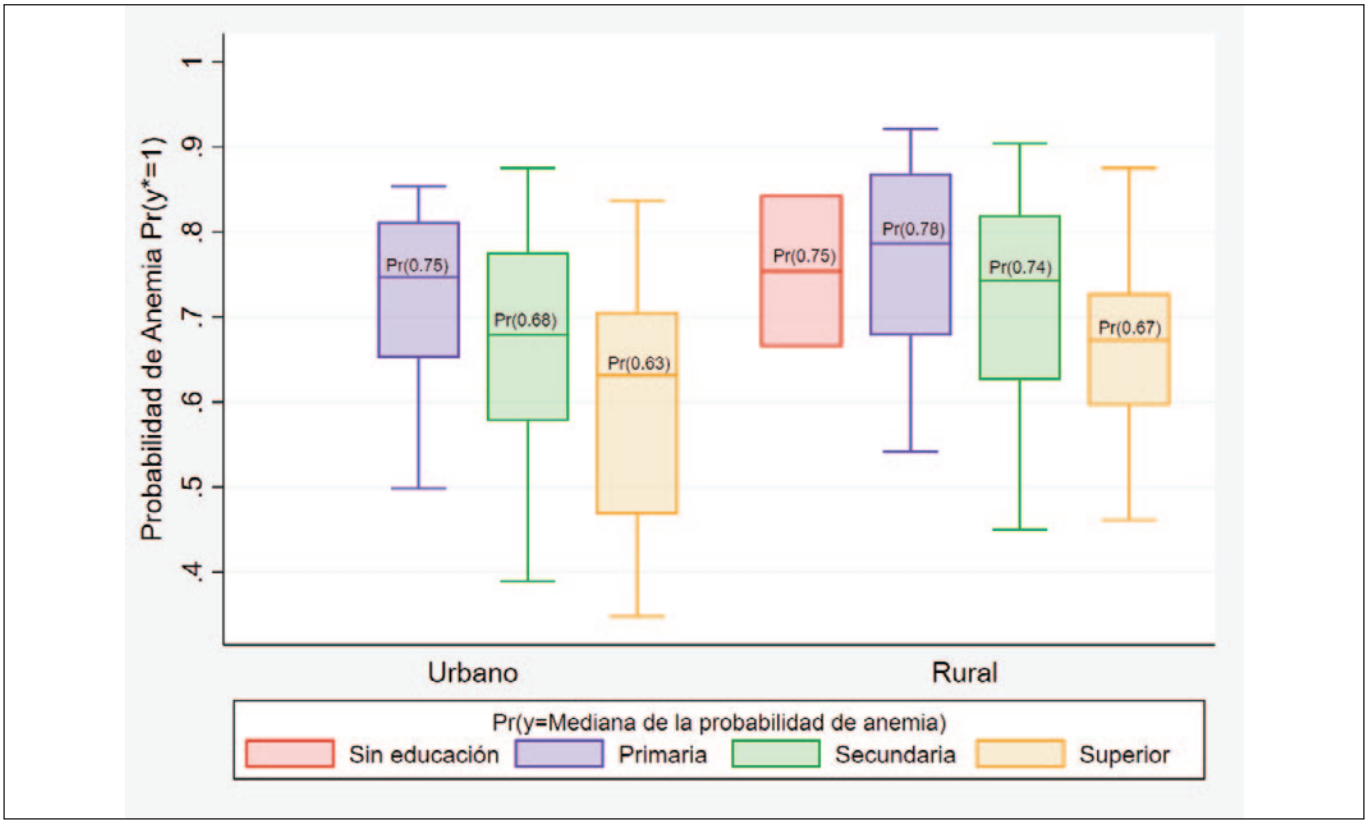

Figura 3. Predicción de probabilidades de la anemia infantil según nivel educativo de la madre y área de residencia

en los últimos 12 años y la implementación de políticas nacionales a través de los programas PAN y PEDIT en el marco del PpR, la anemia solo ha disminuido un 3,3%, manteniéndose como la más alta en comparación con otras regiones del Perú. Aunque estas intervenciones se aplican a través de los tres niveles de gobierno, la prevalencia de la anemia sigue siendo elevada, y las principales medidas, como el Programa Juntos y la suplementación con "chispitas", no han logrado reducirla significativamente[13,23].

Al evaluar de manera integral los efectos de todos los productos que ofrece el programa presupuestario PAN y PEDIT a través del gasto público sobre la anemia infantil, se observa que, aunque los modelos a corto y largo plazo muestran efectos positivos, estos son bastante reducidos. Los resultados del efecto marginal del modelo Logit indican que, a largo plazo, el efecto del gasto público es de -0,163%, y a corto plazo, de -0,147%. Este resultado contrasta con el estudio realizado en Inglaterra por Jenkins et al, donde un mayor gasto público se asocia con una disminución en las admisiones hospitalarias por anemia nutricional, especialmente en áreas desfavorecidas[24]. A pesar del aumento en el gasto público de los programas presupuestarios, los efectos sobre la anemia infantil en la región de Puno siguen siendo limitados, lo que sugiere que el diseño de los programas presupuestarios podría ser ineficiente.

Por otro lado, una posible explicación de los efectos reducidos del gasto público en la anemia infantil, a través de los productos entregados por el PAN y PEDIT, es que el esquema de PpR presenta ineficiencias en su implementación y funcionamiento. Los programas enfrentan dificultades en la ejecución del presupuesto y carecen de la capacidad para mejorar o innovar sus procesos[25], Además, la distribución del presupuesto entre regiones no sigue un criterio claro de priorización, lo que afecta la efectividad de las intervenciones[26].

El programa presupuestarios PAN muestra limitaciones significativas. La falta de coordinación horizontal entre los actores que intervienen y los problemas en la ejecución del presupuesto afectan la implementación. El seguimiento anual del programa PAN revela que las metas físicas alcanzadas en relación con la programación anual presentan un bajo desempeño en los productos relacionados con la promoción de salud infantil[14]. Además, la alta rotación de los equipos técnicos y los retrasos en los procesos logísticos afectan negativamente los resultados[21].

Al evaluar de manera específica los efectos del producto suplementación con hierro en la anemia infantil a través de los programas PAN y PEDIT, los resultados demuestran que su consumo tiene un efecto positivo en la reducción de la anemia infantil en la región de Puno, aunque los efectos

son bastante reducidos. La probabilidad de anemia disminuye en un 0,3% al consumir suplemento ferroso en gotas, en un 0,2% con jarabe, y en un 0,1% con micronutrientes. Estos hallazgos son consistentes con estudios previos, como los de Huamán et al y Munayco et al, que destacan la efectividad de los multimicronutrientes en polvo para combatir la anemia[27,28].

Por otro lado, Francke, confirma que el consumo de micronutrientes "chispitas" mejora la condición de los niños anémicos tras la ingesta de entre 80 y 100 sobres[18]. Asimismo, el estudio de Sevilla et al, refuerza la efectividad de una estrategia combinada de intervención con hierro y micronutrientes[5]. Del mismo modo, Mejia et al, también observo correlaciones lineales positivas entre el número de dosis de multimicronutrientes y el incremento en los niveles de hemoglobina[1], lo que respalda los hallazgos obtenidos en este estudio.

A pesar de la efectividad observada en este estudio de la suplementación con hierro en gotas, jarabe y micronutrientes, la adherencia al tratamiento sigue siendo un problema que puede limitar su efecto en la reducción de la anemia infantil. Como mencionan Trelles y Munayco, la suplementación solo es efectiva cuando se garantiza una buena adherencia al tratamiento[19]. Un estudio en Huánuco reveló que el 91,8% de los niños no cumplió con el tratamiento del hierro, principalmente debido a la falta de citas oportunas para la entrega del suplemento, demoras en el consumo, olvido frecuente, experiencias negativas previas e interrupciones por problemas respiratorios[29]. Este hallazgo subraya la necesidad de implementar estrategias educativas dirigidas a las familias más vulnerables, complementadas con mejoras en la logística de entrega y el seguimiento del tratamiento.

Dado que los efectos de la suplementación con hierro son limitados, sería recomendable explorar otras formas de suplementación a través de nuevos estudios, con el fin de incorporar en dichos programas. Los micronutrientes que estos programas entregan contienen hierro en la forma de fumarato ferroso, un tipo de hierro inorgánico. Existen alternativas, como el Nutrihem, que contiene hierro hemínico y ha demostrado ser más efectivo para aumentar los niveles de hemoglobina en comparación con los micronutrientes convencionales[7].

En cuanto a las variables asociadas a la anemia, se encontró que el nivel educativo de la madre y la lactancia materna reducen significativamente la probabilidad de la anemia. Estos hallazgos coinciden con estudios previos, que destacan la importancia de la educación materna para prevenir la anemia[4,8]. Las madres con mayor nivel educativo tienden a estar mejor preparadas sobre la nutrición y los cuidados preventivos, lo que les permite tomar decisiones más acertadas para garantizar la salud de sus hijos.

Por otro lado, se observó que la probabilidad de anemia aumenta en áreas rurales, lo que coincide con los estudios de Cerda et al y Brissa et al, quienes señalan que la probabilidad de anemia es significativamente mayor en las áreas rurales de la sierra sur[30]. Este hallazgo evidencia las disparidades en la salud pública en la región de Puno, especialmente entre áreas urbanas y rurales. Los hogares rurales enfrentan mayores desafíos para adoptar prácticas saludables para el cuidado infantil, como garantizar una alimentación adecuada y de calidad nutricional, además de lidiar con un acceso limitado a servicios de salud eficientes.

De la variable edad del niño, se observó que, a medida que aumenta la edad, la probabilidad de anemia disminuye. Este hallazgo es consistente con lo reportado por Cabada et al, quienes señalan que, por cada mes adicional de edad de los niños, hay una reducción significativa en la probabilidad de anemia[8]. Este resultado sugiere que, conforme los niños crecen, las intervenciones de salud implementadas por los programas presupuestarios PAN y PEDIT, como la alimentación complementaria, podrían contribuir a reducir la prevalencia de la anemia. Estos programas ofrecen productos fundamentales para mejorar la salud infantil, se enfocan en la promoción de la salud y garantizan el control del crecimiento y desarrollo, el acceso al agua potable, una vacunación completa y un seguimiento nutricional adecuado. Asimismo, incluyen productos para la prevención y tratamiento de enfermedades prevalentes como infecciones respiratorias agudas, diarreas y parasitosis, elementos esenciales para la recuperación y mantenimiento de la salud infantil.

Finalmente, es relevante señalar que este estudio presenta algunas limitaciones debido al uso de datos secundarios del ENDES, lo que podría excluir variables importantes. Sería recomendable que futuras investigaciones evalúen de manera específica otros productos ofrecidos por los programas presupuestarios PAN y PEDIT, con el fin de retroalimentar las políticas públicas de salud.

CONCLUSIONES

En conclusión, los resultados de este estudio confirman que, a pesar de las intervenciones implementadas a través de los programas presupuestarios PAN y PEDIT en el marco del Presupuesto por Resultados, la prevalencia de la anemia infantil sigue siendo alta en la región de Puno. Aunque estos programas muestran efectos positivos, su efecto en la reducción de la anemia ha sido poco significativo. La evaluación integral de todos los productos que ofrecen estos programas a través del gasto público, junto con la evaluación específica de la suplementación con hierro en gotas, jarabe y micronutrientes, demuestra que los avances han sido limitados. Por lo tanto, es necesario revisar y mejorar las estrategias de implementación de los programas presupuestarios PAN y PEDIT en la promoción de la salud infantil, así como explorar nuevas alternativas de suplementación.

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Evidence-based formulation and overall acceptability of spirulina-enriched functional ice cream

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ABSTRACT

Introduction: Spirulina, a cyanobacterium recognized for its antioxidant, antiviral, and immunological properties, has been utilized for centuries as a natural source of protein and essential nutrients. Recent studies have highlighted its hypoglycemic and hypolipidemic effects, demonstrating its potential applications in managing non-communicable chronic diseases. However, the distinct flavor of spirulina can lead to low acceptability when incorporated into food products.

Objective: This research aimed to develop a proposal for a functional ice cream with spirulina containing no artificial flavors or colors based on scientific evidence due to the health benefits of Spirulina platensis and to evaluate its general acceptability in trained and untrained panels.

Methodology: For the collection of scientific evidence on the benefits and recommended dose of spirulina for the formulation of functional ice cream, a minireview was carried out in the indexed databases of Scopus, Embase and Pubmed. Only articles conducted in humans and with the consumption of spirulina powder were selected. For the analysis of general acceptability data, the spps and excel programs were used; for the evaluation of the nutritional profile, the Nutrisurvey software was used.

Results and discussions*:* Our findings indicate that the formulation was better received by health and nutrition professionals, while the trained panel reported a higher acceptability for the version containing less spirulina, primarily due to the aftertaste, as it is not a common ingredient.

Conclusion: New formulations with stronger flavors may be necessary to mask the aftertaste of spirulina, in order to produce an ice cream with functional properties, given that the spirulina content varies from 1 to 2 grams per serving.

KEYWORDS

Nutritional properties, consumer acceptance, fortified ice cream, antioxidants, spirulina.

INTRODUCTION

The prevalence of obesity is rising alarmingly in both developed and developing countries. It is projected that by 2030, 60% of women and 50% of men will be classified as overweight or obese. Additionally, by 2040, one in ten adults is expected to suffer from diabetes, resulting in nearly 642 million individuals living with this condition, with the diabetic population projected to increase by 60%. In response to this public health crisis, functional foods have emerged as vital components in the management of non-communicable chronic diseases. One such functional food is spirulina, a cyanobacterium renowned for its antioxidant, antiviral, and immunological properties. Spirulina has been shown to protect against heavy metal retention and provide antitoxic effects, with multiple studies indicating its efficacy in treating arsenic poisoning. Furthermore, it exhibits protective effects against certain cancers[1]. The Food and Drug Administration (FDA) recognizes spirulina as "Generally Recognized as Safe" (GRAS) for human consumption[2].

Spirulina boasts an impressive absorption rate of 85% to 95% and contains approximately 65% protein, making it a

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complete source of all essential amino acids[3]. Research indicates that spirulina consumption is effective in managing glycemia and lipidemia in individuals with type 2 diabetes mellitus, leading to significant reductions in blood glucose levels, glycosylated hemoglobin (HbA1c), and blood lipid profiles, including decreases in triglycerides and low-density lipoproteins (LDL cholesterol) alongside increases in high-density lipoproteins (HDL cholesterol). Notably, studies have reported substantial decreases in triglycerides and total cholesterol following spirulina supplementation, with one study documenting a 10% reduction in total cholesterol and a 28% reduction in triglycerides among healthy volunteers, as well as a 15% increase in HDL cholesterol[4]. Additionally, spirulina has demonstrated the ability to lower total serum cholesterol, LDL cholesterol, and triglycerides in patients with hyperlipidemia and nephrotic syndrome.

Given its potential health benefits, spirulina may play a key role in dietary interventions aimed at improving lipid profiles in individuals with obesity and its associated comorbidities. Moreover, incorporating spirulina into foods designed for children and adolescents could foster increased consumption throughout adulthood. In this study, we aim to develop an artisanal ice cream formulation enriched with spirulina, free from artificial flavorings and colorings, to encourage its consumption. We assessed the overall acceptability of this product among both trained and untrained sensory panels.

HISTORY

Arthrospira and Spirulina were classified as one genus until their separation in 1989. Arthrospira includes over 50 species, with Arthrospira platensis, Arthrospira maxima, and Arthrospira fusiformis being the most studied. Spirulina has existed for over 3.5 billion years, initially thriving as anaerobic cyanobacterial filaments before evolving to use water in photosynthesis[5]. Its ability to fix carbon dioxide and produce organic matter is utilized in industrial food cultivation. The earliest recorded use dates back to 1520 when Hernán Cortés informed the Spanish monarchy about its production, and the Aztecs relied on it as a primary protein source. Its cultivation declined during Spanish colonial rule[6]. Spirulina has been a food source in Lake Chad, Africa, for centuries. Dangeard noted its consumption by the Kanembu tribe in 1940 and identified Arthrospira platensis in 1960. Commercial cultivation began in Mexico in the 1970s and is now widespread in countries like the United States, India, and China. The International Energy Agency (IEA) estimates global annual Spirulina production at around 10,000 tons of dry biomass, with China contributing nearly 50%[7].

NUTRITIONAL ATTRIBUTES

Spirulina exhibits an exceptionally high absorption rate, ranging from 85% to 95%. It is rich in protein, comprising approximately 65% of its composition, and contains low levels of sugars and carbohydrates. Notably, spirulina provides all the essential amino acids, including isoleucine (6%), leucine (9%), lysine (5%), methionine (2%), phenylalanine (5%), threonine (5%), tryptophan (2%), and others[8]. Additionally, spirulina contains proteins that are resistant to stress induced by high temperatures (35°-40°C) in the presence of light[9].

Moreover, spirulina is a good source of lipids, containing nine types of fatty acids, including palmitic, linoleic, and linolenic acids. It also offers a rich mineral profile, with more than nine minerals present; potassium and sodium are the most abundant, followed by magnesium, phosphorus, calcium, and iron. Spirulina boasts over thirteen vitamins, predominantly from the B vitamin group, along with significant amounts of vitamin A, beta-carotene, choline, and folate. The U.S. Food and Drug Administration (FDA) has classified many dry Arthrospira products as "Generally Recognized as Safe" (GRAS) for human consumption[2]. Doses ranging from 3 to 10 grams per day have been utilized in various clinical trials, and an intake of up to 30 grams daily is considered safe[10]. Additionally, the methionine content of spirulina, whether fresh or dehydrated, is comparable to that found in other meats such as chicken, beef, eggs, pork, and tuna[8].

HEALTH BENEFITS

To elucidate the benefits associated with the consumption of spirulina powder, a mini-review of the literature from the past five years was conducted, concentrating on the advantages of spirulina intake in humans. The primary objective of this review was to develop a functional ice cream based on scientific evidence. A systematic search and selection of pertinent scientific articles were executed, as depicted in the PRISMA 2020 flowchart (Figure 1).

Spirulina has been shown to be effective in managing lipidemia in patients with type 2 diabetes mellitus and other comorbidities[13]. A systematic review of clinical trials indicated that the intake of Spirulina resulted in significant improvements in glycemic control and glycosylated hemoglobin levels, alongside reductions in lipid profiles, including triglycerides and low-density lipoprotein (LDL) cholesterol, as well as an increase in high-density lipoprotein (HDL) cholesterol[18]. Furthermore, the consumption of 2 grams of Spirulina daily for a duration of 8 weeks led to a decrease in triglycerides and cholesterol levels[13], thereby significantly mitigating cardiovascular risk. Notably, a substantial reduction in both systolic and diastolic blood pressure was observed in both male and female participants following the consumption of 8 grams of Spirulina at 120 minutes[17]. Additionally, the intake of 6 grams of Spirulina over a 14-day period significantly increased hemoglobin levels[11]. In patients with non-alcoholic fatty liver disease (NAFLD), significant improvements in fatty liver grade, oxidative stress markers, triglycerides, and Homeostasis Model Assessment of Insulin Resistance (HOMA-IR) were noted with the consumption of 2 grams of Spirulina for 8 weeks[16]. After 8 weeks of sup-

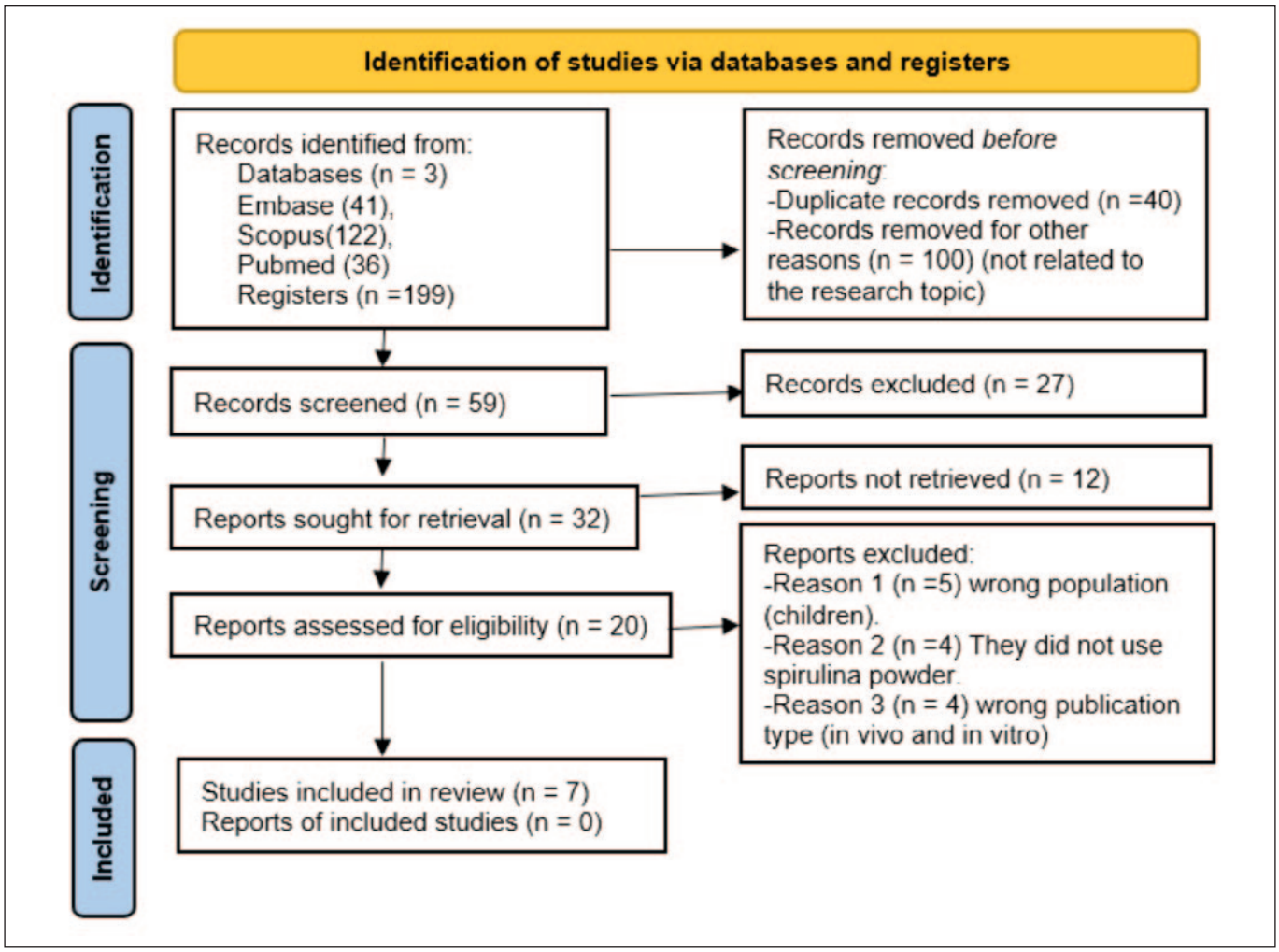

Figure 1. PRISMA 2020 flow diagram

plementation with 2 grams of Spirulina, participants with obesity exhibited significant upregulation of FNDC5 (Fibronectin type III domain-containing protein 5) and a reduction in the expression of NLRP3 (NLR family pyrin domain containing 3) and ACE2 genes (Angiotensin-converting enzyme 2)[12].

MECHANISMS OF ACTION

The mechanisms underlying the action of spirulina remain incompletely elucidated; however, existing studies suggest its metabolic effects. Notably, spirulina supplementation may offer potential benefits for weight management and the reduction of serum lipids. Its high amino acid content, which includes L-tyrosine and L-phenylalanine, could influence appetite and energy expenditure. Nevertheless, a systematic review did not find significant reductions in body measurements associated with spirulina consumption[18]. Spirulina has been shown to reduce hepatic lipid accumulation and improve lipid profiles by inhibiting low-density lipoprotein cholesterol (LDL-C) and increasing high-density lipoprotein cholesterol (HDL-C) through the action of C-phycocyanin, which also plays a role in cholesterol metabolism[18]. Additionally, spirulina may enhance insulin production and sensitivity, potentially leading to lower blood glucose levels; however, no significant changes were observed in the participants studied[18].

Phycocyanin and other bioactive compounds derived from Spirulina platensis have been shown to effectively enhance glucose and lipid metabolism in obesity-related metabolic disorders through mechanisms such as AMP-activated protein kinase (AMPK) activation, Akt signaling, and anti-inflammatory pathways. Although there is significant preclinical evidence[21,22] supporting these effects, robust studies in human populations remain limited[21]. Phycocyanin activates AMPK and Akt pathways, resulting in reduced hepatic gluconeogenesis and increased glycogen synthesis and glucose uptake in insulin-resistant models[21,22].

Furthermore, it enhances the translocation of glucose transporter type 4 (GLUT4) and provides protection to β-cells

through its antioxidant properties, thereby reducing oxidative stress and preserving insulin secretion[22]. Additionally, spirulina has been found to reduce lipogenesis by downregulating sterol regulatory element-binding protein 1c (SREBP-1c) and peroxisome proliferator-activated receptor gamma (PPARγ), while promoting fatty acid oxidation via the activation of carnitine palmitoyltransferase 1 (CPT1)[23]. It also inhibits pancreatic lipase activity, which reduces cholesterol absorption and improves lipid profiles[24]. Moreover, spirulina suppresses nuclear factor kappa-light-chain-enhancer of activated B cells (NF-κB) signaling and upregulates antioxidant enzymes such as superoxide dismutase (SOD) and catalase (CAT), thereby reducing systemic inflammation and oxidative stress[22]. Lastly, it modulates gut microbiota composition, leading to an increase in short-chain fatty acids (SCFAs) and enhanced insulin sensitivity[23].

The results presented in the table 1 indicate that a minimum consumption of 1 gram of spirulina yields health benefits. Furthermore, the majority of studies conducted over the past five years involving human subjects have utilized a minimum consumption of 2 grams. In light of the scientific evidence identified in the review, the homemade ice cream was formulated with servings containing 1 gram and 2 grams of spirulina, which will be assessed for general acceptability by both trained and untrained panels.

Table 1. Spirulina Studies in Humans

Reference	Country	Design	Population	Sample size	Doses	Duration	Comparison	Main Results
Y. Ali et al. 2023[11]	United Kingdom	RDBPC crossover	Active cyclist Age 23 ± 5 yrs	n=17 GE= 10 GP= 8	6g/day	14 days	Placebo	Significantly improved hemoglobin levels. No changes in performance parameters.
Armannia, F. et al 2023[12]	Iran	RDBPC	Obese subjecs Age 44.83 ± 3.04 yrs	n=24 GE=12 GP=12	2g/day	8 weeks	Placebo	Significant upregulation of FNDC5, reduction of NLRP3 and ACE2 genes expression. No changes in antropometric measures.
Rezaiyan M. et al 2023[13]	Iran	RDBPC	T2DM patients	n=46 GE= 23 GP= 23	2g/day as Spirulina sauce	8 weeks	Placebo	TG, TC and Waist circumference were significantly decreased, No significant changes for glycemic control.
Moradi, S. et al 2023[14]	Iran	RDBPC	Ulcerative colitis patients	n=80 GE= 40 GP= 40	1g/day	8 weeks	Placebo	Significantly increased serum iron levels in patients with ulcerative colitis. Non significant changes were observed in FOBT.
Far, Z. et al 2022[15]	Iran	Tripled Blind Placebo RCT	Patients with Hypertension	n=48 GE=24 GP=24	2g/day as Spirulina fortified dressing	8 weeks	Placebo	Non significant changes in anxiety levels based on the Holmes- Rahe questionnaire.
Mazloomi, S. et al 2022[16]	Iran	RDBPC	NAFLD patients	n=46 GE= 23 GP= 23	2g spirulina	8 weeks	Placebo	Significant improvement in fatty liver grade, oxidative stress markers, TG, and HOMA- IR. No significant change was found in BP and anthropometric measures.
Lympaki F., et al 2022[17]	Greece	Randomized crossover clinical trial	Healthy adults (Both male and female)	n=13	Trial 1: 2,5g spirulina cookie, Trial 2: 4, 6, 8 g spirulina	Postprandial effect for a Day	D-glucose, cookie without spirulina	Both 4 g and 8 g doses of spirulina reduced postprandial glucose levels at 120 minutes. Only the 8 g dose significantly reduced the AUC for glucose and systolic BP by 4% during the 90 to 120-minute interval

RDBPC (Randomized Double Blind Placebo Control trial), FNDC5 (Fibronectin type III domain-containing protein 5), NLRP3(NLR family pyrin domain containing 3), ACE2 (Angiotensin-converting enzyme 2), TG (Tryglicerides), TC (Total Cholesterol), FOBT (Fecal occult blood test), BP (Blood pressure), AUC (Area Under the Curve).

MATERIAL AND METHODS

In order to determine the recommended dosage of spirulina for the formulation of a functional ice cream, a scoping review was conducted. The review involved a comprehensive search of the SCOPUS, Embase, Web of Science, and PubMed/Medline databases, which was completed by July 20, 2023. The keywords employed in the search included "Spirulina," "Arthrospira platensis," "Health benefits," "Nutritional benefits," "Clinical trials," and "Consumption." All articles pertaining to human studies on the consumption of spirulina powder were included in this minireview. Based on the scientific evidence identified in the minireview, two formulations of homemade ice cream were developed, each containing servings of 1 gram and 2 grams of spirulina, which will be evaluated for general acceptability by both trained and untrained panels.

The ice cream formulations were created using an artisanal recipe based on an anglaise sauce infused with fresh mint. Specifically, two samples were produced: Sample 1, which contained 12 grams of dried spirulina, and Sample 2, which contained 24 grams. The quantities of each formulation are detailed in Table 2 and 3. The nutritional composition of both

Table 2. Spirulina – enriched ice cream formulation

Ingredients	Sample 1 with 12 g Spirulina		Sample 2 with 24 g of Spirulina	
	g	%	g	%
Dried spirulina	12	0.83	24	1.64
Fresh mint	60	0	60	0
Stabilizer	5	0.35	5	0.34
Sugar	120	8.29	120	8.22
Powdered milk	80	5.53	80	5.48
Milk cream	150	10.37	150	10.28
Egg yolks	80	5.53	80	5.48
Fresh milk	1000	69.11	1000	68.54

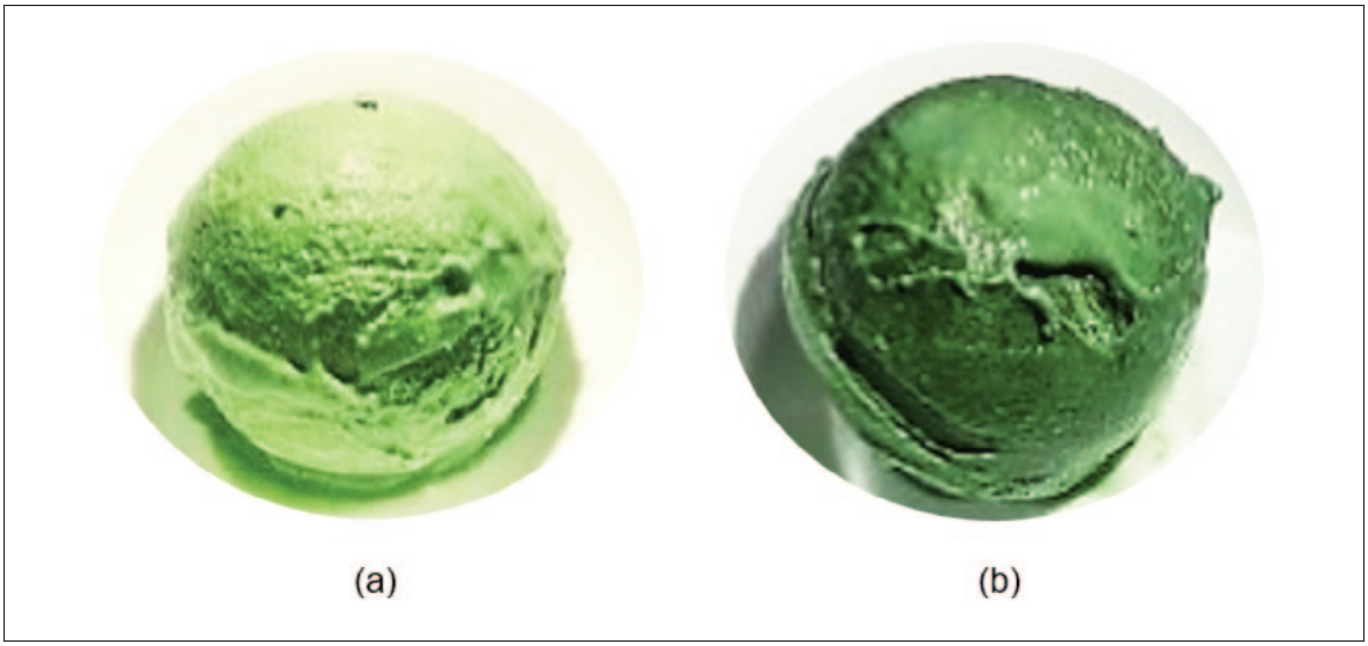

Figure 2. (a) Recipe of the Spirulina ice cream (Sample 1 with 12 g); (b) Spirulina ice cream of sample 1 (With 24 g of spirulina)

Table 3. Spirulina-enriched ice cream nutritional Composition per serving (90g)

Nutrients	Ice Cream Sample 1 (formulation with 12 g of spirulina)		Ice Cream Sample 2 (formulation with 24 g of spirulina)	
	g	%(DV)	g	%(DV)
Calories	**106 kcal**	**-**	**108 kcal**	-
Carbohydrates (g)	11.57	4.00	11.73	4.05
Fat (mg)	4.83	7.00	4.88	7.05
Protein (g)	**4.12**	6.84	**4.48**	7.47
Dietary fiber (g)	0.27	0.89	0.30	1.00
Iron (mg)	**0.52**	3.47	**0.7**	4.68
Magnesium (mg)	14.23	4.58	15.464	5.00
Calcium (mg)	**120.58**	12.05	**121.34**	12.16
Potassium (mg)	161.72	4.63	170.32	4.84
Sodium (mg)	52.65	2.63	59.26	2.95
Vitamin C (mg)	1.56	1.58	1.63	1.63
Folic acid (ug)	14.89	3.74	15.49	3.89
Vitamin B6 (mg)	0.06	4.89	0.06	5.11
Vitamin B2 (mg)	**0.22**	18.11	**0.24**	20.00
Vitamin B1 (mg)	0.06	6.37	0.08	7.89
Vitamin E (mg)	0.02	0.16	0.02	0.16
Carotene (mg)	0.02	-	0.02	-
Vitamin A (ug)	**68.14**	8.53	**68.32**	8.53
Cholesterol(mg)	57.84	-	57.84	-
PUFA (mg)	0.39	3.95	0.41	4.05

samples was analyzed using nutritional software (Nutrisurvey). Furthermore, a general sensory acceptability evaluation was conducted with two panels: a trained panel (n=23), which included chefs (n=5), professors (n=8), and graduated gastronomy students (n=10), and a non-trained panel (n=22), comprising administrators (n=5) and nutritionists (n=17). The sensory evaluation utilized a five-point scale: "I like it very much," "I like it moderately," "I neither like nor dislike," "I dislike moderately," and "I dislike it very much." For the analysis of general acceptability data, the SPSS and Excel programs were employed, while the evaluation of the nutritional profile was conducted using Nutrisurvey software.

RESULTS AND DISCUSSION

All the details regarding the formulations and nutritional profiles of the ice cream recipes for Sample 1 (containing 12 g of spirulina) and Sample 2 (containing 24 g of spirulina) are presented in detail in table 2 and 3 below.

A comparative analysis of the nutritional profiles of our functional ice cream formulation, which incorporates spirulina, and a commercially available vanilla ice cream with analogous characteristics reveals notable differences. Our formulation contains 50% fewer calories, includes dietary fiber, exhibits a lower total carbohydrate content, and has

300% less total fat. Furthermore, it offers a greater quantity of micronutrients in comparison to conventional commercial ice creams.

The hedonic scale assessment of ice cream with 12 g and 24 g of spirulina showed no significant difference in overall acceptability. The 12 g sample scored 3.91 out of 5, while the 24 g sample scored 3.84. The lower acceptance of the higher concentration may stem from limited exposure to spirulina. Our artisanal recipe excluded artificial colors and flavors as the study of Ramón-Garcia did[25], making it harder for non-experts to identify the spirulina flavor. Acceptability decreased with increased spirulina content, yet overall scores were higher than expected, indicating a need for prior exposure. Acceptability levels were nearly identical, though slightly more individuals preferred the lower concentration. These results align with other evaluations noting an aftertaste in higher spirulina samples.Notably, a significant portion of the population was unfamiliar with spirulina, and the acceptability of spirulina ice cream containing 12 and 24 grams was predominantly attributed to the group of nutritionists. This may be due to their knowledge and familiarity with health-beneficial products. Additionally, the graduates demonstrated a high level of acceptability, even surpassing that of the chefs who participated in the tasting; this could be attributed to the age of the graduates, as younger individuals exhibited a greater openness to new flavors and a willingness to experiment with them.

Sensory tests on various products containing spirulina were conducted. Gershwin (2008) describes a study in which tests were performed using 1 g, 2.5 g, and 5 g of spirulina per recipe in cookies, yielding general acceptability scores of 3.00, 2.66, and 2.41, respectively, on a scale of 5 points. Notably, as the concentration of spirulina increased, the acceptability decreased[26]. To minimize bias, we did not disclose the specific products used or the functional benefits of spirulina prior to the tests, as knowledge of health benefits or nutritional composition may influence acceptability. After the tests, participants were informed about the composition of the samples and their associated health benefits. We then inquired about their knowledge, previous consumption, potential acceptance of these products, and other related items. Very few studies have been conducted on the incorporation of spirulina into ice cream formulations. A recent study developed a functional ice cream using Spirulina platensis, in which both fat and sugar content were reduced[27]. All recipes featured a 50% reduction in fat and a

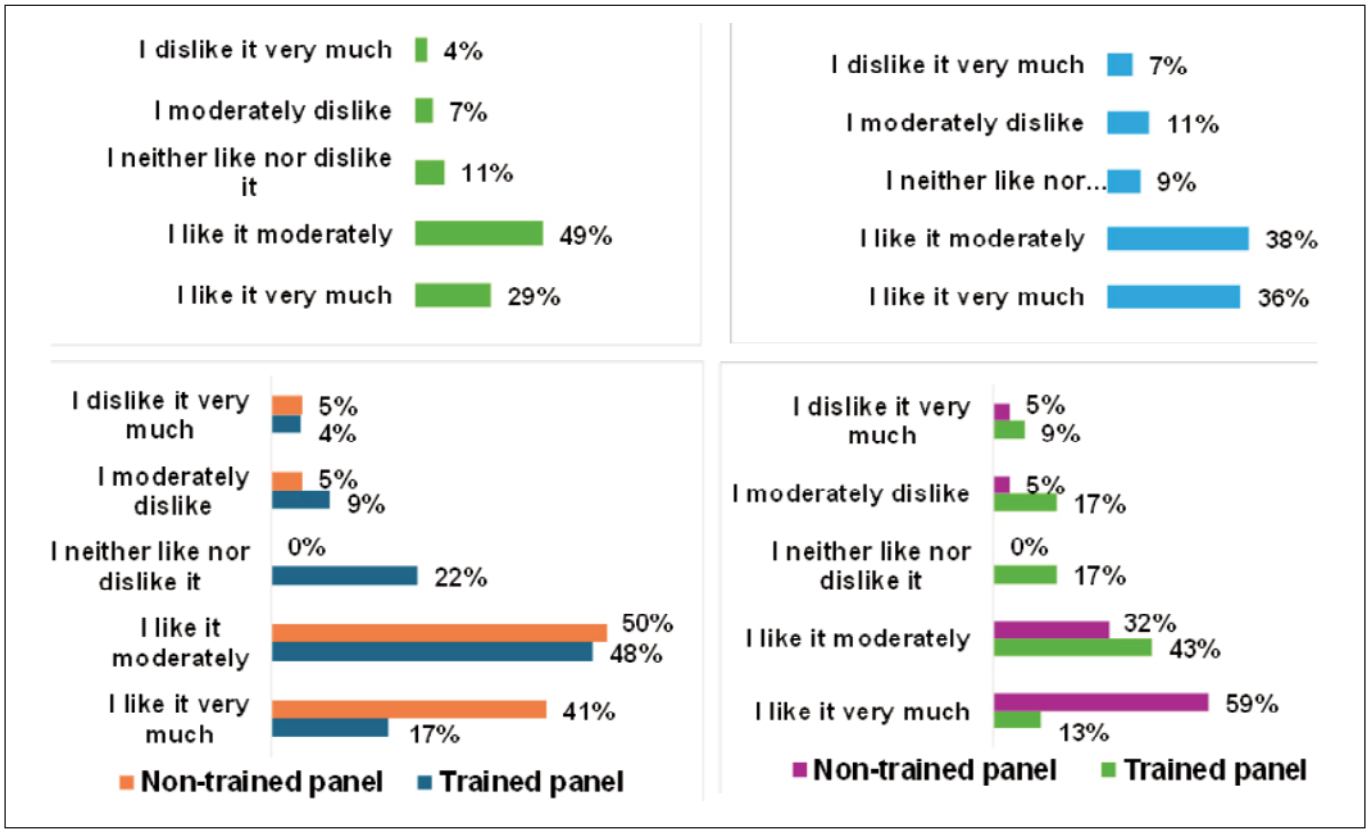

Figure 3. (a) Hedonic scale of mint ice cream with spirulina 12 g (Sample 1) in general (b), by panel; (c) Hedonic scale of mint ice cream with spirulina 24 g (Sample 2) in general and (d) by panel

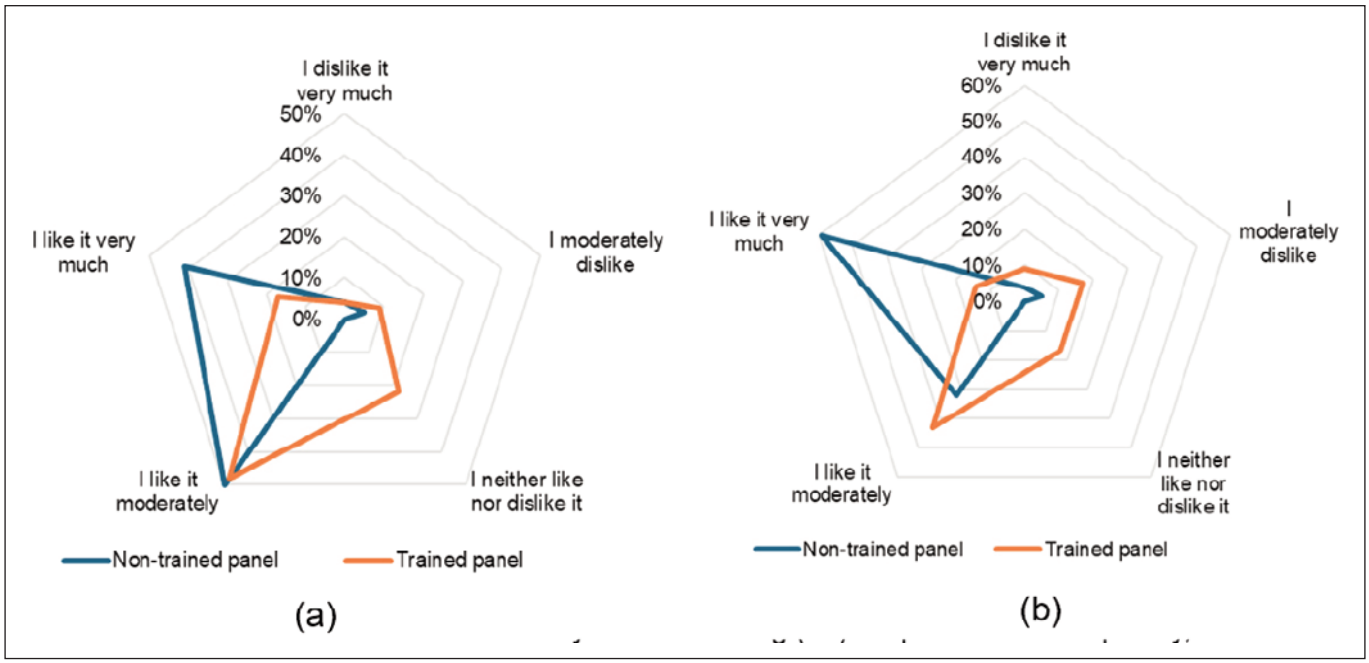

Figure 4. General sensory acceptability of spirulina enriched mint ice cream : (a) with 12 g spirulina (Sample 1), (b)with 24 g spirulina (Sample 2)

25% reduction in sugar. Additionally, spirulina, inulin, and emulsifiers were incorporated into some formulations. The total amount of spirulina powder added varied from 7.3 to 8.6 grams per recipe, which is lower than the quantity used in this research, ranging from 12 to 24 grams per recipe. The primary ingredients are similar to those used in this formulation, including powdered milk, stabilizers such as carboxymethyl cellulose, sugar, and cream. Another study added spirulina powder to an enriched vanilla ice cream formulation, developing four samples (T1, T2, T3, and T4) with 1.25 g, 2.5 g, 3.75 g, and 3.75 g of spirulina powder added to 825 g of vanilla ice cream[28].

A sensory acceptability evaluation was performed on two samples: Sample 1 with 12 g of spirulina powder in mint-infused ice cream and Sample 2 with 24 g of spirulina. Using a 5-point scale, results revealed that 7% of participants strongly disliked Sample 1, while 4% strongly disliked Sample 2. Additionally, 11% moderately disliked both samples, with 11% neutral toward Sample 1 and 8% neutral toward Sample 2. Moderate liking was reported by 49% for Sample 1 and 38% for Sample 2. Finally, 29% liked Sample 1 very much, compared to 36% for Sample 2. The average acceptability rating was 3.91 (78.22%) for Sample 1 and 76.89% for Sample 2.

When comparing our results with those presented in the study by Jadhav[28], which examined four samples of vanilla ice cream infused with spirulina, it is crucial to note that none of the samples contained the quantities of spirulina utilized in our research. Specifically, we incorporated 12 g of spirulina in Sample 1, whereas the sample with the highest spirulina content in Jadhav's study contained only 5 g (T4). The second formulation evaluated in that study included 3.75 g (T3) of spirulina. Consequently, our Sample 1 contained 220% more spirulina than T3 and 38% more than T4. In contrast, Sample 2 contained 540% more spirulina than T3 and 176% more than T4.

Despite the significantly lower amounts of spirulina in the ice cream samples T3 and T4 from the Jadhav study, their acceptability ratings were notably high, with T3 at 87.33% and T4 at 89.22%. In contrast, our results indicated that Sample 1 received a rating of 78.22%, while Sample 2 received a rating of 76.89%. In a separate study conducted by da Silva Faresin[27], four formulations of ice cream containing spirulina were evaluated, each containing between 10% and 15% more spirulina than our Sample 1. Comparatively, our Sample 2 contained 70%, 75%, 80%, and 73% more spirulina than samples IC6, IC7, IC10, and IC11, respectively. Despite the varying percentages of spirulina—and a greater difference with Sample 2—the samples from the da Silva Faresin study achieved acceptability ratings of 71.00% (IC6), 71.56% (IC7), 74.11% (IC10), and 72.78% (IC11). These ratings are quite close to those obtained in our study: 78.22% for Sample 1 and 76.89% for Sample 2.

Unlike the sugar and fat-reduced recipe, which contains additional ingredients that may diminish certain sensory charac-

teristics of spirulina powder, such as Chantilly and flavoring agents, the overall impression from the nine-point evaluation of ice cream formulations with spirulina powder ranged from 71% ± 19.37% to 74.11% ± 18.44%. In contrast, the overall acceptability of our samples varied from 73.33% to 78%, despite having a higher spirulina content. This suggests that mint, as an aromatic herb, may be more effective in masking the taste and aftertaste of spirulina compared to traditional flavoring agents.

Notably, the amount of spirulina in each recipe significantly influences its protein content. Our formulations contain 5.41 g (12 g of spirulina per recipe) and 5.84 g (24 g of spirulina per recipe) of protein per 100 g portion. In contrast, the fat- and sugar-reduced ice cream contains between 2.52 g and 2.85 g of protein per 100 g. Additionally, a handmade spirulina ice cream formulation with 0.6% to 1.2% spirulina powder contains between 3.48 ± 0.07 g and 3.54 ± 0.14 g of protein per portion[29]. Therefore, our formulations provide a higher protein content due to their spirulina content, making them an excellent alternative for increasing protein intake in children and teenagers.

The trained and untrained panelists were analyzed separately. For sample 1, which consisted of 12 grams of spirulina, a higher percentage of untrained panelists (41%) indicated that they liked it a lot, compared to only 17% of the trained panelists. However, the responses for the "I like it moderately" option were quite similar, with untrained panelists at 50% and trained panelists at 48%. In sample 2, which comprised 24 grams of spirulina, the untrained panelists again demonstrated a higher percentage (59%) of those who expressed a strong preference for the product, while only 14% of the trained panelists reported the same. Similarly, in the "I like it moderately" category, the untrained panelists accounted for 32%, while the trained panelists were slightly higher at 43%.

Another study[30] developed a handmade ice cream that incorporated 1% Spirulina biomass relative to the total mass of the ice cream. In contrast, other research formulated ice creams with 0.6% and 1.2% Spirulina[29], which fall between the percentages used in this study: 0.83% and 1.64% for each formulation, respectively. However, the carbohydrate content was higher due to the inclusion of condensed milk, resulting in an overall sensory acceptability that was lower than our findings. The average sensory evaluation scores for aroma, color, texture, and flavor of the ice cream samples were converted to percentages, yielding 76.33% (±9.67%) for the ice cream with 0.6% Spirulina powder and 70.56% (±12%) for the ice cream with 1.2%. As indicated by our results, an increase in Spirulina powder correlates with a decrease in overall acceptability. Since inulin does not negatively impact palatability, it may be beneficial to include it in future formulations to enhance fiber content and reduce sugar levels. Consequently, Spirulina could be incorporated into the development of ice cream and other functional products.

CONCLUSIONS

Due to its antioxidant, hypolipidemic, and hypoglycemic properties, spirulina can be beneficial for obesity-related metabolic disorders. Notably, spirulina supplementation has been shown to significantly reduce total cholesterol and triglyceride levels. In terms of carbohydrate metabolism, the consumption of spirulina enhances glycosylated hemoglobin, improves insulin resistance, and positively impacts glucose response, thereby supporting the treatment of metabolic syndrome. This improvement in glucose metabolism is attributed to its phycocyanin content, which activates the expression of glucokinase and insulin signaling pathways in the pancreas and liver. As a result, spirulina enhances pancreatic and liver function and increases the synthesis of hepatic glycogen, leading to lower blood glucose levels.

Despite its numerous benefits, there have been very few studies on the incorporation of spirulina into ice cream formulations. Interestingly, higher concentrations of spirulina powder in formulations tend to correlate with lower overall acceptability. Therefore, more research is needed to explore the incorporation of spirulina into various ice cream formulations, particularly those that are easy to consume, to promote the development of functional food products containing spirulina.

Additionally, no existing studies have utilized aromatic herbs to mitigate the unique taste of spirulina. This highlights the need for further research into alternative formulations to achieve optimal sensory acceptability and to demonstrate the potential health benefits of this product. The nutritional profile of spirulina, which includes vitamins, minerals, and amino acids, positions it as a promising ingredient for developing functional products aimed at improving nutritional status and health, as well as managing chronic diseases related to obesity.

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Hospital malnutrition and stroke: a study of nutritional risk and patient outcomes

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ABSTRACT

Introduction: Hospital malnutrition is a prevalent issue among stroke patients, with significant impacts on immune function and clinical outcomes. Malnutrition is associated with poor outcomes such as increased complications, prolonged recovery, and higher mortality. This study aims to assess the prevalence of malnutrition using the Malnutrition Screening Tool (MST) and its association with clinical outcomes, including length of stay (LOS), inflammatory markers, and mortality.

Methods: A retrospective cohort study was conducted, including 230 stroke patients who were admitted between January 2022 and January 2024. Nutritional status was assessed using the MST, with key outcomes including LOS, Total Lymphocyte Count (TLC), Neutrophil-to-Lymphocyte Ratio (NLR), serum albumin, Prognostic Nutritional Index (PNI), and mortality. Statistical analyses were performed using chi-square tests for categorical variables and t-tests or Mann-Whitney U tests for continuous variables, with a p-value of <0.05 considered statistically significant.

Result: The study found that 26.5% of patients had an MST score of 2 or higher, indicating a high risk of malnutrition. Patients with high MST scores had significantly lower TLC ($p = 0.01$), indicating a weakened immune response. No significant differences were observed in LOS ($p = 0.63$), mortality ($p = 0.40$), or other inflammatory markers such as NLR, albumin, and PNI between the high-risk and low-risk groups.

Conclusion: Malnutrition is common among stroke patients and is associated with impaired immune function, as evidenced by lower TLC in malnourished patients. Although no significant differences were observed in LOS or mortality, the findings underscore the importance of routine nutritional screening and timely intervention to improve patient outcomes.

KEYWORDS

Nutritional Support, Hospital Management, MST, Immune Function, TLC.

INTRODUCTION

Hospital malnutrition is a critical issue that frequently affects patients requiring extended care, particularly those with conditions like stroke[1,2]. Malnutrition in hospital settings is often caused by factors such as inadequate intake, increased metabolic demands, and complications from the primary illness[3,4]. Despite the known risks, malnutrition remains underrecognized, leading to poorer patient outcomes such as prolonged hospital stays, increased complications, and higher mortality[5,6,7].

Nutritional status plays a pivotal role in recovery, with malnourished patients being more susceptible to infections, delayed wound healing, and impaired immune function[8,9]. Inflammatory markers like the Neutrophil-to-Lymphocyte Ratio (NLR), serum albumin, and the Prognostic Nutritional Index (PNI) provide valuable insights into the patient's nutritional status, which directly impacts recovery. However, consistent screening using tools such as the Malnutrition Screening Tool (MST) is often overlooked, limiting opportunities for early nutritional intervention[10,11].

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This study assesses the prevalence of malnutrition among stroke patients and explores its impact on clinical outcomes, including length of stay, inflammatory markers, and mortality. By emphasizing the role of nutritional screening and timely intervention, this research seeks to highlight the importance of addressing hospital malnutrition to improve patient outcomes.

METHODS

Study Design and Participants

This study utilized a retrospective cohort design to assess the prevalence of malnutrition and its association with clinical outcomes in stroke patients. The study included patients diagnosed with stroke, admitted between January 2022 and January 2024. Inclusion criteria were patients aged 18 years and older, diagnosed with stroke, and hospitalized for at least seven days. Patients were excluded if they had incomplete medical records or were above the age of 59.

Nutritional Assessment

Malnutrition risk was evaluated using the Malnutrition Screening Tool (MST). Patients with an MST score of 2 or higher were considered at risk of malnutrition. Key laboratory parameters, including the Neutrophil-to-Lymphocyte Ratio (NLR), serum albumin levels, Total Lymphocyte Count (TLC), and Prognostic Nutritional Index (PNI), were also recorded and analyzed in relation to malnutrition status.

Data Collection

Data on patient demographics, nutritional status, inflammatory markers, length of stay, and mortality were collected from the medical records of Wahidin Sudirohusodo Hospital. The primary outcomes measured were LOS, inflammatory response (NLR, TLC, PNI, and albumin), and mortality. Data were analyzed to determine the correlation between malnutrition risk and these outcomes.

Statistical Analysis

Descriptive statistics were used to summarize patient characteristics. Categorical variables were analyzed using chi-square tests, while continuous variables were analyzed using t-tests or Mann-Whitney U tests, depending on the distribution of the data. A p-value of <0.05 was considered statistically significant.

RESULTS

Out of the 606 stroke patients initially identified during the study period, 130 patients were excluded due to not meeting the inclusion criteria: 93 were older than 59 years, and 37 had a length of hospital stay of less than seven days. This left a total of 476 patients for further analysis. After excluding 246 patients with incomplete data, 230 patients were included in the final analysis.

The median age of the patients was 51.5 years (IQR: 42-56), with a majority being male (57.4%). The median body mass index (BMI) was 21.5 kg/m² (IQR: 19.7-23.4 kg/m²). Regarding malnutrition risk, 26.5% of patients had an MST score of 2 or higher, indicating high risk, while 73.5% had a score below 2. The most common stroke type was infarction (65.2%), and hypertension was the most frequent comorbidity (20.9%).

Table 1. Baseline characteristics of the study patients

Age, year	51.5 [42, 56]
Sex	
Men	132 (57.4)
Woman	98 (42.6)
Height, cm	160 [155, 165]
Weight, kg	55 [49, 61.1]
BMI, kg/m2	21.5 [19.7, 23,4]
Education Status	
No Education	9 (3.9)
Elementary	49 (21.3)
Secondary	25 (10.9)
High School	102 (44.3)
Diploma	6 (2.6)
Bachelor	39 (17)
Occupation Status	
Unemployed	88 (38.3)
Student	4 (1.7)
Employee	56 (24.3)
Self-Employee	82 (35.7)
Marital Status	
Unmarried	25 (10.9)
Married	194 (84.3)
Widowed	11 (4.8)
MST	
<2	169 (73.5)
≥2	61 (26.5)

Data are presented as n (%) or median [interquartile range].
BMI, Body Mass Index; MST, Malnutrition Screening Tool; MNT, Medical Nutrition Therapy; LOS, Length of Stay; NLR, Neutrophil to Lymphocyte Ratio; TLC, Total Lymphocyte Count; PNI, Prognostic Nutritional Indeks.

Table 1 continuation. Baseline characteristics of the study patients

Type of Stroke	
Infarction	150 (65.2)
Hemorrhagic	80 (34.8)
Intervention	
No	196 (85.2)
Yes	34 (14.8)
Comorbid	
No Comorbid	156 (67.8)
HT	48 (20.9)
DM	9 (3.9)
HT+ DM	13 (5.7)
CVD	4 (1.7)

MNT	
No	145 (63.0)
Yes	85 (37.0)
LOS	14 [10.7, 22.2]
Mortality	
No	34 (14.8)
Yes	196 (85.2)
NLR	6.3 [3.5, 9.8]
Albumin	3.5 [3.1, 3.9]
TLC	1587 [1055, 2313]
PNI	42.3 [37.4, 48.8]

Data are presented as n (%) or median [interquartile range].
BMI, Body Mass Index; MST, Malnutrition Screening Tool; MNT, Medical Nutrition Therapy; LOS, Length of Stay; NLR, Neutrophil to Lymphocyte Ratio; TLC, Total Lymphocyte Count; PNI, Prognostic Nutritional Indeks.

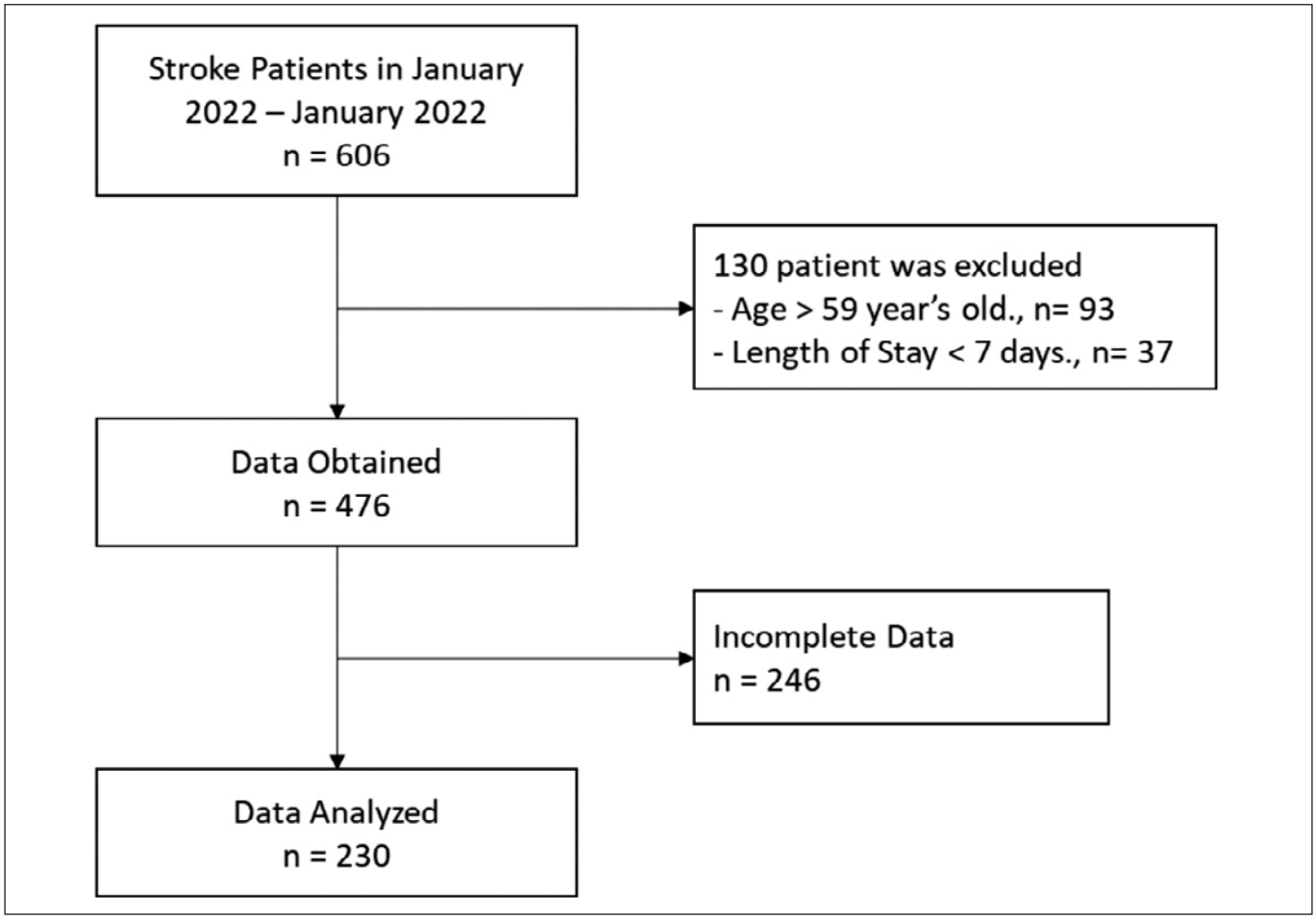

Figure 1. Flowchart for the selection of patients selected for the evaluation of Stroke

Table 2. Correlation between MST with type of stroke, clinical outcome, and laboratory parameters

	MST<2 (n=169)	MST ≥2 (n=61)	p Value
Type of Stroke			
Infarction	102 (60.4)	48 (78.7)	0.01
Hemorrhage	67 (39.6)	13 (21.3)	
MNT			
No	110 (65.1)	35 (57.4)	0.285
Yes	59 (34.9)	26 (42.6)	
LOS	15 [11.25, 22.75]	13 [8, 21.5]	0.63
Mortality			
No	146 (86.4)	50 (82.0)	0.404
Yes	23 (13.6)	11 (18.0)	
NLR	6.38 [3.79, 9.5]	6.15 [3.42, 10,75]	0.283
Albumin	3.6 [3.2, 3.9]	3.4 [2.8, 3.8]	0.107
TLC	1759 [1247, 2342]	1248[666, 2174]	0.017
PNI	43.6 [38.9, 49.6]	41.4 [33.4, 47.1]	0.132

Data are presented as n (%) or median [interquartile range].
BMI, Body Mass Index; MST, Malnutrition Screening Tool; MNT, Medical Nutrition Therapy; LOS, Length of Stay; NLR, Neutrophil to Lymphocyte Ratio; TLC, Total Lymphocyte Count; PNI, Prognostic Nutritional Indeks.

The average length of stay was 14 days (IQR: 10.7-22.2), and the mortality rate was 14.8%. Regarding nutritional status, patients with an MST score of 2 or higher had a lower Total Lymphocyte Count (TLC) compared to those with MST < 2 (1248 vs. 1759, p = 0.01), indicating a weakened immune response in the malnourished group. However, table 2 shows no correlations significant were found in the Neutrophil-to-Lymphocyte Ratio (NLR), albumin, and PNI between the two groups. Furthermore, there were no significant differences in length of stay (p = 0.63) or mortality (p = 0.40) between patients with high and low MST scores.

DISCUSSION

This study highlights the significant prevalence of hospital-acquired malnutrition among stroke patients, with over a quarter of the study population being at high nutritional risk based on the Malnutrition Screening Tool (MST). This finding aligns with prior research, which has consistently reported malnutrition as a common issue in stroke patients due to factors such as dysphagia, reduced intake, and increased metabolic demands[8,12]. The high prevalence of malnutrition underscores the importance of routine nutritional screening in this vulnerable population[4,10].

One of the key findings of this study is the association between malnutrition risk and immune function, as reflected by the significantly lower Total Lymphocyte Count (TLC) in patients with an MST score of 2 or higher. This suggests that patients at higher nutritional risk have compromised immune systems, making them more vulnerable to infections and other complications. Previous studies have similarly shown that malnutrition impairs immune function by reducing lymphocyte production and activity, which increases susceptibility to infections and delays recovery[13,14]. The lower TLC in malnourished patients emphasizes the need for early nutritional intervention to support immune function and potentially reduce the risk of infections in stroke patients[15,16].

Interestingly, this study did not find significant differences in key outcomes such as length of stay (LOS) and mortality between patients with high and low MST scores. This contrasts with previous literature, which typically shows that malnourished patients have longer hospital stays and higher mortality rates[2,5,17,18]. Several factors may account for this discrepancy. First, the clinical condition of stroke patients can vary widely, and the severity of stroke, rather than nutritional status alone, may have a more substantial impact on LOS and mortality. Additionally, the provision of medical nutrition ther-

apy (MNT) to patients identified as malnourished could have mitigated the adverse effects of malnutrition, helping to stabilize these outcomes[9]. In this study, 37% of patients received MNT, which likely contributed to more favorable clinical outcomes in the malnourished group.

Another important observation in this study is the higher prevalence of infarction stroke among malnourished patients compared to hemorrhagic stroke. Patients with an MST score of 2 or higher were more likely to have experienced an infarction stroke, whereas hemorrhagic stroke was more common in patients with an MST score below 2. While the reasons for this association are not entirely clear, it is possible that infarction stroke patients face unique nutritional challenges due to the nature of their condition, including prolonged immobility, which can exacerbate nutritional deficits[18,19]. Further research is needed to explore the mechanisms behind this association and to determine whether specific interventions could better address the nutritional needs of infarction stroke patients.

The study's strengths lie in its focus on a well-defined stroke population and the use of validated screening tools such as the MST and laboratory markers like TLC, NLR, albumin, and PNI. However, there are some limitations. First, the retrospective nature of the study limits the ability to establish causality between malnutrition and clinical outcomes. Additionally, the relatively small sample size may have reduced the study's power to detect significant differences in outcomes such as LOS and mortality. Larger, prospective studies are needed to confirm these findings and further explore the impact of nutritional interventions on clinical outcomes.

CONCLUSION

In conclusion, this study underscores the high prevalence of hospital malnutrition among stroke patients and its association with weakened immune function. While no significant differences in length of stay or mortality were found, the findings highlight the importance of early nutritional screening and intervention in this population. Addressing malnutrition through timely and targeted nutritional therapy may improve immune function and reduce the risk of complications, ultimately contributing to better outcomes for stroke patients.

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The effect of nutritional assistance "Gammara'Na" on food acceptance and nutritional status of children in South Sulawesi, Indonesia

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ABSTRACT

Background: Nutritional deficiencies are a public health issue requiring serious attention in Indonesia. This study evaluates the impact of the Gammarana Program on infant and child feeding practices and nutritional status in South Sulawesi. The program includes nutritional education and counseling provided by Village Nutrition Assistants (TPGD) in stunting-prone villages. The study aimed to assess the program's effectiveness in improving feeding frequency, dietary diversity, food acceptance, and overall nutritional status of children.

Methods: A pretest-posttest design without a control group was used, involving 114 stunting-prone villages and 2,148 families. Over six months, TPGD provided education and counseling on infant and child feeding, growth monitoring, and supplementary feeding. Data were collected through interviews and anthropometric measurements and analyzed using McNemar's test to determine changes before and after the intervention, with significance set at $p<0.05$.

Results: Results showed a 12.1% increase in feeding frequency, a 27.1% increase in dietary diversity, and a 25.3% improvement in food acceptance. The proportion of underweight children decreased by 1.2%, stunted children by 5.4%, and underweight children by 2.6%. Significant improvements were observed in feeding frequency, dietary diversity, and stunting reduction. Additionally, the increase in average nutritional Z-scores indicated an overall improvement in children's nutritional status.

Conclusion: The Gammarana Program effectively improved feeding practices and reduced stunting rates in South Sulawesi.

KEYWORDS

Childhood, Community Nutrition, Nutrition Education.

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INTRODUCTION

Nutritional deficiencies are a public health issue requiring severe attention in Indonesia. The 2022 SSGI analysis showed an increase in the prevalence of stunting from 13.7% to 22.4% among infants aged 6-11 months and children aged 12-23 months[1]. This is linked to poor nutrition during the first two years of life, significantly influenced by inadequate infant and young child feeding practices. Proper feeding practices during the first two years are crucial for achieving good nutrition, protecting undernutrition and overweight in both the short and long term[2].

Globally, there is an agreement on the global indicators for infant and young child feeding practices[3], which include three key components: minimum meal frequency (MMF), dietary diversity score (DDS), and acceptable diet (AD)[4,5]. Nutritional assistance can improve children's feeding practices, nutritional status, and growth. Since 2020, the Indonesian government has implemented a national program to accelerate stunting reduction. Following this national program, the South Sulawesi provincial government launched the "Gammarana" program, a stunting reduction acceleration program through targeted family nutritional assistance by Village Nutrition Assistants (TPGD). The main focus of this program is infant and young child feeding (IYCF) and growth monitoring. This program is a flagship initiative of the South Sulawesi government to improve the nutritional status of children under five

and accelerate stunting reduction. In this context, we evaluated the program's impact on children's food acceptance (IYCF) and the nutritional status of children under five.

The research problem in this study is the high prevalence of malnutrition in South Sulawesi, particularly stunting, wasting, and underweight, despite the region's potential as a food producer. This study aims to evaluate the impact of nutritional assistance by TPGD on children's food acceptance (IYCF) and the nutritional status of children under five in South Sulawesi. This objective is based on evidence that proper feeding practices during the first two years of a child's life are crucial for preventing malnutrition. This research is expected to provide further understanding of the effectiveness of the nutritional assistance program in improving children's feeding practices and the nutritional status of children under five in the region.

METHOD

Design, Location, and Time

This study is part of the stunting reduction acceleration program in South Sulawesi Province. The program was conducted in specific stunting locations spread across 24 districts/cities in South Sulawesi in 2021. Each district and city was allocated 10 villages for nutritional assistance. The program was implemented through community intervention with a pretest-posttest study approach without a control group.

The study was conducted in 114 specific stunting locations across 24 districts/cities in South Sulawesi Province, Indonesia. The determination of stunting locations was based on local government decisions, with criteria including a higher-than-average proportion of stunting, a higher-than-average number of stunted children, and below-average nutrition service coverage (average less than 50%)[6]. Subsequently, the proposed stunting locations for each district/city were established through a decree by the Governor of South Sulawesi, prioritizing implementing nutritional assistance activities. The study sample consisted of families with children under five in the stunting locations targeted for nutritional assistance in 2022. Sample selection was based on the following inclusion criteria: complete baseline (pretest) and final evaluation (posttest) data, including family characteristics, anthropometric data, child feeding data, and residency in the stunting location during the assistance period. If more than one child under five was found in a family, the youngest child was selected. The total sample meeting the criteria was 2.148 children

Intervention Program

The nutritional intervention began with recruiting Village Nutrition Assistants from graduates of nutrition vocational education (Diploma 3/Diploma 4), nutrition undergraduates, or public health nutrition majors. They underwent one week of training before being placed in their respective villages. The training materials included Infant and Young Child Feeding (IYCF), growth monitoring, early detection and management of severe malnutrition, local food-based supplementary feeding, specific and sensitive interventions for accelerating stunting reduction, micronutrient supplementation, data collection, data entry techniques, and data analysis using ePPGBM. Nutritional assistance was provided for six months by TPGD through nutrition education and counselling activities about IYCF, growth monitoring, local food-based supplementary feeding, and micronutrient supplementation. These activities were conducted in groups at posyandu (integrated health posts) and individually through home visits. Pretest and posttest evaluations of nutritional status and child feeding practices were conducted before and after the nutritional assistance intervention.

Data Collection Methods

Quantitative data were collected through face-to-face interviews using structured, validated, and reliable questionnaires. Data types collected included sociodemographic information (parents' education and occupation), child height or length, minimum meal frequency, dietary diversity, and food acceptance. Enumerators in this study were the nutrition assistants, trained in data collection techniques, including interviews and anthropometric measurements for eight hours. All enumerators were graduates of D3, Bachelor of Applied Nutrition, or Public Health with a nutrition specialization. Researchers supervised data collection.

Assessment of IYCF Practices

Minimum Meal Frequency (MMF) is the proportion of children who received complementary feeding with a minimum frequency according to recommendations, three times for breastfed children aged 12-36 months and four times for non-breastfed children, recalled in the last 24 hours. Children meeting these recommendations are categorized as having good MMF, while those not meeting them are categorized as not good. Dietary Diversity Score (DDS)[7], is considered good if children aged 12-36 months are fed from at least four of seven food groups. The seven food groups are: (1) grains, (2) legumes, (3) dairy products, (4) flesh foods, (5) eggs, (6) vitamin A-rich fruits and vegetables, and (7) other fruits and vegetables. Children meeting at least four groups are categorised as having good DDS, and those not meeting four groups are categorized as not good. Acceptable Diet (AD) is measured based on MMF and DDS. Children meeting both good MMF and good DDS are categorised as having an adequate diet, while those not meeting either or both criteria are categorised as not having an acceptable diet.

Nutritional Status Assessment

The length measurement was done with the child lying down using a fiberboard (longboard) produced by the Indonesian Ministry of Health in 2021. Two people took measurements, one at the head and one at the feet. Each child was

measured twice, and the average value was recorded. This method was used for children aged 12-23 months, while children aged 24-59 months were measured standing using a stadiometer produced by the Indonesian Ministry of Health. Height measurements were taken by one person, with two repetitions recorded, and the average value was used. Both measuring instruments have an accuracy of 0.1 cm. Stunting was assessed by calculating the height-for-age z-score using the WHO Anthro 2006 software. The process involved entering the child's identity, measurement date, sex, measurement method (standing or lying), oedema status (yes or no), and height or length in centimetres. According to the height-for-age index (HAZ), nutritional status categories are stunted if the HAZ z-score is <-2 SD and standard if the HAZ z-score is >=-2 SD[8]. The acceptable z-score range is between -5 SD and +5 SD; data outside this range were excluded.

Data Quality Control Measures

Quality control in this study was carried out through several steps, including selecting enumerators from D3 and Bachelor of Applied Nutrition graduates who have competency certificates verified by registration certificates, training in anthropometry and interview techniques, explaining and practising child feeding interviews (MMF, DDS, and AD), and practising anthropometric measurements. Researchers conducted supervision during data collection, with random location selection, without notifying enumerators. Daily briefings and discussions were held with enumerators before and after data collection to anticipate technical issues during data collection. Different data entry personnel performed anthropometric data entry into the WHO Anthro software twice. Discrepancies were checked against hardcopy instruments to ensure accurate measurement values. The data entry was excluded if extreme z-scores (<-5 SD or >+5 SD) were found.

Data Processing and Analysis

Data were input into SPSS using a numeric system, and all categorical data were named and numbered according to SPSS guidelines published by SPSS Inc., Chicago. Bivariate McNemar analysis assessed changes in children's food acceptance and nutritional status before and after nutritional assistance. The impact of food acceptance variables on children's nutritional status post-nutritional assistance was analysed using an independent sample t-test. Conclusions for both statistical tests used an alpha of 5%.

Ethical Approval

This study received approval from the Ethics Committee of the Health Polytechnic of Makassar (No. 0625 / KEPK-PTKMS/X /2021). All data collection procedures adhered to the Helsinki Declaration. Each interviewee signed an informed consent form approved by the ethics committee. Respondents signed the informed consent form after the Enumerator had read the Explanation Consent Form (PSP) carefully.

RESULTS

Characteristics of Children and Parents

The gender distribution among children in the study population is approximately equal between boys and girls. The age distribution reveals that the largest cohort comprises children under two years of age, accounting for 40.9% of the sample. This is followed by children over three years old (32.3%) and those between two and three years of age (26.8%). Regarding parental education, the most prevalent level for both mothers and fathers is completion of elementary school. However, it is noteworthy that a subset of parents has not completed formal elementary education. Interestingly, mothers generally exhibit higher educational attainment compared to fathers. In terms of occupation, the majority of fathers (68.2%) are employed in primary sector jobs such as farming, fishing, or manual labor (Table 1). Conversely, a significant proportion of mothers (86.4%) are primarily engaged in household management as homemakers.

Table 1. Characteristics of Children and Parents

Variables	n	%
Gender:		
Male	1068	49.7
Female	1080	50.3
Age (months):		
6-11	315	14.7
12-23	563	26.2
24-35	576	26.8
36-47	470	21.9
48-59	224	10.4
Mother's Education:		
Did not finish elementary school	99	4.6
Completed elementary school	706	32.9
Completed junior high school	502	23.4
Completed senior high school	580	27.0
Higher education	261	12.2
Father's Education:		
Did not finish elementary school	128	6.0
Completed elementary school	852	39.7
Completed junior high school	431	20.1
Completed senior high school	568	26.4
Higher education	169	7.9

Table 1 continuation. Characteristics of Children and Parents

Variables	n	%
Mother's Occupation:		
Civil servant/State-owned enterprise (SOE)	58	02.7
Government contract worker	63	02,9
Housewife	1855	86.4
Employee/Private sector	70	0,32
Trader	48	02,2
Farmer/Fisherman/Laborer	45	02.1
Others	9	00.4
Father's Occupation:		
Civil servant/State-owned enterprise (SOE)	47	2.2
Employee/Private sector	365	17.0
Trader	59	2.7
Farmer/Fisherman/Laborer	1464	68.2
Others	213	9.9
Total	2148	100.0

Child Feeding

The frequency of child feeding exhibited a notable increase of 12.1% following the implementation of the nutritional assistance program. Concurrently, dietary diversity demonstrated a substantial improvement of 27.1%. Food acceptance, a composite variable encompassing both feeding frequency and dietary diversity, also showed a significant enhancement of 25.3%. The specific magnitudes of changes across various categories for each child feeding variable are comprehensively presented in the accompanying table. This investigation revealed both positive and negative fluctuations in child feeding frequency. Notably, the proportion of cases showing improved feeding frequency (24.12%) surpassed those exhibiting a decrease (11.96%). Statistical analyses confirmed that the nutritional assistance program had a significant positive impact on child feeding frequency (p=0.000). The family's capacity to provide a diverse range of foods to their children showed a more pronounced tendency towards improvement (29.56%) compared to decline (3.87%). Statistical evaluations corroborated that the nutritional assistance program significantly enhanced the family's ability to offer varied nutritional options to their children (p=0.000). Child food acceptance demonstrated a more frequent increase (33.71%) than decrease (8.43%) following the implementation of the nutritional assistance program. Statistical analyses further substantiated that the program significantly improved child food acceptance (p=0.000) (Table 2).

Table 2. Changes in Child Feeding Practices Before and After the Nutritional Assistance Program

Before	After			Sig*
	Good	Poor	Total	
Feeding Frequency				
Good	1048 (48.79%)	257 (11.96%)	1305 (60.8%)	0.000
Poor	518 (24.12%)	325 (15.13%)	843 (39.2%)	
Total	**1566 (72.9%)**	**582 (27.1%)**	**2148 (100%)**	
Dietary Diversity				
Good	1254 (58.38%)	83 (3.83%)	1337 (62.24%)	0.000
Poor	635 (29.56%)	176 (8.19%)	811 (37.76%)	
Total	**1889 (87.94%)**	**259 (12.06%)**	**2148 (100%)**	
Food Acceptance				
Good	728 (33.89%)	181 (8.43%)	909 (42.32%)	0.000
Poor	724 (33.71%)	515 (23.97%)	1239 (57.68%)	
Total	**1452 (66.61%)**	**696 (32.49%)**	**2148 (100%)**	

Nutritional Status

The nutritional assistance program resulted in a 1.2% decrease in the proportion of underweight children. Additionally, after the program implementation, there was a 5.4% reduction in stunted children and a 2.6% decrease in underweight children. Fluctuations in children's nutritional status for each index were observed. Notably, the recovery rate from wasting (5.31%) exceeded the incidence rate (4.09%). Statistical analysis revealed a significant difference in wasting prevalence before and after the program ($p < 0.05$). Similarly, the recovery rate from stunting (13.64%) surpassed the incidence rate (8.19%), with statistical tests indicating a significant reduction in stunted children post-intervention ($p < 0.05$). The recovery rate from underweight status (10.20%) also exceeded the incidence rate (7.68%), and statistical analysis confirmed a significant reduction in underweight children following the program ($p < 0.05$) (Table 3).

Children exhibiting good food acceptance demonstrated higher average Z-scores for nutritional status. Significant differences in nutritional status Z-scores were observed between children with good food acceptance and those with poor food acceptance. These differences were evident across multiple indices, including weight-for-height ($p < 0.05$), height-for-age ($p < 0.05$), and weight-for-age ($p < 0.05$), as revealed by statistical analyses (Figure 1).

DISCUSSION

The nutritional assistance program, which includes nutritional counselling through home visits, the provision of nutritional intervention packages, and growth monitoring, has significantly impacted the frequency of children's meals. This increase demonstrates the program's effectiveness in improving children's eating patterns, which is crucial for ensuring adequate nutrient intake for their growth and development. Programs that provide direct and personalised nutrition education enable parents to understand their children's nutritional needs better and adopt healthier and more consistent eating practices. Furthermore, a study by Wang et al. (2021) found that dietary interventions, including the provision of healthy food packages, can improve families' access to nutritious foods, ultimately increasing children's meal frequency[9]. The food packages provided help families ensure adequate and regular meals for their children.

In this study, we observed an improvement in children's dietary diversity indicators. This indicates that the nutritional assistance program effectively enhances the variety of foods consumed by children. Research by Ali et al. (2020) confirms that nutritional counselling through home visits greatly increases parents' knowledge about the importance of dietary diversity[10]. Such interventions provide personalised education, allowing parents to understand and implement a more

Table 3. Changes in Nutritional Status of Children Before and After the Program

Before	After			Sig*
	Malnutrition (+)	Normal (-)	Total	
Weight-for-Height:				
Malnutrition (+)	41 (1.91%)	114 (5.31%)	155 (7.2%)	0.000
Normal (-)	88 (4.09%)	1905 (88.69%)	1993 (92.8%)	
Total	**129 (6.0%)**	**2019 (94.0)**	**2148 (100%)**	
Height-for-Age				
Stunted (+)	373 (17.36%)	293 (13.64%)	666 (31.0%)	0.000
Normal (-)	176 (8.19%)	1306 (60.81%)	1482 (69.0%)	
Total	**549 (25.6%)**	**1599 (74.4%)**	**2148 (100%)**	
Weight-for-Age				
Underweight (+)	227 (10.57%)	219 (10.20%)	446 (20.8%)	0.000
Normal (-)	165 (7.68%)	1537 (71.55%)	1702 (79.2%)	
Total	**392 (18.2%)**	**1756 (81.8%)**	**2148 (100%)**	

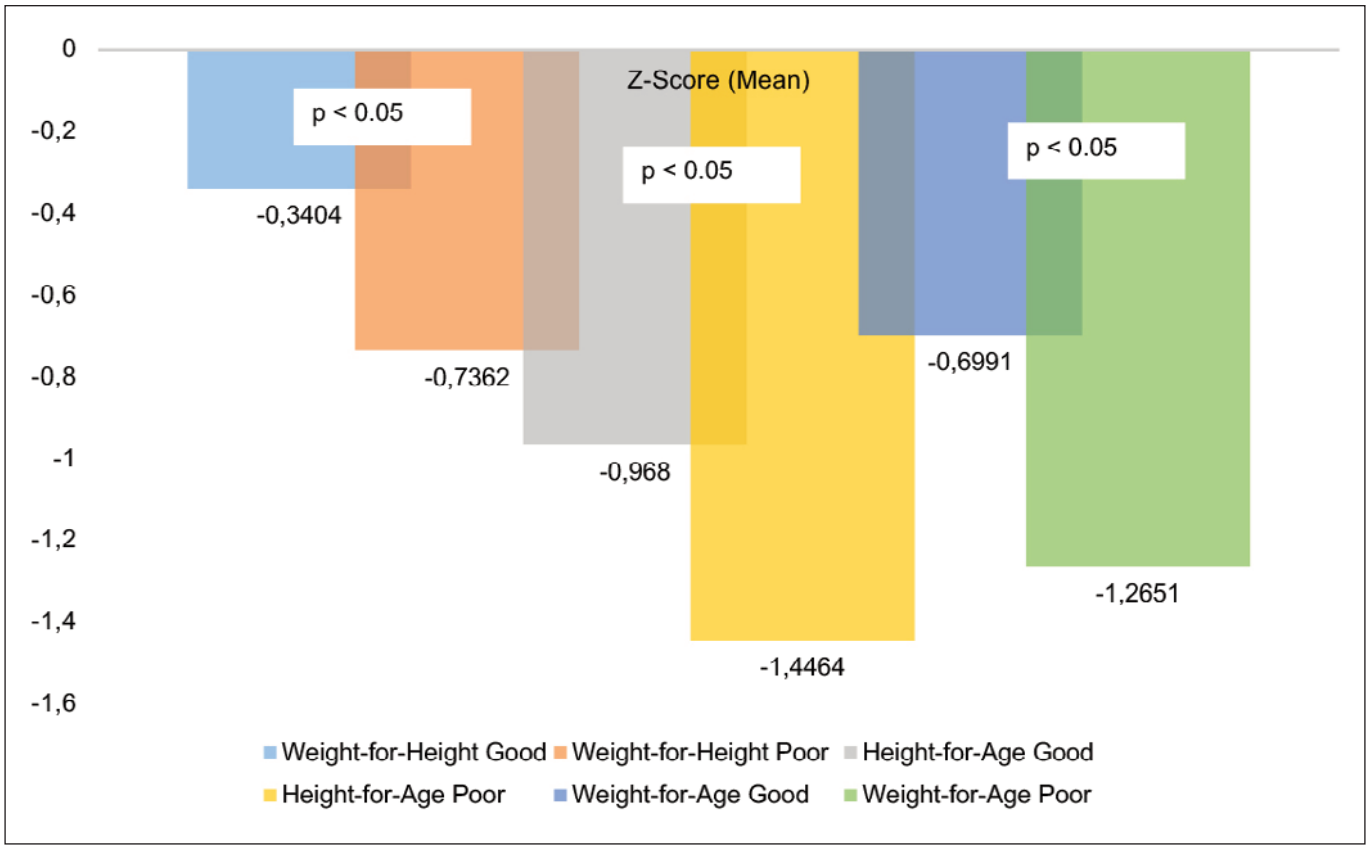

Figure 1. Average Z-Score of Nutritional Status Based on Child Food Acceptance

varied and balanced diet for their children. Additionally, research by Black et al. (2021) shows that providing food packages that include various types of healthy foods can improve families' access to nutritious foods, which is crucial for enhancing children's dietary diversity[11].

Another study by Miller et al. (2022) emphasises that consistent growth monitoring and sustained nutritional interventions significantly improve children's dietary diversity[12]. Structured and ongoing assistance programs enable early detection of nutritional problems and timely interventions, ensuring that children receive a more varied and sufficient diet to meet their dietary needs. Continuing nutrition education is needed to change family eating behaviour and increase children's food diversity[13]. Intensive and ongoing education allows families to continue adopting healthy eating patterns even after the intervention program ends. A study by Smith et al. (2021) also shows that sustained nutritional support can increase parents' awareness and nutritional practices, positively impacting children's dietary diversity[14].

This study found that children's food acceptance increased by 25.3%, from 42.3% before to 67.6% after nutritional assistance. Compared to studies conducted in various countries such as Kenya[14], Ghana[15], and Uganda[16], where food acceptance was 48.5%, 29.9%, and 23.9%, respectively, the food acceptance in this study was higher due to different sample designs. Our study used a sample of children aged 6-59 months, affecting the frequency and diversity of foods and directly influencing children's food acceptance[17]. This contrasts with previous studies that mostly used samples of children aged 6-23 months[18]. The nutritional assistance program in this study has been proven to increase meal frequency and improve families' ability to provide diverse foods for their children, thus increasing children's food acceptance. Previous research also found consistent results, showing that after nutrition education, parents could make healthier choices for their children, even if they did not apply these choices adequately to their food choices. Parents pay more attention to providing nutritious food for their children after receiving nutrition education.

We believe that the messages delivered through nutritional education and counselling during the assistance can enhance parents' knowledge. Nutritional counselling can also increase mothers' nutritional knowledge, affecting their practices in providing food for their children. A study conducted by Hoo-lihan et al. (2021) investigating the relationship between parents' knowledge and children's food consumption found an increase in healthy food consumption for their children alongside the rise in parents' nutri-

tional knowledge[19]. Nutritional education and counselling through the nutritional assistance program significantly impact increasing meal frequency, dietary diversity, and children's food acceptance. Research by Miller et al. (2020) shows that nutritional counselling delivered directly at home through home visits effectively increases parents' knowledge and dietary practices, directly impacting children's infant and young child feeding (IYCF) practices[20].

The findings showing increased child feeding practices (IYCF) after the nutritional assistance program have essential implications for nutrition improvement programs and stunting prevention in Indonesia. Increased frequency and dietary diversity in children directly contribute to better nutrient intake essential for growth and development. A study by Nisbett et al. (2020) shows that increasing diverse food intake can reduce stunting risk as children receive enough micronutrients to support their optimal growth[21]. As described in this study, effective nutritional assistance programs can serve as models for nutrition initiatives across Indonesia to reduce the high prevalence of stunting in some regions. Moreover, enhancing parents' nutritional knowledge and practices through counselling and home visits plays a vital role in the success of stunting prevention programs. Research by Bhutta et al. (2019) emphasises the importance of sustained nutrition education to ensure parents can make informed decisions about children's feeding[22]. Thus, a holistic and integrated approach, as found in this study, can be more widely applied to strengthen existing programs. Nutrition interventions that include education, growth monitoring, and providing nutrition packages can significantly reduce stunting rates in vulnerable populations[23]. With adopting and adapting these strategies, Indonesia can accelerate achieving the stunting reduction targets set by the government.

The proportion of children experiencing malnutrition decreased between before and after the nutritional assistance program, including wasting, stunting, and underweight. Interestingly, the stunting rate reduction was higher than that of wasting and underweight. The proportion of underweight in Gresik Regency decreased from 32.2% to 22.6% after intensive nutritional assistance[24]. Nutritional assistance increases meal frequency, dietary diversity, and food acceptance, ultimately improving children's nutritional status. Children consuming diverse foods have better linear growth and can prevent stunting in those children[25].

We found that the specific nutritional interventions implemented in the nutritional assistance program were carried out according to the program's objectives, although not achieved optimally. The interventions included nutrition education and counselling on infant and young child feeding (IYCF), growth monitoring, local food-based supplementary feeding, and micronutrient supplementation[26]. Several studies on interventions in the nutritional assistance program have reported positive impacts on nutritional status. Among them, the provision of Taburia increases immunity to prevent illness, boosts appetite, prevents nutrient deficiencies, and prevents anemia[27]. Providing local food-based supplementary feeding affects improving the nutritional status of undernourished children[28]. Early growth and development detection activities can avoid growth disorders, thereby improving children's nutritional status.

The nutritional status changes show that the proportion of malnourished children who became normal (from wasting, stunting, and underweight to normal) was relatively high during the nutritional assistance program. However, the number of new malnutrition cases during the assistance period was not effectively controlled. This indicates the intensity of curative efforts in the assistance program, such as screening, searching, and managing malnourished children. Curative efforts seem stronger than promotive and preventive efforts. The same phenomenon was found in the evaluation results of the nutrition program in Buton Regency, Southeast Sulawesi, which showed a more significant reduction in stunting rates compared to underweight and wasting[29]. This differs from previous findings, such as the comprehensive nutrition program intervention in rural Malawi, which reported a higher reduction in wasting cases (18%) than stunting cases (7%)[30]. We believe this difference occurs because the proportion of stunting in our study location is higher, reaching four times the amount of wasting and two-thirds of the amount of underweight.

The findings show that the improvement in children's nutritional status after the nutritional assistance program has significant implications for efforts to improve nutritional status and prevent stunting in Indonesia. Improving children's nutritional status through comprehensive dietary interventions can help reduce the prevalence of stunting, one of the leading health problems in Indonesia. Nutrition interventions, including nutrition counselling and the provision of nutritious food packages, can significantly reduce the prevalence of stunting in high-risk communities.

STUDY LIMITATIONS

The limitations of this study include the absence of a control group, making it difficult to attribute changes solely to the intervention. The study's reliance on self-reported data might introduce bias. Additionally, the six-month intervention period may not be sufficient to observe long-term effects on nutritional status. Variability in the data quality collected by different enumerators might also affect the results.

CONCLUSION AND RECOMMENDATIONS

Efforts in nutritional education and counselling by Village Nutrition Assistants can sustainably improve the frequency,

diversity, and acceptance of children's food. Implementing the Nutritional Assistance Program in stunting-prone villages can help accelerate efforts to reduce stunting and improve the nutritional status of children under five in South Sulawesi.

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Utilizing applications Nutrihas Pro for calculated fluid and electrolyte requirements for patient

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ABSTRACT

Background: Hospital malnutrition is a critical issue, particularly in regions like Makassar, Indonesia, where malnutrition rates surpass national averages. Malnourished patients often experience electrolyte imbalances and prolonged hospital stays, leading to increased healthcare costs. Despite the importance of accurate nutritional therapy, manual calculations are time-consuming and prone to human error, necessitating a more efficient solution.

Objective: This study aims to assess the effectiveness of the Nutrihas-Pro application, developed to improve the accuracy and time efficiency of nutritional therapy planning compared to manual methods.

Methods: An experimental repeated measures design was employed, involving 30 clinical nutrition residents at RSUP Dr. Wahidin Sudirohusodo. Participants manually calculated nutritional therapy and fluid/electrolyte needs for 60 patients and repeated the process using Nutrihas-Pro. Calculation times and accuracy were compared using paired-samples t-tests and chi- square tests.

Results: The Nutrihas-Pro application significantly reduced calculation times ($p < 0.001$) compared to manual methods, without compromising the accuracy of fluid and electrolyte requirement calculations ($p > 0.05$). Patients displayed a high prevalence of electrolyte imbalance (68.3%), particularly hyponatremia (35%).

Conclusion: Nutrihas-Pro improves time efficiency while maintaining calculation accuracy, making it a promising tool for nutritional therapy management. Further research is needed to address its limitations, including its reliance on internet connectivity and comparisons with other clinical calculator applications.

KEYWORDS

Medical Software, Theraupetic Planning, Nutrihas-Pro Application, Electrolyte Homeostasis, Digital Health.

INTRODUCTION

Malnutrition in hospitals is a critical issue that significantly impacts patient outcomes and the healthcare system. The causes of malnutrition in this setting are multifactorial, encompassing insufficient food intake and heightened catabolic processes due to underlying conditions such as metabolic diseases, infections, and malignancies[1]. In Makassar, Indonesia, malnutrition presents a notable public health challenge, with research indicating a high prevalence rate in the region. Studies have shown that the prevalence of malnutrition and poor nutrition reaches 28.1%, surpassing both provincial and national averages[2].

Nutritional therapy is an essential component of patient care, ensuring that hospitalized individuals receive adequate nutrition throughout their stay. Hospital meals are tailored to meet patients' clinical needs, providing specified amounts of protein and energy according to dietary guidelines[3]. Assessing a patient's nutritional status requires the collection of various data points, including anthropometric measurements, age, food intake details (24- hour food recall), dietary history, supplementation, appetite changes, satiety levels, physical activity, metabolic requirements, and stress levels. This comprehensive assessment necessitates significant time and trained healthcare personnel.

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The high incidence of malnutrition in hospitals necessitates prompt and accurate intervention by clinical nutrition specialists. Given the time required for planning nutritional therapy for hospitalized patients, the use of applications could enhance the efficiency of nutritional planning and minimize human errors in calculations[4]. While digital applications for medical calculations are commonly employed by clinicians, particularly in internal medicine, their use in clinical nutrition remains limited and often lacks comprehensiveness.

A prevalent issue among hospitalized patients is the disruption of electrolyte balance, with sodium and potassium imbalances frequently observed in malnourished individuals. Therefore, calculating electrolyte requirements is a critical component of nutritional therapy[5]. Inadequate identification and documentation of malnourished patients not only adversely affect patient outcomes but also impact hospital costs, length of stay, and overall quality of care[6]. The complexity of managing malnourished patients is considerably higher than that of well-nourished patients, underscoring the need for tailored nutritional support and interventions[7].

Nutrihas_Pro is an application developed by the Clinical Nutrition Study Program at Hasanuddin University, aimed at assisting clinical nutritionists in planning nutritional therapy for hospitalized patients. The implementation of Nutrihas_Pro is expected to enhance the effectiveness of clinical nutritionists in delivering quality care, ultimately improving patient outcomes in hospital settings.

METHODS

Research Subjects: This study utilized an experimental repeated measures design, which is commonly used to compare the effectiveness of a manual process with an application-based approach[8]. The population consisted of Clinical Nutrition SpecialistResidency Program students at the intermediate and advanced levels. The sample included 30 residents who met the inclusion criteria: intermediate residents (semester IV-V) and advanced residents (semester VI-VII) who had participated in a training session for the Nutrihas-Pro application. Exclusion criteria included residents stationed in other departments or working in intensive care units. Purposive sampling was employed to ensure that the selected sample accurately represented the target population[9].

Data collection: The study was conducted at RSUP Dr. Wahidin Sudirohusodo Makassar during June 2023. Data were collected in four stages. First stage, Respondents manually calculated nutritional therapy plans and fluid/electrolyte needs for 60 inpatients using a calculator. Next, respondents used the Nutrihas-Pro application to perform the same calculations. Lastly, data analysis was performed.

The instruments included patient data for both phases (manual and application-based), a stopwatch to measure completion times, a calculator (manual phase), and laptops for accessing the Nutrihas-Pro application (application-based phase). Nutrihas- Pro applications was developed to meet the needs of clinical nutrition specialists by assisting them in planning medical nutrition therapy. The planning process for medical nutrition therapy requires time for anthropometric calculations, energy and fluid requirements, laboratory result interpretation, and selecting food compositions for dietary prescriptions. This application is designed with an integrated system, enabling comprehensive and time-efficient therapy delivery.The application integrates various features related to medical nutrition therapy planning, starting from patient data collection, anthropometric calculations, 24-hour dietary recall, and metabolic status determination based on laboratory data input. Additionally, the application includes energy and fluid requirement calculations, electrolyte requirement corrections for patients with electrolyte imbalances, and therapy recommendations. Overall, this application offers a comprehensive medical nutrition therapy planning feature to enhance the efficiency and effectiveness of clinical nutrition specialists' work.

Research Permission and Ethical Clearance: Ethical approval was obtained from the Ethics Committee of the Faculty of Medicine, Hasanuddin University, under registration number 776/UN4-6.4-5.31/PP36/2023.

Data processing and analysis: Data were analyzed by comparing the time required for residents to calculate nutritional therapy manually versus using the Nutrihas-Pro application. Independent variables included the method used (manual vs. application), while dependent variables were the time taken for calculations and the accuracy of the nutritional therapy results. Confounding variables, such as individual resident skills in manual calculation and app usage, were controlled through repeated measures to account for individual differences[10].

RESULTS

The aim of this study was to compare the time efficiency and accuracy of nutritional therapy and electrolyte calculations performed manually versus using the Nutrihas-Pro application. A total of 30 clinical nutrition residents participated in the study, calculating nutritional plans for 60 hospitalized patients.

Patient Characteristics

The study involved 30 respondents, all of whom participated in both phases: manual calculation in phase 1 and application-based calculation in phase 2. The characteristics of the participants are summarized in Table 1.

Table 1 shows that the majority of respondents were aged between 35-40 years (63.3%), while the remaining 36.7% were over 40 years old. The gender distribution was predominantly female (83.3%), with only 16.7% being male. Additionally, the participant levels were evenly distributed between intermediate and advance (50%).

Table 1. Baseline Characteristics of Hospital Residents

Variables	Variabel	n	%
Age	35 - 40 years	19	63.3
	> 40 years	11	36.7
Gender	Male	5	16.7
	Female	25	83.3
Participant Level	Intermediate	15	50.0
	Advanced	15	50.0

Values are n (%).

Characteristics of the Patients

The study utilized 60 patient records from inpatients at Wahidin Sudirohusodo Hospital, each randomly distributed across respondents for manual and application-based testing.

Based on the results, most patients were male (60%), and 70% were categorized under SGA Class C. Electrolyte imbalance was present in 68.3% of patients, with 35% experiencing hyponatremia which is divided into three categories classified by plasma sodium level, mild hyponatremia (130-135 mmol/L), moderate hyponatremia (125-129 mmol/L) and severe hyponatremia (<125 mmol/L)[11]. Data found primarily mild hyponatremia (26.7%). Hypernatremia is defined as a serum or plasma sodium level >145 mmol/L[12]. Hypokalemia classified by plasma potassium level, mild hypokalemia (3.0 – 3.5 mEq/L) moderate hypokalemia (<3.0 mmol/L) and severe hypokalemia < 2.5 mmol/L)[12] and hyperkalemia if plasma potassium level > 5 mmol/L[13]. Furthermore, 25% had a combination of sodium and potassium disturbances, and 20% of patients showed impaired kidney function defined by eGFR <90 ml.

Furthermore, we analysed the comparison of fluid requirement calculations. Table 3 illustrates that there was no statistically significant difference in fluid requirement calculations between the manual method and the application method ($p = 0.110$).

Comparison of Electrolyte Requirement Calculations and Calculation Time

Table 3 also shows that no significant difference was observed in electrolyte requirement calculations between manual and application methods ($p = 0.644$). However, the application method significantly reduced calculation time ($p < 0.001$), indicating greater time efficiency.

Table 2. Baseline Characteristics of Hospital Patients

Variable		n	%
Age	Male	36	60.0
	Female	24	40.0
SGA	B	18	30.0
	C	42	70.0
Fluid Calculation	CKD	6	10.0
	Isocaloric	29	48.3
	Age-related	25	41.7
Electrolyte Imbalance	Present	41	68.3
	Absent	19	31.7
Electrolyte Disturbances	Hyponatremia	21	35.0
	Combination	15	25.0
	Hypokalemia	4	6.7
	Hypernatremia	1	1.7
	No disturbances	19	31.7
Sodium Levels	Mild Hyponatremia	16	26.7
	Moderate Hyponatremia	14	23.3
	Severe Hyponatremia	6	10.0
	Hypernatremia	1	1.7
	Normal	23	38.3
Potassium Levels	Mild Hypokalemia	4	6.7
	Moderate Hypokalemia	5	8.3
	Severe Hypokalemia	2	3.3
	Hyperkalemia	7	11.7
	Normal	42	70.0
Kidney Function	Impaired	12	20.0
	Normal	48	80.0

Values are n (%).

Table 3. Comparison of fluid requirement calculations, Electrolyte requirement calculations and Calculation time using manual and application methods

	Manual			Application			*P*
	Mean	**SD**	**Median**	**Mean**	**SD**	**Median**	
Fluid Requirement	1730	247,2	1800	1716,3	233	1750	0,110
Electrolyte Requirement	280.79	115.72	282.00	278.24	113.69	270.90	0.644*
Calculation Time	28.98	3.37	29.00	8.77	2.48	9.00	0.000**

Values are n (%), comparison was performed using paired-samples t-test for continuous variables unless otherwise stated. Significant if p<0.05.
* Comparison was performed using Pearson chi-square test for categorical variables.
** Comparison was performed using Wilcoxon test.

Table 4. Electrolyte Calculation Time and Electrolyte Requirements by Respondent Level

	Level	Manual			Application			*p*
		Mean	**SD**	**Median**	**Mean**	**SD**	**Median**	
Electrolyte Requirement	Intermediate	293.14	100.42	296.00	285.34	100.86	283.00	0.187
	Advanced	272.04	126.81	260.24	273.22	123.85	265.85	0.890
Electrolyte Calculation Time	Intermediate	28.59	3.36	28.00	9.06	2.73	9.00	0.000
	Advanced	29.13	3.44	29.00	8.63	2.26	9.00	0.000**

Values are n (%), comparison was performed using paired-samples t-test for continuous variables unless otherwise stated. Significant if p<0.05.
** Comparison was performed using Wilcoxon test.

Electrolyte Calculation Time by Respondent Level

Table 4 demonstrates that the application method significantly reduced the calculation time for electrolyte requirements across both Intermediate and Advanced levels ($p < 0.001$), further confirming the time efficiency of using the application. This table also indicates no significant difference in electrolyte requirement calculations between manual and application methods when grouped by respondent level.

DISCUSSION

This study involved the successful introduction and testing of the Nutrihas-Pro application, conducted through a training session on May 19, 2023, at the Clinical Nutrition Department of RSP Universitas Hasanuddin. The participants, comprised of intermediate and advanced level clinical nutrition residents, were enthusiastic about this novel method for calculating patient nutritional requirements. The hands-on approach, including case studies, effectively demonstrated the application's functionality, highlighting its potential to improve clinical nutrition management.

The Need for Change in Hospital Nutritional Assessment

The importance of improving hospital nutrition assessment methods has been emphasized by the recognition that malnutrition is a significant factor impacting patient outcomes. Research shows that 20% to 50% of hospitalized patients are malnourished at admission or become malnourished during their stay[14,15]. Malnutrition prolongs recovery, increases hospital stays and healthcare costs, and leads to higher morbidity and mortality rates[16,17]. Given these challenges, a reform in the way nutritional assessments are conducted is urgently needed. The Nutrihas-Pro application provides a practical solution to this issue, offering an efficient tool to calculate nutritional needs and correct electrolyte imbalances, potentially leading to better patient care.

Time Efficiency and Accuracy in Electrolyte Calculations

One of the major findings of this study was the improved time efficiency associated with using Nutrihas-Pro for calculating fluid and electrolyte needs in patients. The manual process, which requires memorizing formulas and algorithms,

is time-consuming. The application streamlines this by automating the calculations, thereby reducing the calculation time significantly, as also demonstrated by Green et al.[18], who found that medical calculators are integral to improving workflow efficiency. This finding is supported by similar studies, such as that by Dziadzko et al.[19,20], which highlighted the usefulness of clinical calculators in decision-making.

Regarding accuracy, the Nutrihas-Pro application provided results comparable to manual calculations. This suggests that the programmed algorithms and formulas are reliable, offering clinicians confidence in the accuracy of the tool. This is consistent with previous research, such as Bierbrier et al.[21], who found that most medical calculation applications were accurate and reliable. Moreover, the application minimizes human error, making it a valuable tool for achieving consistency and standardization in nutritional planning. The combination of time savings and accuracy positions Nutrihas-Pro as a useful tool for clinical nutrition therapy, particularly when prompt and precise interventions are critical.

CONCLUSION

In conclusion, the Nutrihas-Pro application demonstrates significant advantages in time efficiency without compromising accuracy, making it a promising tool in clinical nutrition management. However, further research and development are needed to address its limitations and maximize its potential in broader clinical settings.

Research Limitations

The lack of prior studies specifically evaluating clinical calculator applications for fluid and electrolyte calculations posed a challenge in comparing the effectiveness of Nutrihas-Pro. Future studies involving larger populations are needed to further validate its effectiveness. Additionally, comparative studies with other established clinical calculator applications, such as MedCalc or Calculate by QxMD, would provide a more comprehensive evaluation. Another limitation of the study was the requirement for an internet connection, as Nutrihas-Pro is a web- based application. This restricts its usability in settings with limited internet access, highlighting the need for offline functionality in future versions of the application.

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Asociación entre conductas alimentarias de riesgo y variables bioquímicas-antropométricas en adultos mayores del norte de México

Association between Risky Eating Behaviors and Biochemical-Anthropometric Variables in Older Adults from Northern Mexico

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RESUMEN

Introducción: En México se ha incrementado el número de adultos mayores, representando el 14% de la población. Esta etapa es complicada debido al desarrollo de enfermedades crónicas que afecta a las personas de este grupo de edad. La problemática nutricional en los adultos mayores esta influenciada por diversos fatores bio-psico-sociales, así como por los cambios fisiológicos, como dificultad para masticar, reducción en la producción de saliva, disminución del olfato, entre otras. Dichas condiciones pueden provocar la aparición de Conductas Alimentarias de Riesgo (CAR) que afectan el estado nutricional de los adultos mayores.

Objetivo: Evaluar la asociación entre CAR con variables bioquímicas y antropométricas en adultos mayores del norte de México.

Materiales y métodos: se realizaron mediciones antropométricas a 62 adultos mayores de peso, talla, circunferencias de cintura, cuello, pantorrilla, brazo y muñeca. Se aplicó el Cuestionario Holandés Sobre el Comportamiento Alimentario (DEBQ). También se midió la tensión arterial y variables bioquímicas: hemoglobina, glucosa, colesterol y triglicéridos. Se realizó una correlación de Spearman para determinar la asociación de CAR y variables bioquímicas, para la comparación de las dimensiones CAR y concentraciones de glucosa se aplicó la prueba de Kruskal-Wallis.

Resultados: se encontró una correlación entre las concentraciones de glucosa y las dimensiones Comer en Respuesta a Señales Externas (-0,2781; $p<0,05$) y Comer Restrictivo (CR) (-0,2781; $p<0,05$). Además, se observó que para la dimensión CR, hubo diferencias estadísticamente significativas entre categorías, mostrando una tendencia inversa entre la mediana de CR y la glucosa ($p<0,06$).

Discusión: Los resultados evidencian una asociación significativa entre las conductas alimentarias de riesgo y las variables bioquímicas-antropométricas en adultos mayores del norte de México. Estos hallazgos subrayan la importancia de abordar las problemáticas nutricionales en este grupo, dado su riesgo elevado de desarrollar complicaciones derivadas de enfermedades crónicas.

Conclusiones: Las conductas alimentarias de riesgo son frecuentes en adultos mayores, además se observó una tendencia inversa de correlación entre CR con niveles de glucosa.

PALABRAS CLAVE

Hábitos alimentarios, salud metabólica, factores de riesgo, estilo de vida, indicadores antropométricos.

ABSTRACT

Introduction: In Mexico, the number of older adults has increased, representing 14% of the population. This stage is

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complicated due to the development of chronic diseases that affect people in this age group. Nutritional problems in older adults are influenced by several bio-psycho-social factors, as well as by physiological changes, such as difficulty in chewing, reduction in saliva production, decreased sense of smell, among others. These conditions can lead to the appearance of Risky Eating Behaviors (RAB) that affect the nutritional status of older adults.

Objective: To evaluate the association between CAR with biochemical and anthropometric variables in older adults in northern Mexico.

Materials and methods: Anthropometric measurements of weight, height, waist, neck, calf, arm and wrist circumferences were taken in 62 older adults. The Dutch Eating Behaviour Questionnaire (DEBQ) was applied. Blood pressure and biochemical variables were also measured: hemoglobin, glucose, cholesterol and triglycerides. A Spearman correlation was performed to determine the association between CAR and biochemical variables, and the Kruskal-Wallis test was applied to compare CAR dimensions and glucose concentrations.

Results: a correlation was found between glucose concentrations and the dimensions Eating in Response to External Signals (-0.2781; $p<0.05$) and Restrictive Eating (RC) (-0.2781; $p<0.05$). In addition, it was observed that for the CR dimension, there were statistically significant differences between categories, showing an inverse trend between median CR and glucose ($p<0.06$).

Discussion: The results show a significant association between risky eating behaviors and biochemical-anthropometric variables in older adults in northern Mexico. These findings underscore the importance of addressing nutritional issues in this group, given their elevated risk of developing complications derived from chronic diseases.

Conclusions: Risky eating behaviors are frequent in older adults, furthermore, a correlation trend was observed between CR with glucose levels.

KEYWORDS

Dietary habits, metabolic health, risk factors, lifestyle, anthropometric indicators.

ABREVIATURAS

CAR: Conductas Alimentarias de Riesgo.

OMS: Organización Mundial de la Salud.

INEGI: Instituto Nacional de Estadística y Geografía.

TCA: Trastornos de la Conducta Alimentaria.

DT2: Diabetes Tipo 2.

LDL: Lipoproteína de baja densidad.

HDL: Lipoproteína de alta densidad.

INAPAM: Instituto Nacional de las Personas Adultas Mayores.

ISAK: Sociedad Internacional para el Avance de la Cineantropometría.

IMC: Índice de Masa Corporal.

CMB: Media de brazo.

DEBQ: Cuestionario de Conducta Alimentaria para Adultos Mayores.

CE: Comedor Emocional.

CR: Comer Restrictivo.

CExt: Comer en Respuesta a Señales Externas.

CV: Coeficiente de variación.

ADA: Asociación Americana de Diabetes.

TGC: Triglicéridos.

INTRODUCCIÓN

De acuerdo con la Organización Mundial de la Salud (OMS), para el año 2030 se espera que una de cada seis personas tendrá 60 años o más, y para el 2050 esta población se habrá duplicado, pasando de 1,400 millones a 2,100 millones[1]. En México, en los últimos años, también se ha observado un cambio demográfico significativo, con un incremento en el número de adultos mayores[2]. El Instituto Nacional de Estadística y Geografía (INEGI) reporta que el 14% de la población mexicana tiene 60 años o más[3]. Esta situación se complica debido a la alta prevalencia de enfermedades crónicas en la mayoría de los adultos mayores, quienes a menudo sufren del síndrome geriátrico, caracterizado por inmovilidad, inestabilidad-caídas, incontinencia urinaria y deterioro cognitivo. Estas condiciones son, en gran parte, consecuencia de un estado nutricional inadecuado, que incluye bajo peso, desnutrición, anemia y niveles elevados de colesterol y triglicéridos. La problemática nutricional en los adultos mayores está influenciada por diversos factores bio-psico-sociales que intervienen en la aparición, desarrollo y recuperación de las alteraciones nutricionales en este grupo[4]. Entre los factores asociados a las conductas alimentarias de riesgo y al desarrollo de enfermedades crónicas, como la hipertensión, se encuentran la edad, el género, la actitud, el conocimiento, el rol de los trabajadores de la salud y el apoyo familiar[5]. Además, los cambios fisiológicos que ocurren durante esta etapa de la vida, como la dificultad para masticar, la disminución de la producción de saliva (provocando sequedad en la boca) y la reducción de los sentidos del gusto y del olfato, contribuyen a un desequilibrio en la ingesta de nutrientes, lo que puede llevar a alteraciones metabólicas[6] y aumentar el riesgo de malnutrición en el adulto mayor.

No existe evidencia científica concluyente que relacione directamente las Conductas Alimentarias de Riesgo (CAR) con

el estado del hierro. Sin embargo, en los Trastornos de la Conducta Alimentaria (TCA), la anemia suele presentar valores normales de Volumen Corpuscular Medio, Hemoglobina Corpuscular Media, ferritina, ácido fólico y vitamina B_{12}, y su severidad podría estar enmascarada por depleciones de sodio y hemoconcentraciones debido a conductas purgativas. Santiago et al. (2010) analizaron la prevalencia de alteraciones en el metabolismo del hierro en pacientes con TCA, encontrando que, al inicio del tratamiento, 18,4% presentaban ferropenia latente, 5,7% ferropenia y 2,7% anemia ferropénica. Estos porcentajes disminuyeron significativamente tras seis meses de tratamiento[7].

El trastorno por atracón y el síndrome de alimentación nocturna, asociados con sobrepeso y obesidad, también presentan un mayor riesgo de anormalidades en el metabolismo de la glucosa, como la Diabetes Tipo 2 (DT2), aunque los estudios al respecto no son concluyentes[8].

Puchkova-Sistac et al. (2023) evaluaron la relación entre la conducta alimentaria y el daño cardiovascular en 1,109 participantes del estudio STANISLAS, encontrando que la alimentación emocional se asoció con mayor velocidad de la onda del pulso y riesgo de disfunción diastólica, mediada por el estrés[9]. Nakai et al. (2016) encontraron un mayor riesgo de niveles elevados de colesterol lipoproteína de baja densidad (por sus siglas en inglés LDL) y no lipoproteína de alta densidad (por sus siglas en inglés HDL) en pacientes con trastornos alimentarios, lo que podría incrementar el riesgo de enfermedades cardiovasculares[10].

Por lo anterior, el presente estudio tiene como **objetivo** evaluar las CAR con variables bioquímicas y antropométricas en adultos mayores del norte de México.

MATERIALES Y MÉTODOS

Diseño y Población de Estudio: Este trabajo se basó en un estudio transversal de naturaleza analítica con un enfoque cuantitativo. La población de estudio estuvo conformada por adultos mayores que asistieron a las instalaciones del Instituto Nacional de las Personas Adultas Mayores (INAPAM) en cualquiera de sus sedes en Cajeme, Sonora, México, durante el periodo de recolección de datos, que abarcó de enero a agosto de 2024.

La muestra se seleccionó de manera intencional, obteniendo un total de 62 sujetos; involucrando a la totalidad de los adultos mayores que asistían regularmente a cuatro de seis sedes. Los criterios de inclusión consideraron a adultos mayores que asistían regularmente a alguna de las sedes del INAPAM en Cajeme, quienes expresaron su voluntad de participar y firmaron el consentimiento informado. Se incluyeron participantes de ambos sexos, con edades superiores a los 60 años.

Cada participante recibió una carta de consentimiento informado por escrito, en la que se detallaron los objetivos de la investigación, las actividades a realizar, así como los beneficios y limitaciones del estudio. Además, se les informó que tenían la libertad de retirarse del estudio en cualquier momento, sin que ello implicara consecuencias para su vida persona. Asimismo, se les brindó la oportunidad de plantear cualquier duda que surgiera durante el proceso, las cuales fueron aclaradas en detalle. Tras comprender plenamente el proceso, cada sujeto firmó la carta de consentimiento informado de manera libre y voluntaria. El estudio se condujo siguiendo los lineamientos del Código de Ética Médica de Nuremberg y los principios éticos establecidos en la Declaración de Helsinki para la investigación médica en seres humanos, presentando un riesgo mínimo para los participantes. Todos los documentos relacionados con el estudio fueron resguardados por los autores y el protocolo fue aprobado por el comité de ética en investigación (No. registro: CEI-ENFERMERÍA-EINV-002-202) del Departamento de Enfermería de la Universidad de Sonora, México.

*Medición y Definición de las Variables***:** Las determinaciones antropométricas, bioquímicas y clínicas fueron realizadas por estudiantes de la Licenciatura en Ciencias Nutricionales, quienes recibieron capacitación. La estandarización de las variables bioquímicas fue realizada por un investigador principal especialista en el área químico-clínica. Para la medición de la tensión arterial, se instruyeron a los estudiantes dos semanas antes asegurando el uso correcto del baumanómetro digital.

Antropometría: El peso se midió utilizando balanzas electrónicas marca Tanita, modelo HD-313, con una capacidad máxima de 150 kg y una precisión de 0.1 kg. La talla se midió con estadiómetros portátiles marca SECA 213, con un rango de medición de 20 a 205 cm. A partir de estos datos, se calculó el Índice de Masa Corporal (IMC) utilizando la fórmula peso (kg)/talla (m^2), y se categorizaron los resultados siguiendo los puntos de corte descritos por el Ministerio de Salud y Protección Social[11].

Las mediciones de la circunferencia de cintura, cuello, pantorrilla, media de brazo (CMB) y muñeca se realizaron utilizando una cinta antropométrica metálica TAQ tipo Rosscraft, con una escala de 0 a 200 cm, siguiendo el protocolo de ISAK. Los puntos de corte para categorizar la circunferencia de cintura se establecieron según las recomendaciones del Instituto Nacional del Corazón, Pulmón y Sangre[12].

Tensión Arterial: La tensión arterial se midió utilizando un baumanómetro digital. Se registró tanto la presión arterial sistólica (TAS) como la presión arterial diastólica (TAD). Los puntos de corte para la categorización de la tensión arterial se establecieron según las guías para la prevención, detección, evaluación y tratamiento de la presión arterial alta en adultos[13].

Variables Bioquímicas:

Hemoglobina: la concentración se determinó mediante una muestra de sangre utilizando un hematofluorómetro portátil Hb801 (HemoCue, Ängelholm, Suecia). Los puntos de corte

empleados fueron los sugeridos por la Organización Mundial de la Salud (OMS)[14].

Glucosa: Se obtuvieron muestras de sangre tras un ayuno nocturno de 12 horas para determinar la concentración de glucosa, utilizando un autoanalizador Accu-Check Active (Roche, Mannheim, Alemania), con un rango de medición de 20-600 mg/dL y un coeficiente de variación (CV) ≤6%. Para la categorización en concentraciones normales, prediabetes o diabetes, se siguieron los puntos de corte establecidos por la Asociación Americana de Diabetes (ADA)[15].

Colesterol y Triglicéridos (TGC): Las muestras de sangre fueron obtenidas después de un ayuno nocturno de 12 horas y analizadas mediante el autoanalizador Accutrend Plus (Roche, Mannheim, Alemania). Para la categorización de las concentraciones de colesterol total y triglicéridos, se utilizaron los puntos de corte sugeridos por el panel ATP III[16].

Cuestionario de Conducta Alimentaria para Adultos Mayores (DEBQ)[17]: Se utilizó la versión corta del Cuestionario Holandés de Conducta Alimentaria, modificada para su aplicación en población de adultos mayores, que consta de 16 ítems. Este cuestionario evalúa tres dimensiones clave del comportamiento alimentario: Comer Emocional (CE), Comer Restrictivo (CR) y Comer en Respuesta a Señales Externas (CExt). Cada ítem se califica en una escala de 0 a 4 puntos, con un puntaje total máximo de 64 y un mínimo de 0. Para el análisis, se consideraron las puntuaciones medias de cada ítem, así como las medias del puntaje general del instrumento y por dimensión. Además, se realizó una categorización basada en terciles, dividiendo a los sujetos en función de la sumatoria total de las respuestas, según la siguiente clasificación: riesgo alto, con puntaje de 44 a 64; riesgo medio, con puntaje de 22 a 43; y riesgo bajo, con puntaje de 0 a 21.

Análisis estadístico

Se evaluó el comportamiento de las variables utilizando las pruebas de Levene y Shapiro-Francia, encontrando que algunas variables no seguían una distribución normal. En consecuencia, se llevó a cabo un análisis mixto. Para las variables con comportamiento no paramétrico, los resultados se expresaron en medianas, percentil 25 (P25) y percentil 75 (P75). Las variables con comportamiento paramétrico, como las dimensiones de las Conductas Alimentarias de Riesgo, se reportaron en medias y desviación estándar. Las variables categóricas se presentaron en frecuencias y porcentajes.

Para determinar la asociación entre las CAR y las variables bioquímicas-antropométricas, se realizaron correlaciones de Spearman, considerando una relación muy alta 0,90-1,0, alta 0,70-0,90, moderada 0,50-0,70, baja 0,30-0,50 y muy baja >0,30. Finalmente, para comparar la puntuación de la dimensión CR con las concentraciones de glucosa, se aplicó la prueba de Kruskal-Wallis. Se estableció la significancia estadística con un valor de $p<0,05$.

RESULTADOS

Se evaluaron 62 adultos mayores con una mediana de edad de 71,5 (68,0-78,0) años.El 72,58% de la muestra fueron mujeres y 27,42% hombres. La mediana de IMC fue 28,04 (25,93-32,42) kg/m2, de TAS 129,5(123,0-135,0) mmHg, TAD 77 (71,0-83,0) mmHg y de las concentraciones de glucosa 106,5 (99,0-118,0) mg/dL. El resto de la descripción de las variables bioquímicas y antropométricas se muestran en la (Tabla 1).

Respecto a la presencia de CAR en la muestra, se observó que, de las tres dimensiones evaluadas, la dimensión de comedor externo y comedor restrictivo tuvieron las ponderaciones más altas en comparación al comedor emocional (6,80±4,94 CExt, CR vs 4,19±6,03 CE), además los ítems del instrumento con mayores ponderaciones están dentro de las dimensiones anteriormente señaladas. La media total de las tres dimensiones fue 16,74±14,13 (Tabla 2) y cuando se realiza la estratificación en terciles para el riesgo bajo, medio y alto, se observo que el porcentaje combinado para riesgo moderado y alto fue de 29,03% (Figura 1).

Tabla 1. Características generales de los participantes

Variable	Mediana n=62	P25-P75
Edad (años)	71,5	68-78
Ingreso Mensual (MXN)	6000	3,700-11,000
IMC (kg/m^2)	28,64	25,93-32,42
C,Cintura (cm)	99,25	90-107
C, Cuello (cm)	37,5	35-42
CMB (cm)	32	28,3-34,3
C,Pantorrilla (cm)	35	33-38
Glucosa (mg/dL)	106,5	99-118
Colesterol total (mg/dL)	195	152-228
Triglicéridos (mg/dL)	148,5	89-217
Hemoglobina (g/dL)	13,15	12,1-14,1
TAS (mmHg)	129,5	123-135
TAD (mmHg)	77	71-83

P25: Percentil 25; P75: Percentil 75; MXN: Moneda Nacional Mexicana; IMC: índice de Masa Corporal; Kg/m2: Kilogramos sobre metros cuadrados; mg: Miligramos; dL: decilitro; cm:centímetro; g: gramos; mmHg: milímetros de mercurio; C.cintura: Circunferencia de cintura; C.Cuello: circunferencia de cuello; C.Pantorrilla: circunferencia de pantorrilla; CMB: Circunferencia Media de Brazo; TAS: Tensión arterial sistólica; TAD; Tensión arterial diastólica.

Tabla 1 continuación. Características generales de los participantes

Variable	Frecuencia (n)	Porcentaje (%)
Sexo		
Hombre	17	27,42
Mujer	45	72,58
Escolaridad		
Primaria	18	29,03
Secundaria	20	32,26
Bachillerato	17	27,42
Estudios profesionales	7	11,29
Estado civil		
Soltero	11	17,74
Casado	48	77,42
Viudo	3	4,84
Trabajo actual		
Si	2	3,23
No	60	96,77
Situación de vivienda		
Vive solo	15	24,19
Vive acompañado	47	75,81

P25: Percentil 25; P75: Percentil 75; MXN: Moneda Nacional Mexicana; IMC: índice de Masa Corporal; Kg/m2: Kilogramos sobre metros cuadrados; mg: Miligramos; dL: decilitro; cm:centímetro; g: gramos; mmHg: milímetros de mercurio; C.cintura: Circunferencia de cintura; C.Cuello: circunferencia de cuello; C.Pantorrilla: circunferencia de pantorrilla; CMB: Circunferencia Media de Brazo; TAS: Tensión arterial sistólica; TAD; Tensión arterial diastólica.

Cuando se realiza la categorización de las variables bioquímicas y antropométricas, se observo que alrededor del 58% tienen prediabetes y 12,90% concentraciones de glucosa superiores o iguales a 120 mg/dL. Además, 46,77% presentaron concentraciones de colesterol total en límite alto o alto y 50% para las concentraciones de triglicéridos. En cuanto a la tensión arterial alrededor del 30% tiene la tensión elevada y el 61,29% obtuvieron cifras de tensión que caen dentro de las categorías de HTA I y II. El porcentaje de sujetos con sobrepeso y obesidad fue de 67,74% y de la muestra alrededor del 87% tiene una circunferencia de cintura en las categorías de riesgo alto o muy alto, (Tabla 3).

Al realizar las correlaciones, se observó que la única correlación estadísticamente significativa fue entre las concentraciones de glucosa y las dimensiones CExt y CR, (Tabla 4).

Al evaluar las dimensiones de CAR respecto a las categorías de glucosa, se observó que para la dimensión CR, se tuvieron diferencias marginalmente significativas entre categorías, mostrando una tendencia inversa entre la mediana de CR y la glucosa, $p<0,06$ (Figura 2).

DISCUSIÓN

En el presente estudio, se analizó la información de 62 adultos mayores del norte de México, revelando que las conductas alimentarias restrictivas y el comer en respuesta a señales externas fueron las que tuvieron puntajes más altos, con una media de 6,80±4,94 para ambas dimensiones. Además, se identificó una asociación significativa entre estas conductas alimentarias de riesgo y las concentraciones de glucosa, sugiriendo que estos patrones de comportamiento alimentario pueden tener un impacto adverso en el control glucémico en esta población. Al estratificar las CAR en terciles, se observó

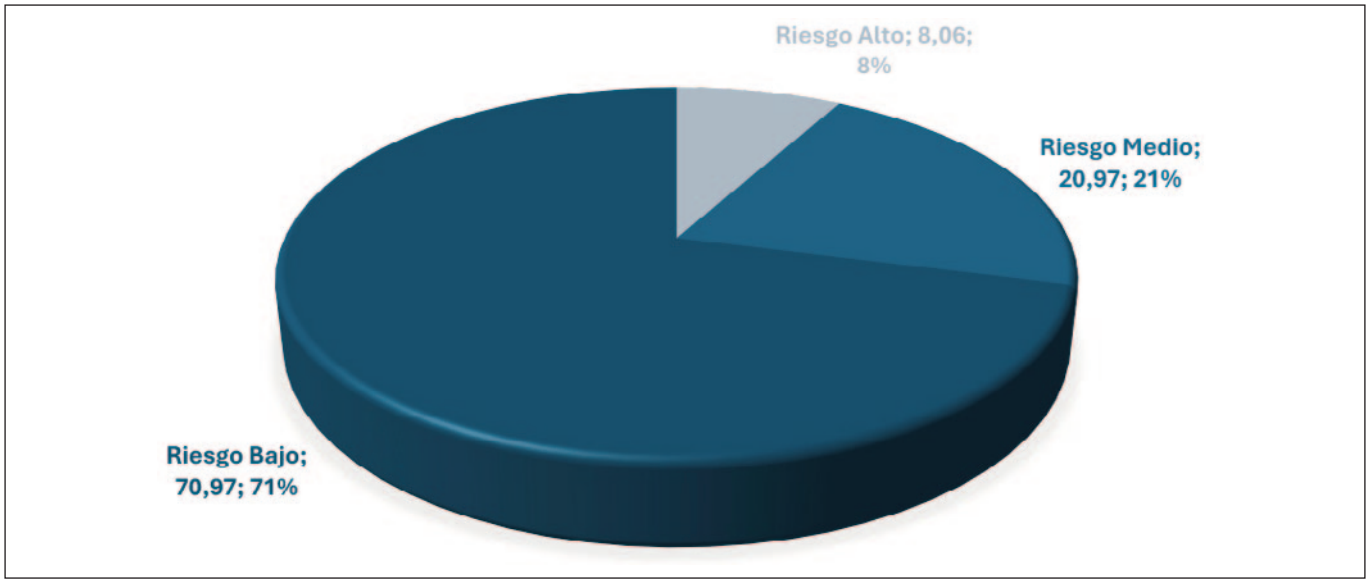

Figura 1. Prevalencia de CAR por categorías en los adultos mayores, n=62

Tabla 2. Dimensiones de la conducta alimentaria en adultos mayores según el instrumento DEBQ

Dimensión	Ítem	Media ±DE n=62
CE	Deseo de comer cuando estoy molesto,	0,58±1,18
CExt	Como más cuando veo comer a otros,	0,77±1,24
CExt	Deseo comer cuando veo comer a otros,	0,83±1,28
CR	Como menos después de comer demasiado,	1,32±1,63
CR	Como menos de lo que me gustaría,	1,32±1,51
CExt	Deseo comer cuando paso por la panadería,	1,145±1,37
CR	Como menos para evitar aumentar de peso,	1,22±1,51
CE	Deseo comer cuando algo desagradable está por suceder,	0,67± 1,19
CE	Tengo deseos de comer cuando me siento solo,	0,91±1,38
CR	Cuido lo que como,	2,45± 1,70
CE	Tengo deseo de comer cuando estoy deprimido o desanimado,	0,62± 1,19
CE	Tengo deseo de comer cuando las cosas van mal,	0,70±1,31
CExt	Deseo de comer al ver u oler la comida,	1,56±1,45
CR	Consumo alimentos adelgazantes,	0,48±1,02
CExt	Como más si la comida está rica o sabe bien,	1,419±1,56
CE	Deseo de comer cuando estoy emocionalmente alterado,	0,67±1,26
Puntaje total y por dimensión		
Todas las dimensiones		16,74±14,13
CE		4,19± 6,03
CExt		6,80±4,94
CR		6,80±4,94

CE: Comedor emocional; CExt: Comedor externo; CR: Comedor restrictivo.

que el 29,03% de los participantes se encontraban en las categorías de riesgo moderado y alto, lo que subraya la relevancia de estas conductas en el perfil de salud de los adultos mayores evaluados. Asimismo, se observó una alta prevalencia de prediabetes (58%) y de dislipidemias, lo que resalta la necesidad de abordar las CAR como parte de un enfoque integral para mejorar la salud metabólica de los adultos mayores. Es importante considerar que los adultos mayores pueden presentar CAR que posteriormente se pueden transformar en un TCA, como lo mencionan Mulchandani et al., anteriormente se consideraba que los TCA eran exclusivos de jóvenes, por lo cual no se pensaba que un adulto mayor presentara un TCA y mucho menos una CAR, ya que al no cumplir con todos los criterios para los TCA o CAR no se diagnosticaba[18]. Sin embargo, es importante considerar estos problemas en este grupo de edad, una investigación realizada sobre anorexia nerviosa en geriatría, reporto que de las muertes relacionadas con la anorexia nerviosa fueron en adultos mayores (10% en el grupo de 55 a 64 años, 12% en el grupo de 65 a 74 años y 28% en el grupo de 85 y más)[19]. Fostinelli et al., indican que las conductas alimentarias van cambiando durante esta etapa debido a los cambios propios de la edad como son cambios fisiológicos, psicológicos y sociales, por lo cual es importante evaluar las conductas alimentarias en los adultos mayores para detectar si se están presentando conductas alimentarias de riesgo[20], además desde el modelo socio ecológico destaca una serie de factores interrelacionados que influyen en los comportamientos alimentarios de los adultos mayores. A nivel individual, aspectos como la salud física, el conocimiento sobre nutrición, las preferencias alimentarias, y la conciencia y actitudes hacia la salud son determinantes clave. Además, el control dietético percibido, la salud mental, el estado de ánimo, las emociones, y el disfrute de la comida también juegan un papel importante. En el ámbito interpersonal, las re-

Tabla 3. Distribución de indicadores clínicos y metabólicos de la muestra, n=62

Variable	Frecuencia (n)	Porcentaje (%)
Glucosa (mg/dL)		
Normal	18	29,03
Prediabetes	38	58,06
Diabetes	8	12,90
Colesterol total (mg/dL)		
Deseable	33	53,23
Límite alto	17	27,42
Alto	12	19,35
Triglicéridos (mg/dL)		
Normal	31	50,00
Límite alto	10	16,13
Alto	21	33,87
Hemoglobina (g/dL)		
Sin anemia	54	87,10
Anemia Leve	8	12,90

Variable	Frecuencia (n)	Porcentaje (%)
Tensión Arterial (mmHg)		
Normal	5	8,06
Elevada	19	30,65
HTA grado 1	34	54,84
HTA grado 2	4	6,45
IMC (kg/m^2)		
Bajo	4	6,45
Normal	16	25,81
Sobrepeso	20	32,26
Obesidad	22	35,48
C. cintura (cm)		
Deseable	8	12,90
Riesgo alto	11	17,74
Riesgo muy alto	43	69,35

Kg/m^2: Kilogramos sobre metros cuadrados; mg: Miligramos; dL: decilitro; cm:centímetro; g: gramos; mmHg: milímetros de mercurio; C. cintura: Circunferencia de cintura.

Tabla 4. Correlaciones de Spearman entre Conductas Alimentarias de Riesgo y variables antropométricas- bioquímicas

Variable	CAR (3 dimensiones)	CE	CExt	CR
Glucosa (mg/dL)	-0,0862	0,0396	-0,2781*	-0,2781*
Colesterol total (mg/dL)	-0,2148	-0,1753	-0,1045	-0,1045
Triglicéridos (mg/dL)	-0,0350	-0,0297	0,0458	0,0458
Hemoglobina (g/dL)	-0,1185	-0,0144	-0,1715	-0,1715
TAS (mmHg)	0,1039	0,0775	0,0393	0,0393
TAD (mmHg)	-0,0940	-0,0746	-0,0733	-0,0733
IMC (kg/m^2)	0,1760	0,0468	0,1416	0,1416
C. Cintura (cm)	0,0789	-0,0492	0,0845	0,0845
C. Cuello (cm)	0,1851	-0,0047	0,1553	0,1553
CMB (cm)	0,1558	0,1048	-0,0143	-0,0143
C. Pantorrilla (cm)	0,1209	-0,0329	0,1042	0,1042

IMC: índice de Masa Corporal; Kg/m^2: Kilogramos sobre metros cuadrados; mg: Miligramos; dL: decilitro; cm: centímetro; g: gramos; mmHg: milímetros de mercurio; C. cintura: Circunferencia de cintura; C. Cuello: circunferencia de cuello; C. Pantorrilla: circunferencia de pantorrilla; CMB: Circunferencia Media de Brazo; TAS: Tensión arterial sistólica; TAD; Tensión arterial diastólica.*p<0,05.

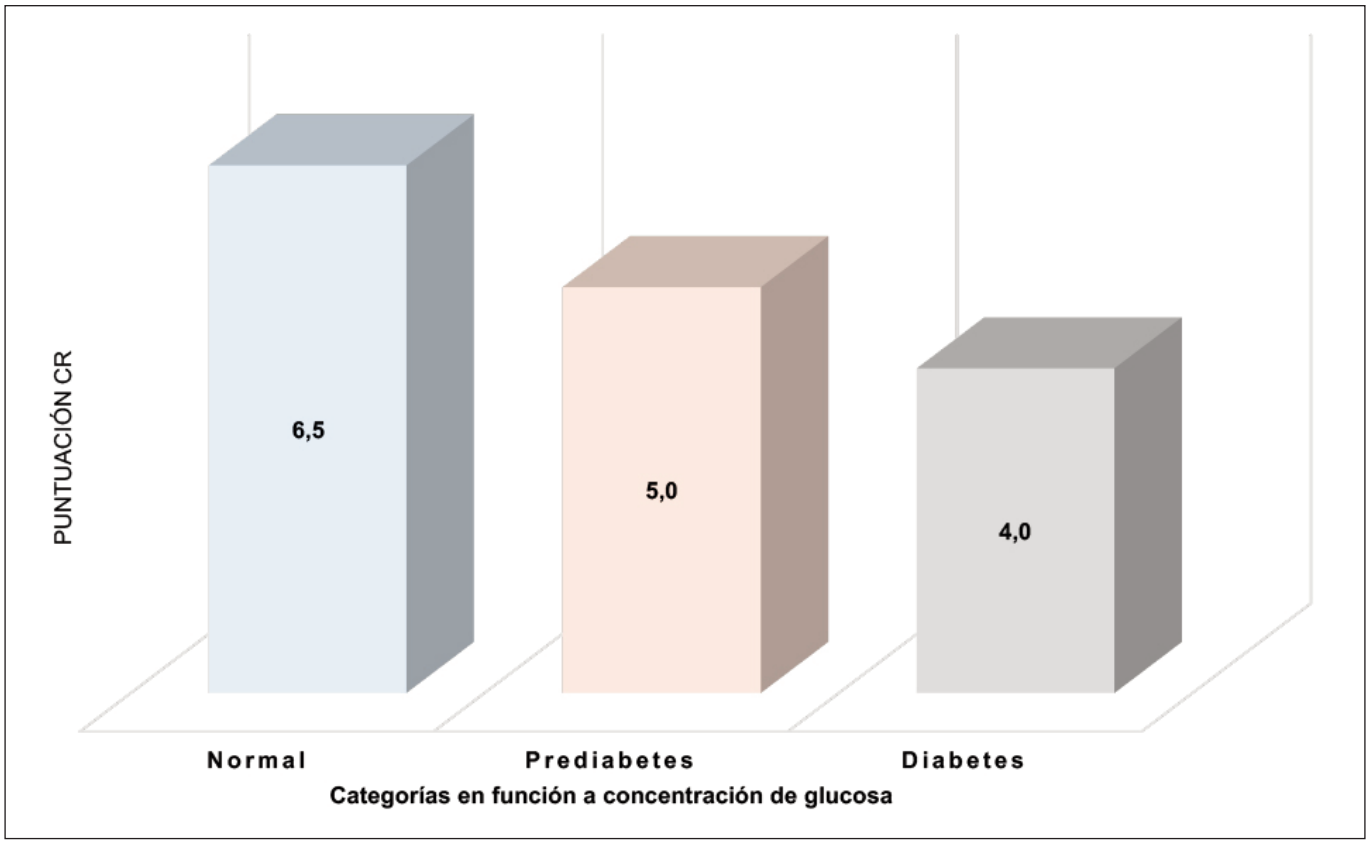

Figura 2. Puntuación media de la dimensión CR, en función de las categorías de glucosa, n=62

laciones con familiares y cuidadores son fundamentales, ya que pueden influir en las decisiones alimentarias y en los hábitos diarios. A nivel comunitario, la disponibilidad de alimentos saludables y la participación en programas comunitarios son cruciales, mientras que, a nivel social, las políticas públicas y las normativas que afectan la accesibilidad y el costo de los alimentos saludables tienen un impacto significativo. Además, las experiencias alimentarias tempranas ejercen una influencia duradera en los comportamientos alimentarios en etapas posteriores de la vida, destacando la complejidad y la importancia de un enfoque multidimensional en la promoción de la salud alimentaria en esta población[21].

En cuanto a las dimensiones del DEBQ, en la presente investigación fueron más prevalentes el CR y el CEx (en ambos 6,80±4,94), seguida de CE (4,19±6,03), similar a lo reportado por Bailly et al., quienes realizaron una evaluación del comportamiento alimentario utilizando el cuestionario DEBQ en 262 participantes mayores de 65 años. Reportan que la conducta alimentaria más prevalente fue la restrictiva (2,87±0,92), seguida de la externa (2,48±0,73) y por último la emocional (2,02±0,97). Otro estudio realizado por Maître et al., reportan la percepción alimentaria, estilo de vida, estado nutricional y de salud en las personas mayores: tipologías y factores asociados al envejecimiento saludable. Al dividir a su población en 7 conglomerados de acuerdo a personas jóvenes (<80 años) y personas mayores viejas (80+ años), así como por medio del análisis de conglomerados y de componentes principales disjuntos (CDPCA), encontraron que el grupo 3 presentó la puntuación más alta en la dimensión CR en comparación a los demás grupos; los autores sugieren que esto puedo haberse debido a temas relacionados con la salud, ya que el grupo 3 estaba más conscientes en la elección de alimentos y en el cambio de hábitos saludables para estar sanos y por el hecho de padecer más enfermedades que los otros grupos[22].

Con relación a la variable de glucosa que indica prediabetes, se encontraron niveles más altos (58,06%) que la media nacional (22%) y respecto a la prevalencia de diabetes se observaron niveles iguales (12,90%) a la media nacional (12,6%) reportadas ambas prevalencias por Basto-Abreu et al. en población mexicana[23]. En un estudio realizado en Rumanía con 314 pacientes con DT2, se encontró que la alimentación restringida se correlacionó con la duración de la diabetes ($r = -0,169$ $p = 0,003$) y el índice de masa corporal ($r = 0,182$ $p = 0,001$), y la alimentación externa se correlacionó con la hemoglobina glucosilada ($r = 0,114$ $p = 0,044$)[24].

De acuerdo con Campos-Nonato et al., la prevalencia a nivel nacional en adultos mayores mexicanos de 60 años en el

2022 para HTA fue del 40,1%[25] vs 61,92% (este estudio), en cuanto a la dislipidemia (colesterol o TGC altos) se reporta en adultos ≥20 años una prevalencia del 21,1%[26] vs 53,22% de la presente investigación, siendo mayor la prevalencia de hipertensos y dislipidemias en este estudio que la que se reporta a nivel nacional. La prevalencia de anemia reportada en esta investigación (12,90%) fue más alta en comparación a la media nacional (10,3%) reportada en la ENSANUT Continua 2022[27]. Basado en el IMC el sobrepeso a nivel nacional se reportó en un 38% y la obesidad en el 36%, en cuanto a obesidad abdominal definida por circunferencia de cintura se encontró 81% con riesgo y riesgo muy alto[28] dichas prevalencias fueron similares a las reportadas en esta investigación (Sp 32,26%, Ob 35,48% y C.cintura 87,09%).

Respecto a las correlaciones, Warschburger et al., reportan en su estudio sobre el IMC y las conductas alimentarias desadaptativas en adultos mayores, una correlación positiva entre el IMC y la CR[29] para perder peso corporal o evitar aumentar de peso. En el mismo sentido Hawash et al., identificaron los predictores de las conductas alimentarias emocionales entre los adultos mayores, reportaron que el estrés percibido, la edad, el género, el estado civil y el IMC tienen una relación positiva significativa con las conductas alimentarias emocionales ($p < 0,001$)[30], esto contrasta con nuestro estudio en el cual no se encontró dicha correlación entre estas variables y el IMC.

Este estudio destaca diversas fortalezas que respaldan la validez de sus hallazgos. En primer lugar, la integración de un enfoque integral, que combina evaluaciones antropométricas, bioquímicas y del comportamiento alimentario, proporciona una visión holística de la relación entre las conductas alimentarias de riesgo y la salud metabólica en adultos mayores. Esto es particularmente relevante, dado que la evidencia existente sobre la relación entre las CAR y los componentes metabólicos y clínicos en esta población es limitada. Asimismo, la estandarización de los procedimientos de medición, junto con la capacitación rigurosa del personal encargado de la recolección de datos, garantiza la consistencia y precisión en la obtención de información. Por último, la utilización de un cuestionario validado y específicamente adaptado para la población de adultos mayores refuerza la fiabilidad de los resultados obtenidos.

A pesar de las fortalezas mencionadas, este estudio también presenta algunas limitaciones. La muestra de 62 adultos mayores, aunque adecuada para un análisis exploratorio, es relativamente pequeña, lo que podría limitar la generalización de los resultados a poblaciones más amplias. Además, debido a la naturaleza transversal del estudio, no es posible establecer relaciones causales entre las conductas alimentarias de riesgo y las variables bioquímicas. Por último, el uso de un cuestionario autoinformado para evaluar las CAR puede estar sujeto a sesgos de memoria o a la subestimación de comportamientos poco saludables, lo que podría afectar la precisión de las estimaciones.

CONCLUSIÓN

Este estudio enfatiza en la prevalencia de conductas alimentarias de riesgo en adultos mayores del norte de México y su asociación con indicadores bioquímicos clave, como las concentraciones de glucosa. Estos hallazgos subrayan la importancia de considerar las conductas alimentarias en la evaluación y manejo integral de la salud metabólica en esta población. Intervenciones dirigidas a modificar estas conductas podrían tener un impacto positivo en la prevención de complicaciones metabólicas en los adultos mayores, enfatizando la necesidad de investigaciones futuras que amplíen y profundicen en este campo.

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Factors and comparative analysis of COVID-19's impact on household food security in rural and urban regions

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ABSTRACT

Introduction: The COVID-19 pandemic has significantly affected household food security in Indonesia, particularly in both rural and urban areas. This study compares food security between rural and urban households during the pandemic. This study aims to compare food security between rural (Paser Regency) and urban (Balikpapan City) households during the pandemic.

Methods: Using a cross-sectional design, 300 households were sampled (150 each from Balikpapan and Paser), with data collected through interviews and questionnaires. Household income, food, and non-food expenditure were analyzed using Pearson correlation with IBM SPSS Statistics 24.

Result: The results of the correlation test showed that the increase in spending on food consumption during the COVID-19 pandemic had a significant positive correlation with food security in rural areas and moderate overall. Spending on non-food items had a small positive correlation in rural and urban. Post-COVID-19 income positively correlated in rural areas but weaker in urban areas. Social assistance receipts are negatively associated with food security in rural areas and urban areas. Maternal concerns about home food provision significantly negatively correlated with rural and overall.

Conclusion: The COVID-19 pandemic has significantly impacted household spending on food consumption, both in urban and rural areas. A positive correlation exists between increased food expenditure and food security in rural areas, but social assistance recipients tend to have lower food security. The government needs to strengthen food assistance programs and diversify sources of income in rural areas through job training and small business support.

KEYWORDS

Basic needs, food vulnerability, inequality, socioeconomic impact, subsistence.

INTRODUCTION

The COVID-19 pandemic that has spread since early 2020 has changed various aspects of human life throughout the worldwide. The COVID-19 pandemic has significantly impacted Indonesia, with the first confirmed case reported on March 2, 2020. As of June 3, 2020, there have been 28,233 confirmed cases of COVID-19 in the country, resulting in a current incidence rate of 0.11‰. Unfortunately, the senior population has been hit the hardest, with a death rate of 17.68%. Among COVID-19 patients, the most common symptoms reported were fever in the past (50.4%), fever at present (47.1%), and cough (76.2%)[1]. Research by Bautista Jacobo et al. 2023 regarding eating disorders, it was found that one in five University in North-Western Mexico students surveyed were at risk of developing an eating disorder. The dominant level of anxiety in respondents during the pandemic ranged from moderate to severe. The most common symptoms experienced by students are nervousness, lack of relaxation, and fear that something bad will happen. This suggests that the effects of COVID-19 can attack psychology.

One of the significant impacts of this pandemic is related to household food security, especially in rural and urban areas. Food security is the ability of a household or community to meet staple food needs such as food, and access to sufficient, safe, balanced, and nutritious food. The COVID-19 pandemic has triggered several factors that can influence

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household food security, including limitations on the acquisition of farm inputs, movement restrictions, and job loss or reduced income[3,4].

Indonesia's economy has been significantly impacted by COVID-19, which has caused economic decline in several sectors. The industries most impacted were the household sector, trade, tourism, transportation, and health[5]. The impact of the pandemic on economic activity and food supply networks has raised serious concerns about the relationship between COVID-19 and food security in Indonesia. Research has indicated that food insecurity has increased because of the epidemic, especially for vulnerable groups like young children[6].

During the COVID-19 pandemic, food security in Indonesia is a complicated problem that differs depending on the area and people. A study carried out in Indonesia revealed that 42% of the nation still experiences low food security, with areas like DKI Jakarta, West Java, Banten, Bali, Central Kalimantan, East Kalimantan, South Kalimantan, North Sulawesi, West Papua, and Papua being particularly affected[7]. The impact of the COVID-19 outbreak in Indonesia has been different in urban and rural areas, affecting various aspects of life. Furthermore, a cross-sectional study conducted in Indonesia suggested that the limitations placed on community activities during the pandemic hurt the mental well-being of residents living in both urban and rural areas[8]. In another research during the COVID-19 pandemic, 20.2% of individuals in a study on pregnant women in Semarang, Indonesia, reported having mild to moderate to severe anxiety. Low COVID-19 knowledge and gravida for the first or > fourth time were factors linked to anxiety levels[9].

The following are the primary causes of food insecurity in Indonesia during the COVID-19 pandemic: 1. Economic downturn: people who are unemployed or losing their income have seen a decrease in purchasing power due to the epidemic, primarily affected the middle and lower classes[10], 2. Cost increases for staple foods: as a result of the epidemic, staple food costs have gone up, making it more difficult for households to afford a balanced diet[10], 3. Food supply chain disruption: as a result of the pandemic's disruption of food supply systems, there is a shortage of food in some places[7], 4. Legal and economic policies: food insecurity and inequality in Indonesia have been made worse by ingrained elements connected to the country's legal and economic systems[10], and 5. Lack of access to assistance: due to a lack of legal identity, impoverished women, especially those who have recently divorced, may encounter difficulties getting support from programs aimed at reducing poverty[11]. In summary, the relationship between COVID-19 and food security in Indonesia is a complicated one that calls for constant observation and action to lessen its detrimental effects on people who are already at risk. This study aims to compare food security in rural and urban households during the COVID-19 pandemic with 16 independent variables that have been selected.

METHODS

Study Design

The methodology for this study involved a clustered sampling approach, in which each location was carefully chosen based on its frequency in the area[12]. The study honed in on households within each subdistrict and utilized the clusters of each integrated healthcare center as a basis. The total number of samples used was n = 300 with the division of n = 150 Balikpapan City and n = 150 Paser Regency. This study is a cross-sectional investigation aimed at documenting the state of household food security in East Kalimantan, Indonesia, amidst the COVID-19 pandemic. This research encompasses both urban (Balikpapan City) and rural (Paser Regency) areas, guided by the Decree of the Minister of National Development Planning of the Republic of Indonesia Number 42/M.PPN/HK/04/2020[13]. This investigation take place between May and September 2022 and received ethical approval from the Ethics Committee for Research Involving Human Subjects at the Bogor Agricultural Institute (reference number 680/IT3.KEPMSM-IPB/SK/2022).

Data Collection

This study collected primary data obtained from interview using questionnaire and in-depth interview about COVID-19 impact at household level. Household income and expenditure are assessed using instruments adapted from the 2020 National Social Economic Survey[14] about household food expenditure, consumption, income, and revenue. Expenditure covers expenses on food (staple food, vegetables, and raw protein, prepared food, and beverages) and non-food (medicine, vitamins, sanitation, cellular credit/data pacakge). The structure of the selected survey questions is presented in table 1.

Statistical Analysis

The data obtained was processed using Ms. Office Excel 2019 related to the 16 variables selected. Pearson's correlation descriptive statistics were used to analyze 16 variables selected with food security through the Food Insecurity Experience Scale (FIES) using software IBM SPSS Statistic 24.

RESULTS

Based on the data in table 2, several significant findings are related to changes in maternal expenditure and conditions in urban and rural areas during the COVID-19 pandemic. First, changes in household spending on food consumption have mainly remained stable in both regions, with 58% of households in urban areas and 65% in rural areas unchanged. However, there is almost the same percentage between the increase in food expenditure in urban (24%) and rural (25%).

Second, spending on non-food items was essentially unchanged in both regions, although there was a slight difference, with more households in rural areas (58.7%) reporting

Table 1. List of survey questions

No	Questions	Category
1	Compared to the time since the COVID-19 outbreak occurred, how has the expenditure on food/food ingredients consumed/ eaten/ drunk/ cooked/ used/ consumed by your household today?	1. Increase 2. No Change 3. Increase
2	Compared to the time since the COVID-19 outbreak occurred, how has your current expenditure on non-household food items changed?	1. Increase 2. No Change 3. Increase
3	When compared to since the COVID-19 outbreak occurred, what is the total of all your household expenses today?	1. Increase 2. No Change 3. Increase
4	Which production change is the most dominant? Food ingredients (staple food, vegetables, and raw protein sources)?	1. Yes 2. No
5	Which production change is the most dominant? Prepared food and beverages?	1. Yes 2. No
6	Which production change is the most dominant? Health (medicine, vitamins, and sanitation)?	1. Yes 2. No
7	Which production change is the most dominant? Cellular credit/data package?	1. Yes 2. No
8	What has been the impact on your income since the Covid-19 outbreak occurred?	1. Increase 2. No Change 3. Increase
9	During the pandemic, did you ever receive social assistance from the government? (cash or staple food)	1. Yes 2. No
10	The current condition and various news reports about Covid-19, have made me feel (Mother):	1. Not affected 2. Worried
11	After COVID-19, Mother's perception of maternal health	1. Not affected 2. Worried
12	After COVID-19, Mother's perception of the health of family members	1. Not affected 2. Worried
13	After COVID-19, Mother's perception when going outside the house	1. Not affected 2. Worried
14	During COVID-19, did you experience unwanted weight loss?	1. Yes 2. No
15	During COVID-19, did your child experience unwanted weight loss?	1. Yes 2. No
16	During COVID-19, are you worried about food availability at home?	1. Yes 2. No

no change than in urban (48.7%). The same is true for changes in total household spending, with most households in rural (56%) and urban (45.3%) reporting no change. Expenditure on staple foods showed a dominance of increase in both regions, although slightly higher in urban areas (78.7%) than in rural areas (74%). As for ready-to-eat food and beverages, more households in rural areas (54.7%) reported changes compared to urban (50%).

Regarding health, most households in both regions experienced increased spending on medicines and sanitation, with the percentage almost the same between urban (75.3%) and rural

Table 2. Results of percentage data processing of each variable in urban and rural

Variabel	Category	Urban, n (%)	Rural, n (%)
Change in food consumption expenditure during COVID-19	1. Increase	36 (24)	37 (25)
	2. No Change	87 (58)	97 (65)
	3. Increase	27 (18)	16 (11)
Change in spending on non-food items by current households during COVID-19	1. Increase	62 (41.3)	54 (36)
	2. No Change	73 (48.7)	88 (58.7)
	3. Increase	15 (10)	8 (5.3)
The total change in all household expenditure now compared since the COVID-19 outbreak occurred	1. Increase	56 (37.3)	53 (35.3)
	2. No Change	68 (45.3)	84 (56)
	3. Increase	26 (17.3)	13 (8.7)
The most dominant change in total expenditure for food ingredients (staple food, vegetables, and raw protein sources)	1. Yes	118 (78.7)	111 (74)
	2. No	32 (21.3)	39 (26)
The most dominant change in total expenditure for prepared food and beverages	1. Yes	75 (50)	82 (54.7)
	2. No	75 (50)	68 (45.3)
The most dominant change in total expenditure for health (medicine, vitamins, and sanitation)	1. Yes	113 (75.3)	108 (72)
	2. No	37 (24.7)	42 (28)
The most dominant change in total expenditure for cellular credit/data package	1. Yes	40 (26.7)	36 (24)
	2. No	110 (73.3)	114 (76)
Revenue since the COVID-19 outbreak	1. Increase	10 (6.7)	5 (3.3)
	2. No Change	59 (39.3)	87 (58)
	3. Increase	81 (54)	58 (38.7)
Received social assistance from the government during the COVID-19 pandemic (cash or stapel food)	1. Yes	77 (51.3)	92 (61.3)
	2. No	73 (48.7)	58 (38.7)
Mother's worry about conditions during the pandemic due to various report about COVID-19	1. Not affected	16 (10.7)	24 (16)
	2. Worried	134 (89.3)	126 (84)
Mother's worry about own health during COVID-19	1. Not affected	16 (10.7)	24 (16)
	2. Worried	134 (89.3)	126 (84)
Mother's worry about the health of family members during COVID-19	1. Not affected	16 (10.7)	25 (16.7)
	2. Worried	134 (89.3)	125 (83.3)
Afraid to go outside during COVID-19	1. Not affected	15 (10)	27 (18)
	2. Worried	135 (90)	123 (82)
Mother's experience unintended wight loss during COVID-19	1. Yes	27 (18)	27 (18)
	2. No	123 (82)	123 (82)
Mother's experience unintended child's weight loss during COVID-19	1. Yes	5 (3.3)	15 (10)
	2. No	145 (96.7)	135 (90)
Mother's worry about food availability at home	1. Yes	43 (28.7)	46 (30.7)
	2. No	107 (71.3)	104 (69.3)

(72%). However, in terms of spending on mobile data packages, most households have not changed, both in urban (73.3%) and rural (76%). Household income experienced a significant decline in both regions, with 54% of urban households and 38.7% of rural households reporting a decrease in income. In addition, more households in rural areas (61.3%) received social assistance from the government than in urban areas (51.3%).

Maternal concerns related to the pandemic, personal health, and family members are particularly high in both regions, with more than 80% of urban and rural mothers reporting such concerns. In addition, fear of leaving the house is more reported in urban areas (90%) than in rural areas (82%). Regarding weight change, 18% of mothers in both regions reported unintentional weight loss, but child weight loss was more common in rural areas (10%) than in urban areas (3.3%).

Overall, these data show that despite some differences, households in urban and rural areas experienced similar impacts in various aspects during the COVID-19 pandemic, with households in rural areas more vulnerable to declining incomes and more dependent on social assistance.

The results of the correlation test between the selected independent variable and the dependent variable (Food Security) in rural, urban, and overall areas (table 3), reveal several important findings related to changes in expenditure and concerns during the COVID-19 pandemic.

Changes in expenditure on food consumption have a significant positive correlation with food security in rural areas (r = 0.414), which shows that the increase in spending on food during the pandemic is closely related to better food security conditions in rural areas. In urban areas, the correlation was lower (r = 0.077), and overall, a correlation value of r = 0.230 showed that a moderate increase in food expenditure was related to food security.

Changes in expenditure on non-food goods showed a slight positive correlation in rural (r = 0.144) and urban (r = 0.086)

Table 3. Correlation between 16 variables and dependent variables (food security)

No	Variable	Rural (r value)	Urban (r value)	Overall (r value)
1	Change in food consumption expenditure during COVID-19	0.414**	0.077	0.230**
2	Change in spending on non-food items by current households during COVID-19	0.144	0.086	0.113*
3	The total change in all household expenditure now compared since the COVID-19 outbreak occurred	0.190*	-0.013	0.076
4	The most dominant change in total expenditure for food ingredients (staple food, vegetables, and raw protein sources)	0.089	0.155	0.126*
5	The most dominant change in total expenditure for prepared food and beverages	0.160	0.046	0.097
6	The most dominant change in total expenditure for health (medicine, vitamins, and sanitation)	0.080	0.067	0.079
7	The most dominant change in total expenditure for cellular credit/data package	0.060	-0,005	0.034
8	Revenue since the COVID-19 outbreak	0.177*	0.037	0.086
9	Received social assistance from the government during the COVID-19 pandemic (cash or stapel food)	-0.100	-0.141	-0.149**
10	Mother's worry about conditions during the pandemic due to various report about COVID-19	0.071	0.047	0.046
11	Mother's worry about own health during COVID-19	0.071	0.047	0.046
12	Mother's worry about the health of family members during COVID-19	0.085	0.047	0.052
13	Afraid to go outside during COVID-19	0.076	0.036	0.038
14	Mother's experience unintended wight loss during COVID-19	-0.100	-0.175*	-0.132*
15	Mother's experience unintended child weight loss during COVID-19	-0.126	-0.066	-0.125**
16	Mother's worry about food availability at home	-0.293**	-0.082	-0.196**

(**) Correlation is significant at 0.01 level (2-tailed), (*) Correlation is significant at the 0.05 level (2-tailed), and the sign on the correlation coefficient (positive or negative) indicates the direction of the relationship. If it is positive, it shows that the higher the independent variable, the higher the dependent variable. Meanwhile, if it is negative, the higher the independent variable, the lower the dependent variable.

areas, as well as overall (r = 0.113). This indicates that changes in spending on non-food items are related to food security, although not as strongly as spending on food. The total household expenditure change had a minimal correlation (r = 0.076). In rural areas, there was a slight positive correlation (r = 0.190), while in urban areas, the correlation was negative and insignificant (r = -0.013). This shows that the total change in household expenditure does not significantly influence food security.

Expenditure on staple foods was positively correlated with food security in both regions, with higher values in urban (r = 0.155) than rural (r = 0.089), and overall r = 0.126. This shows that spending on staple foods (such as basic foodstuffs, vegetables, and protein) is critical to food security, especially in urban areas.

Since COVID-19, income has shown a positive correlation with food security in rural areas (r = 0.177), but only a minimal correlation in urban areas (r = 0.037). The correlation of income with food security is r = 0.086, indicating that although some households in rural areas have experienced increased revenue, the effect on food security is relatively small.

Social assistance receipts negatively correlated in rural (r = -0.100) and urban (r = -0.141) areas. An overall correlation of r = -0.149 indicates that households receiving social assistance tend to have lower food security, which may be related to more vulnerable economic conditions.

Maternal concerns related to home food provision have a significant negative correlation in rural areas (r = -0.293) and overall (r = -0.196). This suggests that the increasing concern of mothers is linked to a decrease in household food security, particularly in rural areas. Accidental weight loss in urban areas has a significant negative correlation with food security (r = -0.175), indicating that mothers who experience weight loss tend to be in households with lower food security. Similarly, as concerns about food availability at home rise, households' food cesurity is lower.

DISCUSSION

Changes in expenditure on food have not changed significantly in either region. This indicates that changes in food consumption levels tend to be stable. Although the condition in Paser Regency is more stable, it is 10% adrift compared to Balikpapan City. Meanwhile, the increase experienced by respondents in Paser Regency was 35.3%, and Balikpapan City was 37.3%. Based on of the correlation test results, expenditure on food consumption in rural areas is significant (r value = 0.414) compared to urban areas. In general, expenditure on food consumption is positively correlated (r value = 0.230). This condition can occur due to limited mobility and increasing health problems, necessitating increased spending on food and health supplies to ensure safety and health[15,16].

The economic uncertainty during the pandemic also led to a shift in consumption patterns, with a greater emphasis on home-cooked meals than prepared foods[17]. According to Saragih & Saragih (2020) research shows several factors are interrelated. For instance, changes in eating habits correlate with age, food diversity correlates with the type of work, breakfast habits correlate with the type of work, and consumption diversity correlates with changes in eating habits. Conversely, there are no correlations between consumption diversity and concerns about food shortages, breakfast habits and concerns about food shortages, herbal drink habits and meal frequency, and types of herbs and weight gain. The results of another study by Bautista et al. (2024), the consumption of dietary supplements during the COVID-19 pandemic in Mexico shows that more than half of consumers receive recommendations from health experts. Most of respondents considered that dietary supplements contributed to the prevention of COVID-19.

Income during the COVID-19 pandemic was relatively stable in Paser Regency, which experienced a decrease of 38.7% compared to 54% in Balikpapan City. This is in line with the results of the study Varma et al. (2023), which stated that informal workers, who constitute 81% of urban labor in places like India, faced job losses and food access issues during lockdowns.

Urban areas are more affected by several the business sector conditions in urban areas, including tourism, hospitality, and transportation, which are directly affected by the COVID-19 pandemic[21,22], restrictions on mobility and community activities that reduce economic activities in urban areas[23,24], and higher unemployment and layoffs in urban areas[24]. Based on the results of research conducted by Carrillo-Álvarez et al. (2024) The city of Catalonia, Spain, stated that urban areas experienced a 52.1% prevalence of severe food insecurity among food aid recipients, exacerbated by the pandemic. Based on the results of the study by Ajibade et al. (2024), key factors influencing food spending included household income, size, and the age of the household head, with income being the most significant determinant.

However, receiving assistance from the government is an interesting concern based on the findings of this study. Receiving aid from the government in cash or staple food in rural areas reached 61.3% compared to urban areas at 51.3%. This shows that rural areas are more vulnerable to food than urban areas, with the variable of receiving social assistance from the government. At the same time, the overall correlation results show that this variable is negatively correlated significantly (r-value = -0.149). This can be interpreted that the more social assistance obtained, the more food insecurity can suddenly occur. The link between income levels in a region and the prevalence of COVID-19 is stronger in rural areas, indicating a greater need for assistance[27].

The variable of maternal weight loss experience during the COVID-19 pandemic in urban areas was negatively correlated

(r-value = -0.175). This can happen to households in urban areas that experience food insecurity. Overall, this variable also provides a negative correlation to household food security in rural and urban areas (r-value = -0.132). Following the results of research conducted by Vicheet et al. (2024), food security is not significantly correlated with changes in the weight of working women in Malaysia in the 18 – 49 age range.

Of the respondents, 69.3% of mothers in Paser Regency and 71.3% in Balikpapan City stated they were not worried about food availability at home. The results of the correlation analysis related to this independent variable with food security show that concerns about food availability in rural areas are more significant for food availability at home compared to urban areas. However, overall maternal concerns about food availability are significant (r-value = -0.196), although both are negatively correlated. This means that this concern only occurs in households experiencing food insecurity. These variables reflect the heightened economic uncertainty and shifts in consumer behavior during the pandemic, as evidenced by increased expenditure on home-cooked meals and reduced spending on prepared foods in Indonesia[17].

The results showed that the most influential variable on household food security in rural areas was the change in food consumption and income distribution during the COVID-19 pandemic. Meanwhile, there is no positive correlation between independent variables and household food security in urban areas. This suggests a broader impact on household financial decisions and food choices[29,30]. These findings underscore the complex interplay between economic factors and food consumption behaviors during the pandemic, highlighting the need for targeted government interventions to support vulnerable populations[17,31].

STUDY LIMITATIONS

The study involved 300 households from diverse rural and urban settings, utilizing extensive questionnaires and in-depth interviews to gather a comprehensive dataset. Meticulous processing and validation were required to ensure the reliability of findings, particularly when addressing the socioeconomic factors affected by the COVID-19 pandemic. The research included 16 independent variables related to household food security, demanding complex statistical analyses to identify significant patterns. The time-consuming nature of these analyses and the need to cross-validate findings against existing literature extended the research timeline. The evolving socioeconomic impacts of COVID-19 necessitated consideration of longitudinal effects, including the sustained influence of government assistance and shifts in household expenditure patterns, requiring careful contextual interpretation.

CONCLUSION

The conclusion of this study shows that the COVID-19 pandemic significantly impacts household spending, especially on food consumption, in urban and rural areas. Rural households are more vulnerable to declining incomes and are more dependent on social assistance than urban households. There was a significant positive correlation between increased spending on food and food security in rural areas. Still, social assistance showed a negative correlation, indicating that households receiving assistance tended to have lower food security.

The results of this study suggest the importance of more targeted government intervention to support vulnerable households, especially in rural areas that are more dependent on social assistance. The government needs to strengthen food assistance programs by improving sustainable food access. In addition, diversifying sources of income in rural areas through job training programs or support for small businesses can help improve food security. Nutrition and household financial management education can also help people adapt to economic changes during a crisis.

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Relationships between psychological, clinical aspects and eating behavior in individuals with diabetes: cross-sectional study

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ABSTRACT

Introduction: Eating disorders are closely related to mental status, and individuals with diabetes have a significantly increased risk of developing an eating disorder.

Objective: This study aims to evaluate the possible association of cognitive restriction, uncontrolled eating, emotional eating factors, and eating disorders with depression in individuals with diabetes.

Methods: A cross-sectional study was carried out on 132 patients who were diagnosed with diabetes between 2022 and 2024 in the Internal Medicine outpatient clinic of a university hospital in Türkiye. The Beck Depression Inventory (BDI) was used to assess the depression status of individuals, the Three-Factor Eating Questionnaire (TFEQ-R18) to measure eating habits, and the Night Eating Questionnaire (NEQ) to obtain information about night eating behavior. All anthropometric measurements were taken by the researcher.

Results: It was determined that there was a 'mild depression' state in both the Type 1 diabetes patient group (14.10±8.26) and the Type 2 diabetes patient group (14.74±7.64). A linear, moderate, and significant correlation was found between BDI scores and NEQ scores in individuals with type 1 diabetes ($r=0.547$, $p<0.001$). In individuals with type 2 diabetes, an inverse, moderate, and significant correlation was found between BDI scores and cognitive restriction scores ($r=-0.406$, $p=0.029$). For the individuals in the two groups, statistically significant differences were found in the scores obtained from the BDI, NEQ, and TFEQ-R18 in terms of the history of mental illness and obesity, diabetic diet, and hypoglycemia ($p<0.05$).

Conclusions: In this study, it has been shown that the effect of mental illness and obesity history on current eating behavior may be on night eating behavior, cognitive restriction, and uncontrolled eating. It is likely that compliance with the diabetic diet and prevention of hypoglycemia will be reflected in eating behavior and anthropometric measurements.

KEYWORDS

Depression; Diabetes Mellitus; Eating Behavior; Mental Health, Night Eating Syndrome.

INTRODUCTION

Eating disorders include a wide range of unhealthy and dangerous eating attitudes and behaviors (rigid attitudes and irrational beliefs about foods such as good and bad)[1]. The risk of developing eating disorders is high, especially in chronic diseases (like diabetes) in which nutrient intake (limitations) is important in their medical treatment and management[2]. Due to the nature of diabetes, factors such as diet lists that must be followed to keep blood sugar under control, the presence of prohibited foods, and being a chronic disease lead to psychiatric disorders in patients and cause mental preoccupations to focus on food and weight control. For all these reasons, deterioration in the eating attitudes and behaviors of patients is observed[3].

There is a bidirectional relationship between diabetes and some mental disorders such as depression, anxiety disorders, eating disorders, and cognitive deficits, and these diseases are more common in the diabetic population[4]. Psychological status may affect the risk of eating disorders in individuals with diabetes. In a study conducted with 194 adults with type 2 diabetes, it was found that 7% met the criteria for Night Eating

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Syndrome (NES) and that increased night eating symptoms were associated with increased levels of clinical depressive symptoms[5]. In another study investigating night eating behavior in individuals with type 2 diabetes, higher emotional eating behavior (Cohen's d=0.52, p=0.04) was found in those who ate at night compared to diabetic patients who did not eat at night. However, no differences were observed between individuals in terms of depressive symptoms[6].

OBJECTIVE

This study aims to evaluate the causes of cognitive restriction, uncontrolled eating, emotional eating factors and eating disorders in individuals with diabetes and the possible relationship of these eating patterns with depression.

METHODS

This study was conducted with adult individuals between the ages of 19-65 who were diagnosed with diabetes and applied to the Internal Medicine outpatient clinics of a university hospital in Türkiye between 2022-2024. A total of 132 volunteers, 62 of whom were diagnosed with type 1 diabetes and 70 with type 2 diabetes, were reached. Exclusion criteria include pregnancy, breastfeeding, being diagnosis with depression, amputation, and diabetic complications. The study was approved by the Erzincan Binali Yildirim University Human Research Ethics Committee and written informed consent was obtained from all participants in accordance with the provisions of the Declaration of Helsinki in 2013 (as revised in Finland 2024)[7]. A questionnaire form was applied by researchers to the individuals participating in the study by using face-to-face interview technique.

Assessment of anthropometric measurements

All measurements were taken by the researcher. Participants' body weights (kg) were measured using the Tanita MC 780 Digital Scales; heights (cm) were measured on the Frankfort plane, while standing, with the help of a stadiometer. BMI values were calculated by dividing the body weight of the individuals by the square meter of their height (kg/m^2).

Assessment of depression status

Beck Depression Inventory was used to evaluate the depression status of individuals. The highest score that can be obtained from the scale is 63, and a high total score indicates a high level of depression. According to the total depression score, 0-9 indicates 'minimal depression', 10-16 'mild depression', 17-29 'moderate depression', and 30-63 'severe depression'[8,9].

Three Factor Eating Questionnaire (TFEQ-R18)

The Three Factor Eating Questionnaire (TFEQ-R18) was used to measure the nutritional habits of individuals. With this questionnaire, the degree of restriction of people's conscious eating, the level of uncontrolled eating, and the degree of eating when they are emotional can be measured. TFEQ-R18 assesses current eating habits and measures three different aspects of eating behavior: cognitive restriction, uncontrolled eating, and emotional eating. High scores are an indication of more cognitive eating, uncontrolled eating, or emotional eating[10]. The reliability of the TFEQ-R18 in Türkiye was calculated with the Cronbach alpha value in 2015 and the Cronbach alpha value was found to be 0.721[11].

Night Eating Questionnaire (NEQ)

The Night Eating Questionnaire (NEQ) was applied to get information about food intake during the day, control over night eating behavior, cravings, frequency of waking up at night, awareness of night eating and mood. Those who score 30 and above on the Night Eating Questionnaire are in the risk group[12,13].

Statistical analysis

The data obtained from the study were evaluated with the SPSS 22.0 statistical package program. While frequency was calculated in qualitative data, mean and standard deviation were calculated in quantitative data. Mann Whitney U test was used to compare the numerical variables of the independent data groups that were not normally distributed. Pearson Chi-square test and Fisher's Exact Chi-square test were used in the evaluation of qualitative variables. The relationship between two non-normally distributed numerical variables was tested with Spearman Correlation analysis. In all analyses, $p<0.05$ was considered statistically significant.

RESULTS

The sociodemographic characteristics, disease states of individuals are shown in Table 1. The mean age was 40.9±13.7 years in the patient group with type 1 diabetes (Type 1 DM-PG) and 50.7±9.8 years in the group of patients with type 2 diabetes (Type 2 DM-PG) ($p<0.05$). The number of female and male individuals in both the Type 1 DM-PG and the Type 2 DM-PG is similar (51.6% women and 48.4% men in the Type 1 DM-PG; 50.0% women and 50.0% men in the Type 2 DM-PG).

Considering the diet application status, it was determined that 54.8% of the individuals in the Type 1 DM-PG and 25.7% of the individuals in the Type 2 DM-PG followed a diabetic diet ($p<0.05$). It was determined that the majority of individuals in both groups experienced hypoglycemia (91.9% in the Type 1 DM-PG, 71.4% in the Type 2 DM-PG) ($p<0.05$).

The mean and standard deviation values of the scores obtained from the BDI, NEQ, and TFEQ-R18 scales are given in Table 2. According to the total depression score average, it was determined that there was a 'mild depression' state in

Table 1. Demographic characteristics, disease states, and scale scores of individuals

	Type 1 DM-PG (n:62)		**Type 2 DM-PG** (n:70)		**Total** (n:132)		**p-value**
	n	**%**	**n**	**%**	**n**	**%**	
Age (years) (X±SD)	40.9±13.7		50.7±9.8		47.8±12.0		**0.002[a*]**
Sex							
Female	32	51.6	35	50.0	67	50.8	0.810[b]
Male	30	48.4	35	50.0	65	49.2	
BMI (kg/m^2) (X±SD)	26.23±3.96		29.39±3.96		28.15±4.10		**0.001[c*]**
Disease duration (X±SD)	14.27±10.95		4.48±4.88		7.44±8.50		**<0.001[a*]**
Medical Treatment Applied **							
Oral antidiabetic drug	7	11.3	69	98.6	76	57.6	**<0.001[b*]**
Insulin	57	91.9	7	10	64	48.5	
Insulin pump	2	3.2	-	-	2	1.5	
Diabetic diet application status							
Yes	34	54.8	18	25.7	52	39.4	**0.005[b*]**
No	28	45.2	52	74.3	80	60.6	
The state of experiencing hypoglycemia							
Yes	57	91.9	50	71.4	107	81.1	**0.012[b*]**
No	5	8.1	20	28.6	25	18.9	
Frequency of hypoglycemia							
Every day	-	-	1	2.0	1	0.9	0.419[d]
1-2 times a week	26	45.6	17	34.0	43	40.2	
3-4 times a week	12	21.1	5	10.0	17	15.9	
1 time in 15 days	15	26.3	15	30.0	30	28.0	
1 time per month	4	7.0	9	18.0	13	12.2	
Less often	-	-	3	6.0	3	2.8	
Increased food consumption during hypoglycemia treatment							
Never	-	-	1	2.0	1	0.9	0.351[d]
Sometimes	11	19.3	17	34.0	28	26.2	
Generally	39	68.4	25	50.0	64	59.8	
Always	7	12.3	7	14.0	14	13.1	

*p<0.05, [a] Mann Whitney U test, [b] Chi-square test, [c] Independent Samples t test, [d] Fisher test, BMI: Body Mass Index, ** More than one option has been ticked.

Table 2. TFEQ-R18, NEQ, and BDI scores of individuals

	Type 1 DM-PG (n:62)	Type 2 DM-PG (n:70)	p-value
	$\bar{X}$ ±SD	$\bar{X}$ ±SD	
TFEQ-R18			
Total	40.97 ± 3.74	43.18 ± 6.29	**0.030***
Cognitive restraint	16.71 ± 2.43	15.25 ± 3.13	**0.036***
Uncontrolled eating	10.99 ± 2.22	12.55 ± 3.48	**0.017***
Emotional eating	5.01 ± 2.21	5.86 ± 2.52	0.141
NEQ	17.93 ± 8.91	15.35 ± 8.19	0.150
BDI	14.10 ± 8.26	14.74 ± 7.64	0.504

*p<0.05, Mann Whitney U test, TFEQ-R18: Three Factor Eating Questionnaire, NEQ: Night Eating Questionnaire, BDI: Beck Depression Inventory.

both the Type 1 diabetes patient group (14.10±8.26) and the Type 2 diabetes patient group (14.74±7.64).

The relationship between the depression levels of individuals and their eating behaviors is examined in Table 3. For individuals in the Type 1 DM-PG, a linear, moderate, significant relationship was found between BDI scores and NEQ scores (r=0.547, p<0.001). For individuals in the Type 2 DM-PG, a moderate, inverse, significant relationship was found between BDI scores and cognitive restriction scores (r=-0.406, p=0.029).

Table 3. The relationship between individuals' depression levels and eating behaviors

	BDI			
	Type 1 DM-PG (n:62)		Type 2 DM-PG (n:70)	
	r	p-value	r	p-value
TFEQ-R18				
Total	0.058	0.647	-0.152	0.431
Cognitive restraint	-0.080	0.504	-0.406	**0.029***
Uncontrolled eating	0.041	0.721	0.072	0.712
Emotional eating	0.060	0.618	-0.168	0.385
NEQ	0.547	**<0.001***	0.332	0.073

*p<0.05, Spearman Correlation Analysis, BDI: Beck Depression Inventory, TFEQ-R18: Three Factor Eating Questionnaire, NEQ: Night Eating Questionnaire.

Some factors affecting individuals' eating behaviors are shown in Table 4. The scores obtained from BDI in individuals in both groups were found to be statistically significantly higher in those with a history of mental illness than in those without a history of mental illness (p<0.05). The NEQ scores were found to be higher in the presence of a history of mental illness in the Type 2 DM-PG compared to the absence of it (p<0.05). The total TFEQ-R18 score in both the Type 1 DM-PG and the Type 2 DM-PG was found to be statistically significantly higher in those with a history of obesity than in those without a history of obesity (p<0.05). A statistically significant difference was found in the individuals in the Type 2 DM-PG in terms of cognitive restriction and uncontrolled eating score, presence of obesity history, diabetic diet, and hypoglycemia (p<0.05).

DISCUSSION

The prevalence of depression in individuals with diabetes may vary according to gender, type of diabetes, medical condition, and current conditions[14]. In this study, in which the depression level and its effect on the eating behavior of adults diagnosed with diabetes were evaluated, the average of the scores obtained from the BDI in both the Type 1 DM-PG (14.10±8.26) and the Type 2 DM-PG (14.74±7.64) shows the mild depression level. In addition, moderate and severe depression was detected in 35% of individuals. In a study completed with 171 participants investigating the prevalence of depression symptoms in diabetes in Türkiye, it was determined that 29.2% of the patients had moderate and severe depression symptoms, similar to the results of this study[14].

Diabetic patients with depression are more prone to poor glycemic control[14]. Fluctuations in blood sugar levels are closely related to changes in mood and energy and are affected by what we eat[15]. In this case, fluctuations in HbA1c and fasting blood glucose levels are likely to be reflected in eating behavior and anthropometric measurements. After the diagnosis of diabetes, the increasing need for control over body weight and eating can be exacerbated by depression, and as a result, deterioration in eating attitudes and behaviors of patients can be observed. According to the results of this study, depression was found to be associated with NEQ and cognitive restriction behavior in individuals with diabetes, and this relationship was mediated by adherence to diet, medical treatment (using insulin), blood sugar regulation, maintaining body composition, obesity, and a history of mental illness.

In this study, a linear, moderate, and significant correlation (r=0.547, p<0.001) was found between BDI scores and NEQ scores for individuals in the Type 1 DM-PG. In addition, the higher scores obtained from the NEQ scale support this find-

Table 4. Factors affecting the eating behaviors of individuals

	BDI		NEQ		TFEQ-R18		TFEQ-R18		TFEQ-R18	
					Cognitive restraint		Uncontrolled eating		Emotional eating	
	Type 1 DM-PG	**Type 2 DM-PG**	**Type 1 DM-PG**	**Type 2 DM-PG**	**Type 1 DM-PG**	**Type 2 DM-PG**	**Type 1 DM-PG**	**Type 2 DM-PG**	**Type 1 DM-PG**	**Type 2 DM-PG**
	X̄±SD	**X̄±SD**	**X̄±SD**	**X̄±SD**	**X̄±SD**	**X̄±SD**	**X̄±SD**	**X̄±SD**	**X̄±SD**	**X̄±SD**
Sex										
Female	11.18±6.24	14.34±7.66	17.01±7.77	14.60±7.61	17.15±2.55	15.77±2.74	10.12±2.11	11.46±2.39	4.74±1.98	5.20±1.98
Male	17.41±9.57	15.14±7.70	19.29±9.01	16.11±8.78	16.22±2.30	14.74±3.45	11.32±2.17	13.66±4.05	5.00±2.30	6.51±2.84
p-value	**0.048***	0.642	0.441	0.564	0.610	0.176	0.219	**0.002***	0.710	0.063
Diabetic diet										
Yes	13.10±8.15	15.67±8.83	19.89±8.95	13.33±7.40	16.50±2.64	17.61±2.25	11.48±2.25	11.33±3.83	4.75±2.18	5.72±2.72
No	15.73±8.51	14.42±7.25	15.75±6.55	16.06±8.40	16.80±2.17	14.44±3.00	11.08±2.23	12.98±3.28	5.01±2.04	5.90±2.47
p-value	0.344	0.726	0.340	0.185	0.510	**<0.001***	0.812	**0.049***	0.715	0.688
Hypoglycemia										
Yes	14.75±8.25	15.54±8.06	16.91±8.10	16.10±8.13	16.51±2.46	14.74±2.90	10.61±2.17	13.28±3.31	4.75±1.99	5.86±2.59
No	8.20±5.81	12.75±6.20	14.15±8.02	13.50±8.26	18.52±0.70	16.55±3.41	10.05±2.70	10.75±3.32	5.98±4.23	5.85±2.39
p-value	0.299	0.211	0.210	0.084	0.165	**0.020***	0.620	**0.003***	0.720	0.921
History of obesity										
Yes	15.58±8.85	14.80±7.87	17.88±8.90	15.81±8.29	17.10±2.15	14.95±3.04	11.39±1.83	12.91±3.31	4.55±1.64	5.92±2.54
No	11.09±6.74	13.25±4.03	17.41±9.35	10.00±3.37	16.19±2.90	19.25±1.26	10.21±2.76	7.5±2.38	5.52±2.75	4.25±1.89
p-value	0.098	0.969	0.810	0.120	0.666	**0.005***	0.174	**0.004***	0.421	0.176
History of mental illnes										
Yes	25.71±10.24	21.93±8.03	24.03±11.99	20.50±8.62	16.74±2.97	14.87±4.03	10.21±0.95	12.81±5.22	4.21±1.50	6.44±3.08
No	12.14±6.43	12.61±6.12	15.06±7.11	13.83±7.48	16.73±2.40	15.37±2.86	10.85±2.32	12.48±2.84	4.85±2.18	5.68±2.34
p-value	**0.009***	**<0.001***	0.151	**0.004***	0.995	0.854	0.769	0.916	0.735	0.475

*p<0.05, Mann Whitney U test, BDI: Beck Depression Inventory, NEQ: Night Eating Questionnaire, TFEQ-R18: Three Factor Eating Questionnaire.

ing in the presence of a history of mental illness at any time in the Type 2 DM-PG. A study of 714 individuals with type 1 and 2 diabetes found that, compared to patients without night eating symptoms, those with night eating symptoms were significantly more likely to experience major depression and to eat in response to emotions (anger, sadness, loneliness, worry, and beingupset)[16].

In a study conducted on adults with type 2 diabetes, a linear, moderate and significant relationship (r=0.53, p<0.001) was found between the NES score and depressive symptoms, similar to this study[5]. In another study investigating night eating behavior in individuals with type 2 diabetes, no difference was observed in terms of depressive symptoms between those who ate at night and those who did not[6]. Low mood (especially in the evening) itself is a symptom of NES, but evening hyperphagia as well as night eating also have an effect on depressive syndromes. NES is therefore a complex syndrome that includes symptoms related to malnutrition,

sleep, and mood regulation. Since night eating increases the preference of high-carbohydrate and high-fat foods, it may cause weakening of glycemic control in individuals with diabetes mellitus, which may be reflected in eating behavior[17,18].

The interaction between mood and eating behavior is quite complex. In general, mood regulates mood by changing food selection and amount[19]. Eating behavior is key to understanding people's food choices and is associated with a variety of health outcomes. The Three Factor Eating Questionnaire (TFEQ-R18) questions individuals' cognitive restriction, uncontrolled eating, and emotional eating behaviors. Uncontrolled eating is defined as the tendency to eat more than normal due to loss of control over food consumption, and high scores are associated with overeating and obesity. Emotional eating behavior is a type of psychological eating that usually causes eating more than normal during emotional changes such as loneliness, depression, and anxiety[20,21]. Cognitive restriction behavior is defined as the tendency to consciously reduce food intake to control body weight. The main reason for cognitive restriction behavior is individuals' efforts to control their body weight[22].

When the cognitive restriction behavior is examined, it is seen that the cognitive restriction average score of the individuals in the Type 1 DM-PG (16.71±2.43) is higher than the individuals in the Type 2 DM-PG (15.25±3.13) ($p<0.05$). In a sample of adult patients with type 1 and type 2 diabetes, contrary to the findings of this study, patients with type 2 diabetes reported significantly more restrained when eating compared to patients with type 1 diabetes. It has been suggested that this condition may be the cause or consequence of their high BMI[23]. In this study it is thought that the behaviors of individuals with type 1–diabetes to consciously control their eating habits may result from the use of insulin or insulin pumps in their medical treatment and insulin restriction[24]. As a matter of fact, in a study conducted to evaluate the relationship between mood and eating behaviors and demographic and physical characteristics, treatment, biochemical profiles, and chronic comorbidities in individuals with type 2 diabetes, it was determined that insulin therapy had a positive effect on cognitive restriction[25]. In this study, an inverse, moderate, and significant correlation was found between BDI scores and cognitive restriction scores in individuals in the Type 2 DM-PG ($r=-0.406$, $p=0.029$). In a cross-sectional study examining the links between depression and eating habits, women with higher depression scores had lower cognitive restriction scores ($r=-0.141$, $p=0.022$)[26]. Cognitive restriction behavior is effective in reducing hypoglycemia in individuals with type 2 diabetes. As a matter of fact, the mean score of cognitive restriction was found to be higher in the Type 2 DM-PG who did not experience hypoglycemia (16.55±3.41) than those with hypoglycemia (14.74±2.90) ($p<0.05$). It was observed that cognitive restriction scores of individuals in the same group who did not have a history of obesity in any period of life (19.25±1.26) were higher than those with a history of obesity (14.95±3.04) ($p<0.05$). In addition, it was determined that individuals with type 2 diabetes who had higher cognitive restriction scores had higher diabetic diet adherence. On the other hand, since unsuccessful dieting can show high cognitive restriction and overeating tendencies, cognitive restriction behavior can have the opposite effect and lead to body weight gain[27]. All these findings support that optimal cognitive restriction behavior provides health benefits in preventing hypoglycemia, achieving a healthy body composition, and compliance with diet in conditions where mental health is optimal and the risk of developing depression is low in individuals with type 2 diabetes.

In this study, the mean uncontrolled eating score of the individuals in the Type 2 DM-PG (12.55±3.48) was found to be higher than the individuals in the Type 1 DM-PG (10.99±2.22) ($p<0.05$). In a study conducted on individuals with diabetes, it was found that the diet disinhibition scores of individuals with type 2 diabetes, which means decreased or lost control over eating, were higher than those with type 1 diabetes, but the difference was not statistically significant ($p=0.18$)[23]. In this study, no significant relationship was found between BDI scores and uncontrolled eating scores for individuals in both the Type 1 diabetes patient group and the Type 2 diabetes patient group ($p>0.05$). Similar to the finding in this study, no correlation was found between depression scores and uncontrolled eating behavior in a cross-sectional study ($n=400$)[26]. In this study, 74.3% of the individuals in the Type 2 DM-PG did not follow a diabetic diet, and it was found that the uncontrolled eating scores of those who do not follow a diabetic diet (12.98±3.28) were found to be higher than those who follow a diabetic diet (11.33±3.83) ($p<0.05$). In addition, uncontrolled eating scores of individuals in the Type 2 DM-PG who experienced hypoglycemia (13.28±3.31) were found to be higher than those who did not experience hypoglycemia (10.75±3.32) ($p<0.05$). These findings supports the importance of diet in the regulation of blood sugar in individuals with type 2 diabetes. The fact that individuals with type 2 diabetes with a history of obesity have higher uncontrolled eating scores than those without a history of obesity is an indicator of the high risk of obesity and the possibility of recurrence in these individuals[28,29].

CONCLUSIONS

In this study, it was tried to determine the factors that may cause eating disorders, including diabetes history and management in individuals diagnosed with diabetes. It has been determined that the effect of mental illness and obesity history on current eating behavior in diabetic patients may be on night eating behavior, cognitive restriction, and uncontrolled eating. In addition, it was found that there was a linear relationship between the degree of depression and night eating behavior, and an inverse relationship between the degree of depression and cognitive restriction. It is likely that compliance with the diabetic diet and prevention of hypoglycemia will be reflected in eating behavior and anthropometric measurements.

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Aplicación de nisina y lactobacillus plantarum como bioconservantes en salchicha a partir de dos especies de pescados: tilapia *(Areochromis niloticus)* y paiche *(Arapaima gigas)*

Application of nisin and lactobacillus plantarum as biopreservatives in sausage from two species of fish: tilapia *(Areochromis niloticus)* and paiche *(Arapaima gigas)*

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RESUMEN

Introducción: La producción de salchichas de pescado enfrenta retos microbiológicos y de estabilidad. Estos desafíos son cruciales debido a las crecientes preocupaciones sobre la seguridad alimentaria.

Objetivo: Evaluar la aplicación de nisina y lactobacillus plantarum como bioconservantes en salchicha a partir de dos especies de pescados: tilapia *(Areochromis niloticus)* y paiche *(Arapaima gigas).*

Métodos: Se utilizó un diseño completamente al azar (DCA) con arreglo factorial A*B, donde el Factor A corresponde a los bioconservantes y el Factor B a las especies de pescado. Para determinar diferencias en las medias de los tratamientos, se aplicó la prueba de rangos múltiples de Tukey ($p<0.05$). Se evaluaron características fisicoquímicas (pH, humedad, ceniza, proteína y grasa) y la calidad microbiológica del producto final.

Resultados: En cuanto a la caracterización fisicoquímica, se observó una diferencia significativa ($p<0,05$) en función de la especie de pescado y el tipo de bioconservante utilizado. Los valores de pH se encontraron entre 5,50 y 6,81. Además, al incorporar *Lactobacillus plantarum*, se registró una reducción en los contenidos de humedad y ceniza, alcanzando valores de 19,30% y 2,01%, respectivamente. Por otro lado, el contenido de grasa y proteína estuvo influenciada por la especie utilizada, determinando que las muestras que se empleó Oreochromis niloticus mostraron un mayor contenido de proteína (10,55% - 11,90%) y grasa (15,15%.). En relación a la calidad microbiológica, tanto la nisina como *Lactobacillus plantarum* inhibieron significativamente los micoorganismos patógenos en comparación con las muestras sin bioconservantes.

Conclusiones: El tipo de pescado y los bioconservantes impactan significativamente la calidad de los embutidos. Los elaborados con *Oreochromis niloticus* sin bioconservantes presentaron pH y humedad elevados, mientras que *Lactoba-*

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cillus plantarum y nisina mejoraron la estabilidad del producto. La tilapia mostró mayor contenido proteico y graso que el paiche, y ambos bioconservantes inhibieron el crecimiento bacteriano

PALABRAS CLAVE

Alimentos funcionales, calidad microbiológica, embutidos, innovación proteica, tecnología alimentaria.

ABSTRACT

Introduction: The production of fish sausages faces microbiological and stability challenges. These challenges are crucial due to increasing concerns about food safety

Objective: To evaluate the application of nisin and *Lactobacillus plantarum* as biopreservatives in sausage from two fish species: tilapia (*Oreochromis niloticus*) and paiche (*Arapaima gigas*).

Methods: A completely randomized design (CRD) with an A*B factorial arrangement was used, where Factor A corresponds to the biopreservatives and Factor B to the fish species. To determine differences in the treatment means, Tukey's multiple range test was applied ($p<0.05$). Physicochemical characteristics (pH, moisture, ash, protein, and fat) and the microbiological quality of the final product were evaluated.

Results: Regarding the physicochemical characterization, a significant difference ($p<0.05$) was observed depending on the fish species and the type of biopreservative used. The pH values were between 5.50 and 6.81. In addition, by incorporating *Lactobacillus plantarum*, a reduction in moisture and ash content was recorded, reaching values of 19.30% and 2.01%, respectively. On the other hand, the fat and protein content was influenced by the species used, determining that the samples in which *Oreochromis niloticus* was used showed a higher protein content (10.55% - 11.90%) and fat (15.15%). In relation to microbiological quality, both nisin and *Lactobacillus plantarum* significantly inhibited pathogenic microorganisms compared to samples without biopreservatives.

Conclusions: Fish type and biopreservatives significantly impact sausage quality. Sausages made with *Oreochromis niloticus* without biopreservatives had high pH and moisture, while *Lactobacillus plantarum* and nisin improved product stability. Tilapia had higher protein and fat content than paiche, and both biopreservatives inhibited bacterial growth.

KEY WORDS

Functional foods, microbiological quality, sausages, protein innovation, food technology.

INTRODUCCIÓN

La elaboración de salchichas de pescado enfrenta desafíos específicos relacionados con la microbiología y la estabilidad del producto. Estos retos requieren atención particular, dado que la seguridad alimentaria es una preocupación creciente entre los consumidores. La incorporación de bioconservantes emerge como una solución efectiva para mitigar estos problemas, contribuyendo a la seguridad y calidad del producto final[1]. A medida que los consumidores se muestran cada vez más reacios a los aditivos químicos, el campo de la bioconservación ha ganado impulso, promoviendo estudios sobre el uso de bacterias beneficiosas y sus metabolitos como antimicrobianos naturales. Este enfoque no solo extiende la vida útil de los alimentos, sino que también mejora la seguridad alimentaria[2].

Tradicionalmente, los compuestos sintéticos han sido utilizados como conservantes para prolongar la vida útil de los productos alimenticios. Sin embargo, estos aditivos están sujetos a estrictas regulaciones debido a preocupaciones sobre su toxicidad y efectos adversos en la salud[3]. Ante la creciente demanda de alimentos seguros y de alta calidad, es crucial explorar alternativas efectivas y no tóxicas para frenar el deterioro. Los conservantes naturales ofrecen ventajas significativas, como baja toxicidad ambiental, alta solubilidad en agua, estabilidad térmica y un amplio espectro antimicrobiano[4]. En este contexto, los bioconservantes han surgido como una opción prometedora para prolongar la vida útil de los productos cárnicos, reduciendo así la necesidad de conservantes sintéticos[5].

La bioconservación es una técnica que permite extender la vida útil de los alimentos mediante el uso de microbiota natural o controlada, así como de antimicrobianos[6]. Este proceso implica la selección de productos de fermentación y bacterias beneficiosas para controlar el deterioro y desactivar patógenos[7]. Entre los organismos de interés, las bacterias del ácido láctico (BAL) y sus metabolitos juegan un papel crucial en esta técnica, ofreciendo soluciones eficaces para la conservación de alimentos[5].

Un ejemplo notable es la nisina, un péptido antimicrobiano producido por *Lactococcus lactis*, que ha demostrado eficacia en la inhibición del crecimiento de microorganismos patógenos y de deterioro en salchichas frescas[8]. Este compuesto no solo facilita el control de las bacterias responsables del deterioro, sino que también preserva las características sensoriales del alimento. Es importante mencionar que la concentración máxima aprobada de nisina en embutidos no debe superar los 276 ppm en el producto terminado[9].

Por otro lado, *Lactobacillus plantarum* es una de las bacterias lácticas más utilizadas en la producción de productos cárnicos y vegetales fermentados. Se han identificado varias bacteriocinas producidas por *L. plantarum*, entre ellas plantaricina A, B y C, así como otras variantes[10]. Además,

el uso de pescado en la elaboración de embutidos, especialmente en forma de salchichas, representa una alternativa nutritiva y rica en proteínas[11]. Las especies de tilapia (*Oreochromis niloticus*) y paiche (*Arapaima gigas*) destacan por su alta disponibilidad y valor nutricional, convirtiéndolas en materias primas ideales para la producción de estos productos cárnicos.

La tilapia (*O. niloticus*) es uno de los peces de agua dulce más cultivados en el mundo, particularmente en Asia y América Latina, debido a su fácil cultivo, rápida tasa de crecimiento y alto valor nutricional. En 2023, la producción global de tilapia superó los 4,2 millones de toneladas, representando el 8% de la producción total de acuicultura mundial; de esta cantidad, más de 1,6 millones de toneladas se produjeron en China[12]. Por su parte, el paiche (*A. gigas*), una de las especies de peces de agua dulce más grandes del mundo, tiene una distribución natural que abarca varios países sudamericanos y posee un gran valor cultural e histórico para la región amazónica[6].

En este contexto, la presente investigación tiene como objetivo evaluar la aplicación de nisina y *Lactobacillus plantarum* como bioconservantes en la elaboración de salchichas a partir de las especies de pescado tilapia (*Oreochromis niloticus*) y paiche (*Arapaima gigas*).

MATERIALES Y MÉTODOS

Materia prima

Las materias primas utilizadas en esta investigación fueron seleccionadas de diversas localidades ecuatorianas. La tilapia (*Oreochromis niloticus*) se adquirió en el mercado de mariscos del cantón Quevedo, en la provincia de Los Ríos, mientras que el paiche (*Arapaima gigas*) provino de la Asociación de Paiche "ASOARAPAIMA", ubicada en el cantón Lago Agrio, en Sucumbíos. Por otro lado, la nisina y *Lactobacillus plantarum* fueron obtenidos de la Universidad de las Fuerzas Armadas (ESPE), situada en el kilómetro 24 de la vía Santo Domingo.

El desarrollo del estudio se estructuró en dos fases. La primera consistió en la elaboración de las salchichas, que se llevó a cabo en las instalaciones de la Universidad de las Fuerzas Armadas (ESPE). La segunda fase incluyó los análisis microbiológicos y fisicoquímicos, realizados en los laboratorios de química y bromatología del Campus "La María" de la Universidad Técnica Estatal de Quevedo, ubicada en el cantón Mocache, kilómetro 7 de la vía Quevedo – El Empalme.

Análisis estadístico

Se empleó un diseño completamente al azar (DCA) con arreglo factorial A*B siendo: Factor A = Tipos de bioconservantes (Nisina; *Lactobacillus plantarum* y sin bioconservantes) y Factor B = Tipos de pescados (tilapia *(O. niloticus)* y paiche *(A. gigas)*) con tres repeticiones. Para el análisis estadístico, se utilizó la prueba de Tukey con un nivel de significancia de ($p \leq 0.05$), empleando los softwares estadísticos "STATGRAPHICS" y "STATISTICA" para procesar los datos obtenidos.

Tabla 1. Combinación de los Tratamientos que intervienes en la elaboración de salchicha

N.º	DESCRIPCIÓN
T1	*Nisina* + Tilapia
T2	*Nisina* + Paiche
T3	*Lactobacillus plantarum* + Tilapia
T4	*Lactobacillus plantarum* + Paiche
T5	Sin bioconservantes + Tilapia
T6	Sin bioconservantes + Paiche

Manejo experimental

Se receptaron las carnes de pescado de las especies de la tilapia y paiche, junto con la grasa de cerdo, que debe ser consistente y sustanciosa. Además, se pesaron los ingredientes necesarios para la elaboración, como se detalla en la tabla 2. Una vez pesado, se cortaron la carne de pescado en trozos de 15 mm y la grasa de cerdo en cubos de 20 mm. En

Tabla 2. Ingredientes empleados en la formulación de la elaboración de la salchicha a base carne de pescado tilapia (*O. niloticus*) y paiche (*A. gigas*)

Ingredientes	Cantidad (g)
Carne de pescado	300
Grasa de cerdo	96
Proteína de soja	18
Hielo	144
Sal nitrito	1,80
Tripolifosfato	1,20
Glutamato monosódico	1
Sal de mesa	6
Ácido ascórbico	1,20
Almidón de maíz	37,80
Humo liquido	0,80
Condimento de salchicha	7,80

la fase de cuterado o mezclado, se añadieron los ingredientes de manera gradual hasta lograr una masa homogénea. Posteriormente, esta mezcla se embutió en tripa angosta (artificial) de 30 mm. A continuación, se inicia el proceso de escaldado, que se realiza en una olla o tina de cocción de acero inoxidable durante 5 minutos a 90 °C, asegurando que la temperatura interna de la salchicha alcance los 75 °C. Transcurrido el tiempo de cocción las salchichas son enfriadas por 3 min a 24 °C. Finalmente las salchichas son empacadas al vacío y conservadas en temperaturas <10°C.

Caracterización fisicoquímica de la salchicha a partir de dos especies de pescados: tilapia (Oreochromis niloticus) y paiche (Arapaimas gigas) y distintos bioconservantes

Los contenidos de humedad, ceniza, proteína y grasa se determinaron siguiendo los métodos establecidos por la Asociación Oficial de Químicos Analíticos (AOAC): humedad se determinó por secado en estufa a 110 °C[13], cenizas mediante incineración en mufla[14], proteína empleando Kjeldahl[15], el contenido lipídico[16], mientras que, para el contenido de pH se obtuvo mediante potenciómetro siguiendo la metodología de la Norma Técnica Ecuatoriana NTE INEN 1338:2011[17].

Calidad microbiológicos de la salchicha a partir de dos especies de pescados: tilapia (Oreochromis niloticus) y paiche (Arapaimas gigas) y distintos bioconservantes

La determinación de *E. coli, aerobios mesófilos totales, mohos y levadura* se se realizó siguiendo la metodología establecida en la Norma Técnica Ecuatoriana NTE INEN 1338:2012[18].

RESULTADOS

En la Figura 1 se presentan los resultados obtenidos para la variable pH en los diferentes tratamientos. El valor más alto se registró en los embutidos elaborados con *O. niloticus* sin bioconservantes (T5), alcanzando un pH de 6,81. Por otro lado, el valor más bajo se encontró en las muestras de *A. gigas* en las que se utilizó *Lactobacillus plantarum* como bioconservante con un pH de 5,50.

El contenido de humedad en los embutidos de pescado es un factor crucial que influye significativamente en su calidad y conservación ($p<0,05$). En este estudio, se observó que los embutidos elaborados a partir de dos especies de pescado que no recibieron tratamiento con bioconservantes mostraron niveles de humedad notablemente superiores, variando entre 60,00 % y 62,37 % (figura 2). A diferencia de las muestras que se incorporó *Lactobacillus plantarum* presentaron un porcentaje de humedad considerablemente reducido, oscilando entre 19,30 % y 19,60 %. Esta disminución en la humedad indica que el uso de *Lactobacillus plantarum* no solo mejora la conservación de los productos, sino que también puede prolongar su vida útil al inhibir el crecimiento de microorganismos no deseados.

En cuanto al porcentaje de ceniza (figura 3), se observó que tanto la especie de pescado como el tipo de bioconservante tienen una influencia significativa ($p<0,05$) en este parámetro. En particular, se encontró que el uso de nisina como bioconservante en los embutidos elaborados con tilapia *(Oreochromis niloticus)* incrementa el contenido de ceniza hasta un 2,86 %. Por otro lado, la combinación de *Lactobacillus plantarum* + Paiche mostró una reducción considerable del contenido de ceniza alcanzando un valor de 2,01%.

En la Figura 4 se presentan los resultados del contenido de proteína, donde se evidenció que la especie de pescado tiene un impacto significativo ($p<0,05$) en este parámetro. Los embutidos elaborados con tilapia *(Oreochromis niloticus)* mostraron un mayor contenido de proteína, con valores que oscilaron entre 10,55 % y 11,90 %. Por otro lado, los embutidos elaborados con paiche presentaron valores inferiores, que variaron entre 9,40 % y 10,50 %.

En el análisis de la composición grasa (Figura 5), se observó que los tratamientos elaborados con tilapia nisina como bioconservante exhibieron un contenido graso notablemente más alto, alcanzando un 15,15 %. Este valor es significativamente superior ($p<0,05$) en comparación con las muestras de paiche *(Arapaima gigas),* que presentaron un contenido graso inferior (10 %). Es importante destacar que los embutidos que no incorporaron bioconservantes mostraron una tendencia inferior. Estos resultados demostraron que la utilización de tilapia y nisina no solo contribuye a mejorar la calidad del producto, sino que también influye en el perfil nutricional.

Calidad microbiológicos de la salchicha a partir de dos especies de pescados: tilapia (Oreochromis niloticus) y paiche (Arapaimas gigas) y distintos bioconservantes

En la Tabla 3 se muestran los resultados microbiológicos obtenidos de los diferentes tratamientos aplicados. Se observó que las muestras que incorporaron nisina como bioconservante presentaron una notable reducción en la presencia de microorganismos patógenos. Por otro lado, las muestras que no utilizaron bioconservante mostraron contaminación por *E. coli, Salmonella,* así como la presencia de mohos y levaduras. Así como también, existió mayor presencia de aerobios mesófilos ($7,19x10^6$). Estos resultados resaltan la efectividad de la nisina en la inhibición del crecimiento microbiano y su potencial como una herramienta crucial para mejorar la seguridad microbiológica de los productos alimentarios.

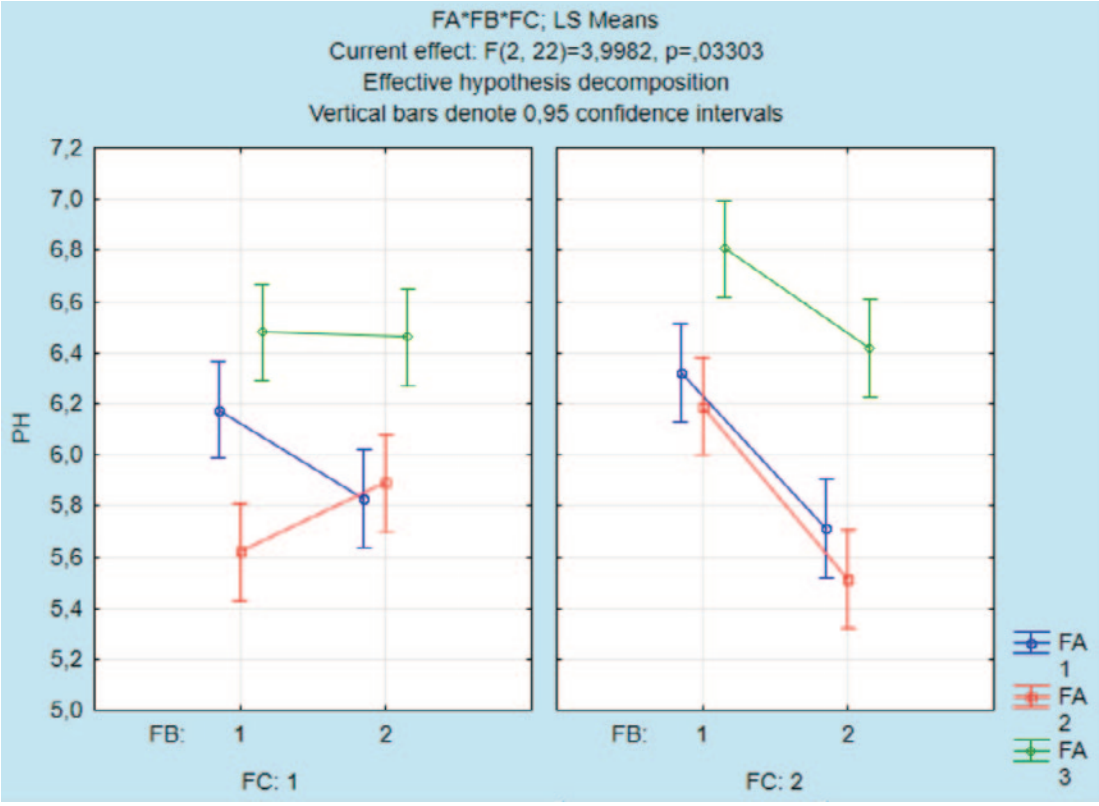

Figura 1. Resultados de pH en embutidos elaborados con dos especies de pescado y diferentes bioconservantes

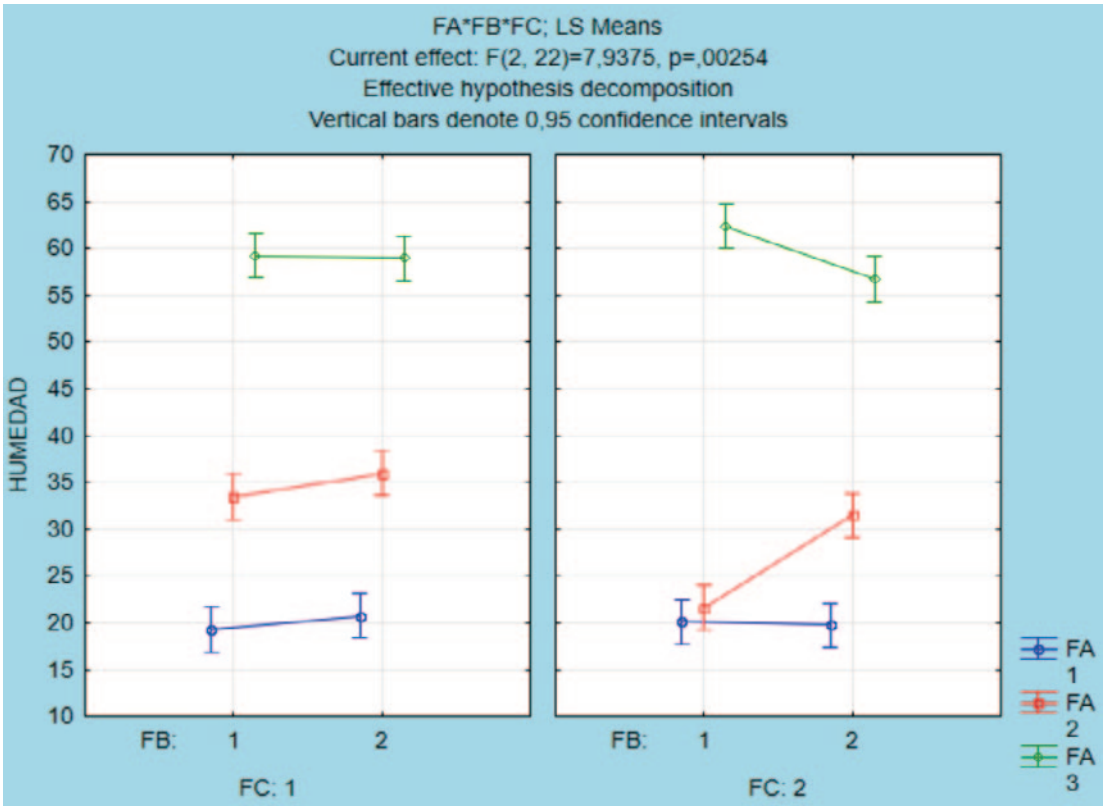

Figura 2. Resultados de humedad en embutidos elaborados con dos especies de pescado y diferentes bioconservantes

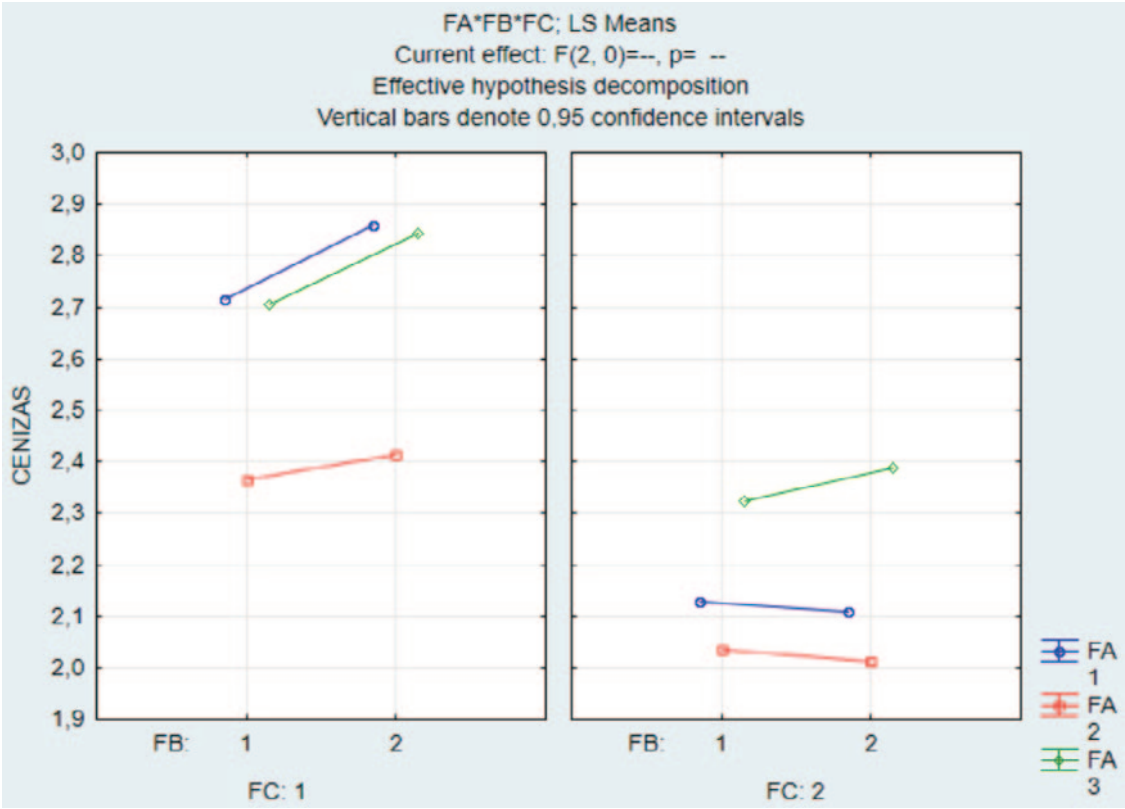

Figura 3. Resultados de ceniza en embutidos elaborados con dos especies de pescado y diferentes bioconservantes

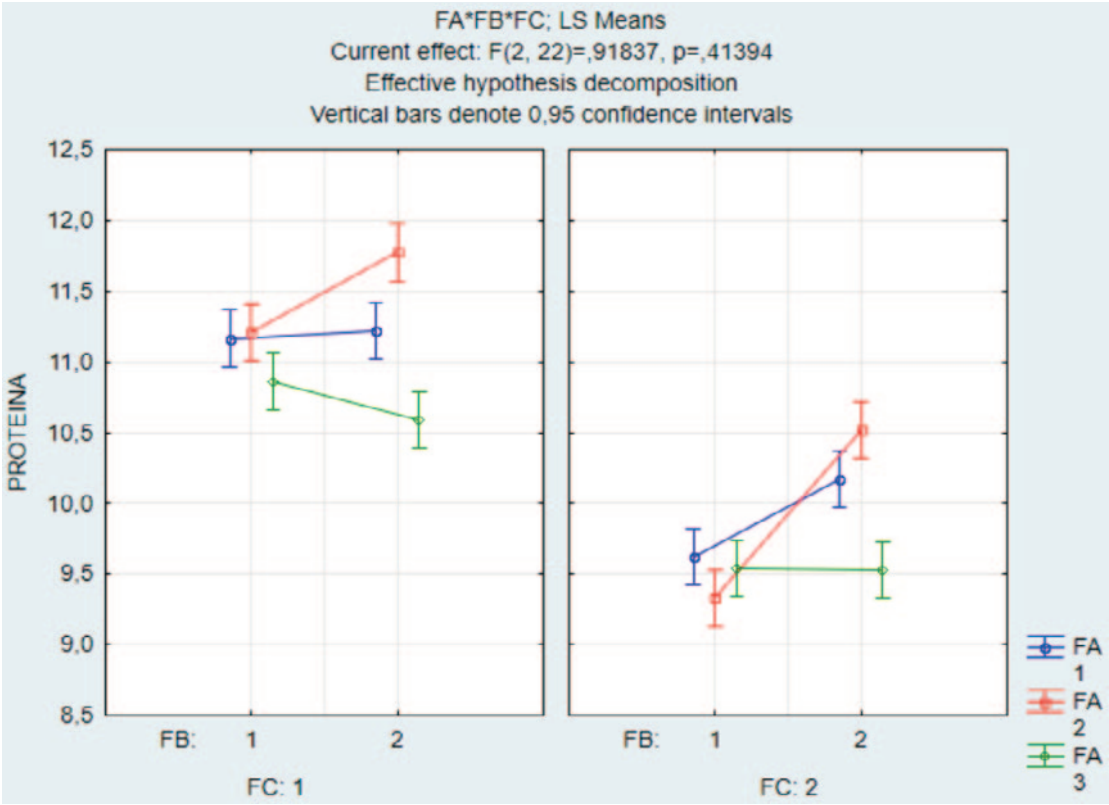

Figura 4. Resultados de proteina en embutidos elaborados con dos especies de pescado y diferentes bioconservantes

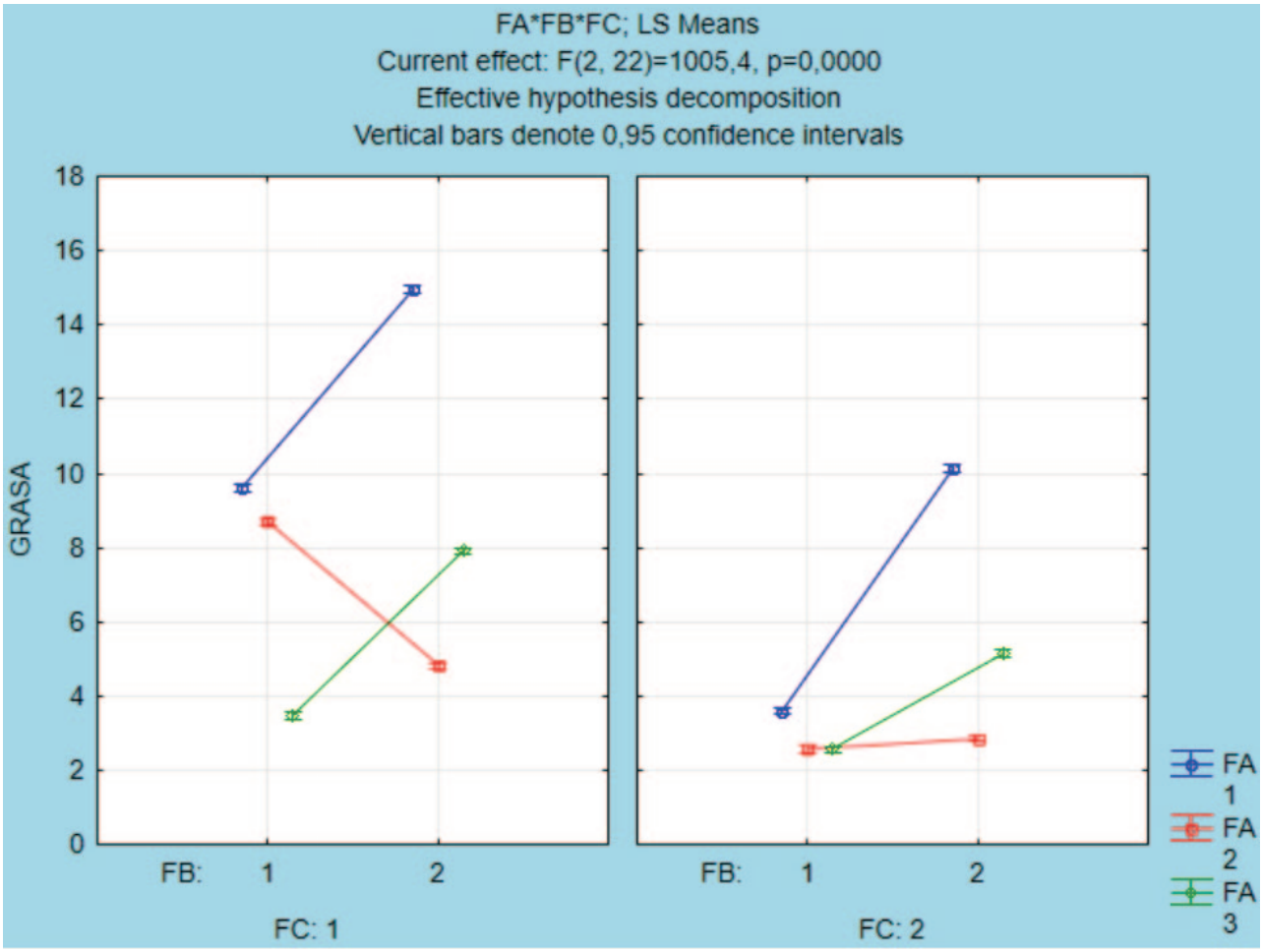

Figura 5. Resultados de grasa en embutidos elaborados con dos especies de pescado y diferentes bioconservantes

Tabla 3. Prueba de significación (Tukey P<0,05) para resultados de análisis microbiológicos

Tratamientos	E. Coli	Salmonella	Mohos y levaduras	Aerobios mesófilos
T1	Ausencia	Ausencia	Ausencia	$2{,}36x10^{6\ A}$
T2	Ausencia	Ausencia	Ausencia	$2{,}40x10^{6\ A}$
T3	Ausencia	Ausencia	Ausencia	$5{,}45x10^{6\ B}$
T4	Ausencia	Ausencia	Ausencia	$5{,}34x10^{6\ B}$
T5	< 1,0 UFC	< 1,0 UFC	< 1,0 UFC	$7{,}19x10^{6\ C}$
T6	< 1,0 UFC	< 1,0 UFC	< 1,0 UFC	$7{,}13x10^{6\ C}$

DISCUSIÓN

Caracterización fisicoquímicos de la salchicha a partir de dos especies de pescados: tilapia *(Oreochromis niloticus)* y paiche *(Arapaimas gigas)* y distintos bioconservantes.

En estudios previos que emplearon bacterias ácido lácticas (BAL), se registraron valores de pH de 6,30 para *Lactobacillu* y 6,33 para *Streptococcus,* en relación con la inhibición microbiológica en tilapia roja *(Oreochromis sp.)*[19]. Mientras que, al emplear nisina como encapsulado en truchas arcoíris *(Oncorhynchus mykiss)* presentaron un valor de 6,0 indicando su efectividad[20].

Por otro lado, al emplear diferentes variedades de pescado como boca colora *(Haemulon spp),* macabí *(Elops saurus)* y blanco pobre *(Pinirampus pinirampu)* en elaboración de chorizos obtuvieron un contenido de humedad del 59,78 %, valor que se encuentra dentro del rango de la presente investigación[21]. Mientras que, al utilizar base de nile tilapia (*Oreochromus niloticus)* en elaboración de mortadela obtuvieron valores entre 56.73 % - 63.63 %. Los resultados en-

contrados en esta investigación demuestran que el empleo de las BAL tiene influencia significativa[22].

Los contenidos de cenizas presentados guardan relación a estudios previos de elaboración de embutido a base de sable (*Trichiurus lepturus*) donde presentaron valores que oscilaron 2,78 % a 2,89 %[23]. El uso de las BAL constituye una herramienta importante, debido a que mejora su calidad fisicoquímica y microbiológica al tiempo que reduce el uso de conservantes y aditivos artificiales[24].

El alto contenido proteico en las salchichas de pescado se atribuye principalmente a la especie utilizada. En este sentido, la tilapia destaca por su notable contenido de proteína, que oscila entre el 20,00% y el 26,00%. Por otro lado, los filetes de paiche presentan un contenido proteico menor, que varía entre el 15,00 % y el 20,86 %[25,26]. Además, investigaciones previas sobre la elaboración de embutidos a partir de *Oncorhynchus mykiss* han demostrado que, al emplear conservantes naturales como el laurel *(Laurus nobilis L.),* el contenido de proteína en los productos finales se sitúa entre 18,06 % y 18,25 %[27].

El contenido de grasa en las salchichas elaboradas con tilapia fue superior al de las producidas con paiche. No obstante, estos resultados son más altos que los reportados en investigaciones anteriores, donde se determinó un contenido lipídico entre 2,56 % y 2,73 % en salchichas tipo frankfurter elaboradas con desechos de filete de tilapia roja *(Oreochromis sp.)* y harina de quinua *(Chenopodium quinoa W.)*[28]. Además, estudios previos han demostrado que el contenido de grasa varía según el corte de pescado; en este caso, el lomo de paiche presenta un 5,31 % de grasa, mientras que el vientre muestra un porcentaje significativamente más alto, alcanzando el 16,69 %[29].

Calidad microbiológicos de la salchicha a partir de dos especies de pescados: tilapia (Oreochromis niloticus) y paiche (Arapaimas gigas) y distintos bioconservantes

Los resultados microbiológicos evidencian que los bioconservantes tienen un impacto positivo en la calidad microbiológica de los tratamientos aplicados. En particular, la nisina mostró un efecto notable, similar al observado en el estudio de Liu *et al.* (2022), en el que se utilizó una combinación de nisina en partículas vivas, polisacáridos de *Tremella fuciformis* y *Lactobacillus plantarum* como conservante en embutidos fermentados, logrando así inhibir la carga microbiana en las muestras[30]. Además, otros estudios han corroborado la efectividad de los bioconservantes en la inhibición del crecimiento bacteriano. En un estudio se demostró que al aplicar quitosano microbiano extraído de *Aspergillus brasiliensis* como conservante en salchichas de pescado, las muestras de control mostraron un aumento en el recuento microbiano a medida que se prolongaba el periodo de almacenamiento, mientras que las muestras tratadas con quitosano presentaron una reducción significativa en la carga microbiana, en función del tiempo[31].

CONCLUSIONES

La investigación sobre embutidos elaborados con *Oreochromis niloticus* y Arapaima gigas, combinados con bioconservantes, resalta la importancia de estos aditivos en la mejora de la calidad físico-química y microbiológica de los productos. Los resultados muestran que el uso de *Lactobacillus plantarum* y nisina no solo optimiza el pH y reduce la humedad, sino que también aumenta la durabilidad del producto al inhibir microorganismos indeseables. Además, se observan diferencias significativas en el contenido de ceniza y proteína entre las especies de pescado, destacando el valor nutricional superior de la tilapia. La efectividad de la nisina en la reducción de patógenos resalta su potencial para mejorar la seguridad alimentaria. En conclusión, estos resultados indican que la aplicación de bioconservantes puede ser clave para la industria alimentaria, no solo para la calidad sensorial y nutricional, sino también para la seguridad de los embutidos de pescado.

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Trastorno de adicción al internet asociado a la composición corporal en estudiantes de la Universidad Nacional del Centro del Perú en la Sierra Central de Perú

Internet addiction disorder associated with body composition in students of the National University of Central Peru in the Central Highlands of Peru

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RESUMEN

Introducción: El trastorno de adicción al internet se ha convertido en una patología emergente con un impacto significativo en la conducta, salud física y mental, contribuyendo al desarrollo de enfermedades crónicas relacionadas con la nutrición.

Objetivo: Evaluar la asociación entre el trastorno de adicción al internet y la composición corporal en estudiantes de la Universidad Nacional del Centro del Perú (UNCP).

Materiales y métodos: Se realizó un estudio observacional, analítico, y transversal en estudiantes de la UNCP, entre 16 y 27 años, seleccionados mediante muestreo probabilístico aleatorio. Se evaluó la composición corporal medida a través de antropometría, y el trastorno de adicción al internet usando la Escala de Adicción al Internet (EAIL). Para evaluar la asociación, se estimaron las Razones de Prevalencia (RP) crudos y ajustados con sus respectivos intervalos de confianza al 95%.

Resultados: Se realizó un estudio en 372 estudiantes universitarios, donde se encontró que el 52.4% presentaron trastorno de adicción al internet. Respecto a la antropometría, se mostraron diferencias significativas en el pliegue tricipital. A través del análisis de regresión de Poisson modificado, un IMC compatible con bajo peso/sobrepeso/obesidad (RP: 5,3; IC 95%: 3,1 - 8,9), un perímetro abdominal de riesgo incrementado a alto riesgo (RP: 2,6; IC 95%: 1,6 - 4,3) y un pliegue tricipital alto/bajo (RP: 1,3; IC 95%: 1,0 - 1,7) estuvieron asociados con una mayor prevalencia de trastorno de adicción al internet. Por otro lado, un pliegue escapular bajo/alto estuvo asociado con una menor prevalencia (RP: 0,8; IC 95%: 0,7 - 1,0).

Conclusiones: Existe una asociación significativa entre la composición corporal con el trastorno de adicción al Internet en estudiantes universitarios de la UNCP. Tanto hombres como mujeres con trastorno de adicción al internet presentaron altos niveles de grasa en diversas mediciones, destacando la importancia de intervenciones para mejorar la salud de los estudiantes.

PALABRAS CLAVE

Salud mental, Conducta adictiva, Antropometría, Índice de Masa Corporal, Estudiantes universitarios.

ABSTRACT

Introduction: Internet addiction disorder has become an emerging pathology with a significant impact on behavior, physical and mental health, contributing to the development of chronic diseases related to nutrition.

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Objective: To evaluate the association between internet addiction disorder and body composition in students of the National University of Central Peru (UNCP).

Materials and methods: An analytical, observational and cross-sectional study was carried out on UNCP students, between 16 and 27 years old, selected through random probabilistic sampling. Body composition measured through anthropometry was evaluated, and Internet addiction disorder was evaluated using the Internet Addiction Scale (EAIL). To evaluate the association, crude and adjusted Prevalence Ratios (PR) were estimated with their respective 95% confidence intervals.

Results: A study was carried out on 372 university students, with a percentage of 66.1% women and 33.9% men, with a median age of 20 years. The results showed that 52.4% presented internet addiction disorder. For body composition, significant differences were shown in the triceps fold. Furthermore, the bicipital fold in women was greater (14.93 mm ± 5.71) compared to men (12.99 mm ± 6.47). On the other hand, the percentage of body fat in women (27.51% ± 5.27) was higher than that found in men (18.47% ± 5.76). There is a significant relationship between Internet addiction disorder and body composition, since a BMI PR of 5.25 means that young people with Internet addiction disorder are almost five times more likely to be underweight, overweight and obesity.

Conclusions: There is a significant association between body composition and Internet addiction disorder in UNCP university students. Both men and women presented high levels of fat in various measurements, highlighting the importance of interventions to improve the health of students.

KEYWORDS

Mental health, Addictive behavior, Anthropometry, Body Mass Index, College students.

INTRODUCCIÓN

En el mundo los problemas relacionados con la alteración de la composición corporal de las personas; como el sobrepeso, la obesidad y la desnutrición han constituido un inconveniente grave de salud pública. Según la Organización Mundial de la Salud (OMS), una de cada ocho personas en el mundo era obesa. Desde 1990, la obesidad se ha duplicado con creces entre los adultos de todo el mundo y se ha cuatriplicado entre los adolescentes. En ese mismo año, 2500 millones de adultos (46%) tenían sobrepeso y de ellos, 890 millones (16%) eran obesos. Estas cifras se vienen incrementando de forma alarmante principalmente en países que se encuentran en vía de desarrollo[1].

Por otro lado, las personas con obesidad y sobrepeso son aquellas que son más propensas de presentar otras enfermedades crónicas no trasmisibles (ECNT) tales como las enfermedades cardiovasculares (ECV), diabetes tipo 2, hipertensión arterial, entre otros. Según la OMS estas enfermedades son la principal causa de discapacidad y muerte en el mundo actualmente. Se prevé que 7 millones de personas perderán la vida a causa de dichas enfermedades para el año 2030[2].

En el Perú según el Instituto Nacional de Estadística e Informática (INEI), la obesidad tuvo una tendencia creciente en los últimos nueve años, incrementándose de 21% en 2017 a 25,6% en 2022, es decir, un aumento de 4,6 puntos porcentuales. Por otro lado, la obesidad y el sobrepeso afectan tanto a hombres como a mujeres, en el año 2022 el 29,8% de las mujeres presentaron obesidad mientras que en los varones el 21,2% lo presentaron, mientras que el 36,6% de las mujeres presentaron sobrepeso y en varones el 38,5%[3].

Según Cía[4], el uso de internet está cada vez más difundido en el mundo globalizado en el que vivimos. Aunque esta herramienta en un principio nos permite hacer mejoras en nuestro día a día, utilización con fines recreativos excesiva y persistente puede conducir a una adicción. De hecho, su importancia clínica y epidemiológica la sitúa como una de las patologías emergentes de mayor impacto en el siglo actual. Por ello las personas que sufren adicción a internet se caracterizan por tiempos de conexión muy prolongados con fines recreativos a lo largo de cada día. Esto puede llevarlos a descuidar otras áreas importantes de su vida como el trabajo, las relaciones sociales, la alimentación, el descanso, entre otros. Por ende, desencadenaría problemas en la salud física del individuo.

En base a dichos estudios se considera que el trastorno de adicción al Internet causa gran daño en el ritmo de vida de las personas, no solo afectando su salud mental, sino también sus estilos de vida, su alimentación y su composición corporal, de los mismos y de las personas que los rodean. Como indicó Estrada et al. El uso excesivo de internet entre los estudiantes universitarios aumenta el riesgo de adicción al internet y sus consecuencias negativas relacionadas. Una de las mayores consecuencias son las vinculadas con la nutrición, los cambios en los sistemas de alimentación, los patrones de trabajo y recreación, la dieta y la actividad física, que conlleva a las enfermedades crónicas como el sobrepeso, obesidad, diabetes, hipertensión, entre otros en los países más pobres[5].

OBJETIVOS

El objetivo de la presente investigación fue determinar la asociación entre el trastorno de adicción al internet y la composición corporal en los estudiantes universitarios de la Universidad Nacional del Centro del Perú (UNCP) de la región peruana de Junín.

MATERIALES Y MÉTODOS

Tipo de estudio y muestra

Estudio observacional analítico, transversal efectuado en 372 estudiantes universitarios de la Universidad Nacional del Centro del Perú. La población fue seleccionada por un muestreo probabilístico aleatorio y compuesta por estudiantes universitarios entre 16 y 27 años de edad matriculados en el periodo 2023 – 2024 en la UNCP.

Tamaño de muestra

La población del estudio estuvo conformada por un total de 10,937 estudiantes de la UNCP, de los cuales se seleccionó una muestra de 372 estudiantes universitarios. El tamaño de la muestra se determinó con un intervalo de confianza del 95%, según la aplicación OpenEpi.

Colecta de datos

Se solicitó permiso a la Dirección General de Administración de la Universidad Nacional del Centro del Perú para la ejecución del presente trabajo dentro de sus instalaciones en forma de campaña.

Asimismo, se solicitó el consentimiento informado a cada uno de los estudiantes, a quienes previamente se les brindó información sobre el propósito del estudio y los procedimientos a realizar, y voluntariamente decidieron participar en dicho estudio. Este consentimiento fue elaborado en base a la Declaración de Helsinki como una propuesta de principios éticos que sirven para orientar al personal de salud y a otras personas que realizan investigación médica en seres humanos[6].

Seguido a ello, se aplicó la recopilación de información, que fue realizada por el equipo de investigación, quienes están capacitadas en el uso de métodos y técnicas de recolección de información sobre antropometría y la Escala de la Adicción a Internet de Lima (EAIL)[7].

Variables de estudio

Para fines de este estudio, se consideró como variable dependiente la presencia de Trastorno de Adicción al Internet (TAI) en el participante. Por otro lado, se consideraron como variables independientes al sexo, facultad, edad, talla, peso, Índice de Masa Corporal (IMC), perímetro abdominal y braquial, pliegue subescapular, pliegue suprailíaco, pliegue tricipital, pliegue bicipital, porcentaje de grasa corporal. Además, la edad se categorizó en <19 años y ≥19 años.

Trastorno de Adicción al Internet

La medición del TAI se utilizó la técnica de la encuesta y el instrumento fue un cuestionario con la Escala de la Adicción a Internet de Lima (EAIL), diseñado por Lam- Figueroa et al. la cual contiene 8 ítems que evalúan Características Sintomatológicas; y 3 ítems para las Características Disfuncionales. El cuestionario fue evaluado por tres psiquiatras especializados en este campo, donde determinaron que solo se contaría con estos 11 ítems con respuestas de tipo Likert, y un barómetro que da los resultados en Ausente y Presente, según los puntajes que se obtienen de estos Ítems. El análisis psicométrico del instrumento presentó un coeficiente Alfa de Cronbach de 0,84, con valores de correlación ítem-total (0,45 - 0,59)[7].

Valoración antropométrica

La medición de peso y talla se obtuvo empleando una balanza de la marca SECA y un tallímetro de madera móvil según especificaciones técnicas del Centro Nacional de Alimentación y Nutrición. Utilizándolos para hallar el Índice de Masa Corporal (IMC) con la formula estándar para determinar si una persona está en un rango de peso saludable en relación con su estatura. Se calcula dividiendo el peso (en kilogramos) entre la estatura (en metros) al cuadrado. Según la Organización Mundial de la Salud (OMS), los puntos de corte del IMC se establecen de la siguiente manera: Bajo Peso (IMC inferior a 18,5), peso normal (IMC entre 18,5 y 24,9), sobrepeso (IMC entre 25,0 y 29,9) y obesidad (Grado I: entre 30,0 y 34,9; Grado II: entre 35,0 y 39,9; Grado III igual o mayor a 40)[8].

Los perímetros Abdominal y Braquial fueron medidos con una cinta ergonómica marca SECA, considerando el P. Abdominal como "bajo riesgo" a los ≤79 cm en mujeres y ≤93 cm en hombres[9], en el P. Braquial mayores de 24 cm como "normal"[10].

Los pliegues cutáneos, constaron de 4 pliegues (Tricipital, Subescapular, Bicipital y Suprailíaco. Estos fueron medidos con un caliper, donde obtuvimos resultados clasificados en Bajo, Normal y Alto según cada pliegue[11]. Los cuales fueron utilizados para hallar el porcentaje de grasa corporal con la fórmula de Durnin y Womersley, clasificándolos en "Promedio" para mujeres fue de 21% - 23% y en varones de 13% - 16%[12].

Personal Estandarizado por el Incap de Guatemala[13].

Análisis estadístico

Los datos fueron analizados con el software STATA versión 17. En el análisis descriptivo, se calcularon frecuencias y porcentajes para las variables nominales, mientras que para las variables numéricas se obtuvieron medidas de tendencia central (como media y mediana) y de dispersión (como desviación estándar y rango). Posteriormente, se clasificaron el IMC (bajo peso, peso normal, sobrepeso y obesidad), el perímetro abdominal y braquial (bajo riesgo, riesgo incrementado, alto riesgo) y porcentaje de grasa corporal (muy bajo, bajo, promedio). Se realizó la prueba estadística no paramétrica de U de Mann Whitney ya que nuestros datos no cum-

plen el supuesto de normalidad, lo que nos permite evaluar si existe una diferencia significativa y evaluar la asociación entre la composición corporal y la presencia de TAI, se estimaron las Razones de Prevalencia crudos (RPc) y ajustados (RPa) a través del análisis de regresión de Poisson modificado. Finalmente, se consideró un valor de p<0,05 para determinar significancia estadística.

Aspectos éticos

El estudio fue aprobado por el Vicerrectorado de Investigación de la Universidad Nacional del Centro del Perú (UNCP), también por el Comité de Etica. Todos los participantes firmaron un consentimiento informado según la Declaración de Helsinki[6].

RESULTADOS

Se incluyeron 372 estudiantes universitarios en el estudio, de los cuales el 66,1% fueron mujeres y el 33,9% varones, con un valor de mediana de 20 años. La mayoría de los participantes pertenece a la Facultad de Educación (13,4%), mientras que el resto (86,6%) proviene de diversas facultades de la universidad (ver Tabla 1). En cuanto al Trastorno de Adicción a Internet (TAI), 195 estudiantes (52,4%) fueron clasificados con el trastorno de adicción al internet.

En la Tabla 2, las personas que no presentan Trastorno de Adicción a Internet (TAI) tienen 2.29 veces más probabilidad de sobrepeso RPa: 2.29 (IC 95% 1.97–2.67), P < 0.001 en comparación con las personas sin TAI, por otro lado, el TAI incrementa significativamente el riesgo de obesidad con un RPa: 2.23 (IC 95% 1.87–2.66), P < 0.001, lo cual podría reflejar hábitos alimenticios inadecuados asociados al tiempo excesivo en Internet.

En cuanto al perímetro abdominal, las personas con TAI tienen 1.55 veces más probabilidad de presentar un perímetro abdominal que indica riesgo incrementado con RPa: 1.55 (IC 95% 1.24–1.94), P < 0.001, adicional a ello el TAI duplica el riesgo de presentar un perímetro abdominal que indica alto riesgo con RPa: 2,09 (IC 95% 1,73–2,54), P < 0,001.

Por otro lado, cuando el TAI incrementa en 1.27 veces la probabilidad de tener un pliegue iliaco alto, RPa: 1,27 (IC 95% 1,02–1,57), P = 0,033, lo cual indica un marcador de acumulación de grasa corporal.

Y por último el TAI se asocia significativamente con hipertensión, RPa: 1,86 (IC 95% 1,64–2,10), P < 0,001, lo que hace referencia a que las personas con TAI tienen 1,86 veces más probabilidad de presentar hipertensión arterial que aquellos q no presentan TAI, esto puede ser a consecuencia del estrés relacionado con el tiempo excesivo en Internet y el sedentarismo.

Tabla 1. Resultados de Variables Demográficas de los estudiantes universitarios de la UNCP

	n=372	
	Número	**%**
Sexo		
Mujer	246	66,1
Varón	126	33,9
Facultad		
Administración	22	5,9
Agronomía	13	3,5
Antropología	10	2,7
Arquitectura	13	3,5
Civil	1	0,2
Comunicación	16	4,3
Contabilidad	6	1,6
Derecho	2	0,5
Economía	14	3,8
Educación	50	13,4
Educación física	4	1,1
Eléctrica	12	3,2
Enfermería	46	12,4
Forestales	9	2,4
Industrias alimentarias	13	3,5
Mecánica	4	1,1
Medicina	19	5,1
Metalurgia	20	5,4
Minas	8	2,2
Química	48	12,9
Sistemas	6	1,6
Sociología	10	2,7
Trabajo social	17	4,6
Zootecnia	9	2,4
Edad – Mediana (Min – Max)	**20 (16 - 27)**	

Tabla 2. Razones de Prevalencia crudos (RPc) y ajustados (RPa) de las características de los participantes para la presentación de Trastorno de Adicción al Internet

Variables		Trastorno de Adicción al Internet				Regresión de Poisson Modificada			
		Ausente		Presente		Análisis crudo		Análisis ajustado[a]	
		n	%	n	%	RPc (IC 95%)	Valor de P	RPa (IC 95%)	Valor de P
IMC	Normal	163	92,1%	114	58,5%	Referencia		Referencia	
	Bajo peso	10	5,6%	5	2,6%	0,81 (0,39 – 1,69)	0,573	0,81 (0,39 – 1,68)	0,567
	Sobrepeso	4	2,3%	68	34,9%	2.30 (1,97 – 2,67)	< 0,001*	2,29 (1,97 – 2,67)	< 0,001*
	Obesidad	0	0,0%	8	4,1%	2.43 (2,11 – 2,80)	< 0,001*	2,23 (1,87 – 2,66)	< 0,001*
Perímetro Abdominal	Bajo riesgo	158	89,3%	140	71,8%	Referencia		Referencia	
	Riesgo incrementado	18	10,2%	39	20,0%	1,46 (1,18 – 1,81)	0,001*	1,55 (1,24 – 1,94)	< 0,001*
	Alto riesgo	1	0,6%	16	8,2%	2,00 (1,69 – 2,38)	< 0,001*	2,09 (1,73 – 2,54)	< 0,001*
Perímetro Braquial	Normal	151	85,3%	170	87,2%	Referencia		-	
	Riesgo de desnutrición	12	6,8%	14	7,2%	1,02 (0,70 – 1,48)	0,930	-	-
	Desnutrición	14	7,9%	11	5,6%	0,83 (0,53 – 1,31)	0,426	-	-
Pliegue Escapular	Normal	76	42,9%	105	53,8%	Referencia		Referencia	
	Bajo	80	45,2%	64	32,8%	0,77 (0,61 – 0,96)	0,018*	0,78 (0,63 – 0,98)	0,029*
	Alto	21	11,9%	26	13,3%	0,95 (0,72 – 1,27)	0,745	0,94 (0,71 – 1,24)	0,659
Pliegue Iliaco	Normal	99	55,9%	111	56,9%	Referencia		Referencia	
	Bajo	58	32,8%	39	20,0%	0,76 (0,58 – 1,00)	0,052	0,78 (0,59 – 1,03)	0,078
	Alto	20	11,3%	45	23,1%	1,31 (1,07 – 1,61)	0,011*	1,27 (1,02 – 1,57)	0,033*
Pliegue Tricipital	Normal	114	64,4%	105	53,8%	Referencia		Referencia	
	Bajo	3	1,7%	1	0,5%	0,52 (0,09 – 2,88)	0,455	0,53 (0,10 – 2,85)	0,456
	Alto	60	33,9%	89	45,6%	1,246 (1,03 – 1,51)	0,025*	1,20 (0,99 – 1,47)	0,067

RPc: Razón de Prevalencia Crudo, RPa: Razón de Prevalencia Ajustado, IMC: Índice de Masa Corporal, NC: No Computable.
[a] Modelo múltiple ajustado por grupo etario y sexo.
* Valor de P < 0.05.

Tabla 2 continuación. Razones de Prevalencia crudos (RPc) y ajustados (RPa) de las características de los participantes para la presentación de Trastorno de Adicción al Internet

Variables		Trastorno de Adicción al Internet				Regresión de Poisson Modificada			
		Ausente		Presente		Análisis crudo		Análisis ajustado[a]	
		n	%	n	%	RPc (IC 95%)	Valor de P	RPa (IC 95%)	Valor de P
Pliegue Bicipital	Normal	41	23,2%	42	21,5%	Referencia		Referencia	
	Bajo	0	0,0%	0	0,0%	NC	NC	-	-
	Alto	136	76,8%	153	78,5%	1,05 (0,82 – 1,33)	0,711	-	-
% grasa corporal	Normal	41	23,2%	33	16,9%	Referencia		-	
	Muy bajo	4	2,3%	4	2,1%	1,12 (0,53 – 2,36)	0,763	-	-
	Bajo	18	10,2%	18	9,2%	1,12 (0,74 – 1,70)	0,590	-	-
	Muy alto	49	27,7%	46	23,6%	1,09 (0,78 – 1,51)	0,625	-	-
	Exceso de grasa	65	36,7%	94	48,2%	1,33 (1,00 – 1,77)	0,054	-	-
Nivel de glucosa	Normal	158	89,3%	171	87,7%	Referencia		-	
	Hipoglucemia	0	0,0%	0	0,0%	NC	NC	-	-
	Hiperglucemia	18	10,2%	21	10,8%	1,04 (0,76 – 1,41)	0,823	-	-
	Diabetes provisional	1	0,6%	3	1,5%	1,44 (0,81 – 2,57)	0,213	-	-
Presión arterial	Normal	165	93,2%	179	91,8%	Referencia		Referencia	
	Hipotensión	12	6,8%	5	2,6%	0,57 (0,27 – 1,19)	0,134	0,58 (0,28 – 1,21)	0,149
	Hipertensión	0	0,0%	11	5,6%	1,92 (1,74 – 2,13)	< 0,001*	1,86 (1,64 – 2,10)	< 0,001*

RPc: Razón de Prevalencia Crudo, RPa: Razón de Prevalencia Ajustado, IMC: Índice de Masa Corporal, NC: No Computable.
[a] Modelo múltiple ajustado por grupo etario y sexo.
* Valor de P < 0.05.

DISCUSIÓN

El siguiente estudio es el primero a nivel de la región mostrando en el resultado general, una asociación significativa entre el trastorno de adicción al internet (TAI) y diversas medidas de composición corporal. Específicamente, se halló que el sexo, el IMC, el perímetro abdominal, el pliegue escapular, el pliegue iliaco, el pliegue tricipital y la presión arterial tienen una asociación significativa con la adicción al internet. En cambio, no se encontró asociación significativa con la edad, el perímetro braquial, el pliegue bicipital, el porcentaje de grasa corporal y el nivel de glucosa.

La asociación entre el TAI y la composición corporal encontrada en este estudio corresponde a lo descrito en otros estudios internacionales previos. El estudio de Cortázar et al., en España, proporcionó un contexto relevante al considerar el Mindfulness Disposicional como un factor de protección

contra problemas de adicción, incluyendo el uso problemático del internet. Los resultados que asocian el IMC y la adicción al internet pueden reflejar una relación similar en estudiantes universitarios, destacando la importancia de factores psicológicos y comportamentales en la gestión de la adicción al internet[14]. De similar manera, Pacheco et al., en Chile, investigaron las relaciones entre conducta alimentaria y composición corporal, encontrando que la alimentación emocional y la restricción cognitiva están relacionadas con un IMC y obesidad central más altos[15]. La conclusión de este estudio es similar, dado que se encontró una asociación significativa entre el IMC, el perímetro abdominal y el trastorno de adicción al internet.

De manera más específica, se halló que el sexo y el TAI tienen asociación. Este hallazgo se asemeja al estudio de Ramos F et al. en Cañete, donde se observaron diferencias significativas en los niveles de adicción al internet entre géneros, encontrando que los hombres tendían a mostrar mayores niveles de adicción[16]. Sin embargo, se diferencia del estudio de Panea et al. que no encontró una relación significativa entre los trastornos alimentarios y la adicción a internet, sugiriendo que los factores de género pueden no ser tan determinantes en todas las poblaciones[17].

Por el lado, el IMC también se mostró una asociación altamente significativa con el TAI. Este resultado es consistente con el estudio de Pacheco et al. en Chile, que encontró una relación entre un IMC más alto y comportamientos de alimentación descontrolada, indicando que una mayor masa corporal podría estar asociada con comportamientos adictivos[15]. Contrariamente, el estudio de Medrano et al. en México sobre el uso excesivo de internet no reportó una relación directa entre IMC y adicción al internet, sugiriendo que otros factores podrían mediar esta relación en diferentes contextos[18].

En cuanto a la relación entre el perímetro abdominal y el TAI, el resultado se parece al de González en España, quien subrayó la importancia de evaluar la composición corporal para manejar trastornos como la obesidad, la cual se midió con el perímetro abdominal[19]. Sin embargo, en el estudio de Bueno et al. en Lima, no se encontró una relación significativa entre el uso de redes sociales y el perímetro abdominal, lo que sugiere variaciones contextuales y metodológicas entre los estudios[20].

Sobre la relación entre el pliegue escapular y el TAI Este resultado es coherente con el estudio de Gao et al., que encontró una relación entre problemas físicos y el tiempo prolongado en juegos de internet, incluyendo medidas de pliegues cutáneos como indicadores de composición corporal afectada[21]. Similarmente, la relación entre el Pliegue Iliaco y el TAI, se evidenció una relación significativa, este hallazgo se alinea con los resultados de Moreno et al. en Estados Unidos, donde se encontró que el uso problemático de internet se asocia con diversos problemas de salud física, incluyendo medidas de pliegues cutáneos[22].

Por otro lado, sobre la relación entre el pliegue Tricipital, se mostró una asociación significativa entre el pliegue tricipital y la adicción al internet. Este resultado es similar al hallazgo de Pacheco et al. en Chile, que encontró una relación entre la restricción cognitiva y mayores medidas de pliegues cutáneos, incluyendo el pliegue tricipital[15]. No obstante, el estudio de Bueno et al. en Lima no reportó una relación significativa entre el uso de redes sociales y el pliegue tricipital, sugiriendo que diferentes comportamientos adictivos pueden afectar la composición corporal de distintas maneras[20]. En cuanto a la presión arterial, se halló que también está asociado con el TAI, un resultado parecido es el de Gao et al., quien en su meta-análisis sobre factores de riesgo de trastornos de juegos de internet, incluyeron la presión arterial como un factor significativo[21].

Por el lado, del porcentaje de Grasa Corporal, no se relacionó con el TAI. Esto contrasta con el estudio de Pérez et al. en Chiclayo, que encontró una correlación significativa entre el uso de internet y el porcentaje de grasa corporal, sugiriendo que el contexto y otros factores pueden influir en esta relación[23]. De manera similar, el estudio de Pacheco et al. en Chile también encontró una relación entre la alimentación emocional y un mayor porcentaje de grasa corporal, lo cual no se observó en el presente estudio[15].

Para el nivel de Glucosa, indicó que no hay una asociación significativa entre el nivel de glucosa y la adicción al internet. Este resultado difiere del hallazgo de Moreno et al. en Estados Unidos, donde se encontraron asociaciones entre problemas de salud relacionados y el uso problemático de internet y redes sociales, que incluían alteraciones en los niveles de glucosa[22]. Por otro lado, el estudio de González en España no reportó una relación significativa entre los niveles de glucosa y la adicción al internet, apoyando los resultados del presente estudio[19].

Por el lado, teórico, el resultado del estudio se alinea con la teoría de la composición corporal organizada en cinco niveles (atómico, molecular, celular, tisular y global), donde el tejido adiposo y la distribución de grasa son componentes críticos. La antropometría, como método para evaluar la composición corporal, utiliza medidas como el IMC, pliegues cutáneos y perímetros corporales para estimar la cantidad de tejido graso total del cuerpo y su relación con el riesgo cardiovascular, especialmente por la masa grasa en la zona abdominal[24]. Asimismo, el hallazgo va en conjunto con la teoría del trastorno de adicción al internet (IAD), definido por Iván Goldberg y posteriormente expandido por Young, el cual se caracteriza por un deterioro en el control del uso de internet, manifestándose en síntomas cognitivos, conductuales y fisiológicos. Según la teoría de Young, las adicciones tecnológicas, incluyendo la IAD, pueden llevar a cambios en la composición

corporal debido a la inactividad física y alteraciones en los patrones alimentarios. Este marco teórico respalda el hallazgo de que la adicción al internet está significativamente asociada con diversas medidas de composición corporal en estudiantes universitarios[25].

Se halló que existe un porcentaje significativo (52,4%) de estudiantes que presentan trastorno de adicción al internet en la UNCP. El resultado de esta investigación se parece al estudio de Ramos F et al. en Cañete, donde se encontró que el 19% de los estudiantes adolescentes presentaban niveles altos y muy altos de adicción al internet, mientras que el 47% tenía un nivel medio. Aunque la prevalencia es menor en el estudio de Ramos, la tendencia a un uso problemático del internet en ambos casos es notable[16]. Además, la conclusión es similar al hallazgo de Medrano et al. en México, quienes identificaron que el uso excesivo de internet es común entre los estudiantes universitarios. Este estudio encontró que el uso problemático de redes sociales y dispositivos móviles es prevalente, lo que coincide con la alta proporción de adicción a la internet encontrada en la UNCP[18]. Otro estudio similar fue el de Gao et al., donde se encontró que el uso problemático de internet y la adicción a los juegos en línea son comunes en adultos jóvenes. Este estudio, que incluyó una amplia muestra internacional, confirma que la adicción al internet es un fenómeno global que afecta significativamente a la población joven[21].

La contrastación con la teoría, indicó que el incremento del uso de internet y dispositivos electrónicos ha sido documentado como una preocupación de salud pública. La Organización Mundial de la Salud (OMS) ha realizado varias reuniones para analizar la epidemiología, naturaleza y consecuencias del uso excesivo de internet, subrayando la magnitud del problema a nivel global[26]. El hallazgo en la UNCP se refleja en este contexto global, indicando que la adicción al internet es una problemática significativa que también afecta a la población universitaria local. Además, la adicción a internet, como se menciona en el marco teórico, tiene dos dimensiones: características sintomatológicas y características disfuncionales. La alta prevalencia de adicción al internet entre los estudiantes de la UNCP sugiere que ambos componentes están presentes, lo que implica una combinación de síntomas y disfuncionalidades que requieren atención[6].

Se halló que existe un alto contenido de grasa en mujeres y hombres estudiantes universitarios de la UNCP. En particular, el perímetro abdominal, perímetro braquial, pliegue tricipital, pliegue bicipital y porcentaje de grasa corporal mostraron asociaciones significativas con el sexo (mujeres y hombres); mientras que la edad, IMC, pliegue escapular y pliegue iliaco no mostraron asociaciones significativas.

El perímetro abdominal mostró una asociación significativa con el sexo. Este resultado es similar al estudio de Pacheco et al. en Chile, que encontró que las puntuaciones de restricción cognitiva y alimentación emocional estaban relacionadas con un mayor perímetro abdominal, reflejando diferencias significativas entre hombres y mujeres en cuanto a la distribución de grasa corporal[15]. Además, el perímetro braquial también mostró una asociación significativa con el sexo. Este hallazgo es consistente con el estudio de González en España, quien destacó la importancia de evaluar la composición corporal para entender mejor las diferencias entre géneros, especialmente en áreas como el perímetro braquial[18]. Sin embargo, el estudio de Panea et al. en España no encontró diferencias significativas entre la adicción a internet y los trastornos alimentarios en mujeres, lo cual puede indicar variaciones en las metodologías y las poblaciones estudiadas[17].

Por el lado del pliegue tricipital, también tuvo una asociación significativa con el sexo. Este resultado se asemeja al hallazgo de Medrano et al. en México, donde se identificó una relación entre el uso excesivo de dispositivos y medidas de pliegues cutáneos como el pliegue tricipital[18]. Por otro lado, el estudio de Ramos F et al. en Cañete no encontró una relación significativa entre el nivel de adicción al internet y el pliegue tricipital, lo que podría deberse a diferencias en las características de las muestras[16]. Por el lado del porcentaje de grasa corporal, también se observó una asociación significativa con el sexo. Este hallazgo es coherente con el estudio de Pacheco et al. en Chile, que identificó una relación entre la alimentación emocional y un mayor porcentaje de grasa corporal, destacando diferencias entre hombres y mujeres[15].

Ahora, el factor edad no mostró una asociación significativa con el contenido de grasa en los estudiantes. Este resultado difiere del estudio de Gao et al., que encontró que el tiempo prolongado en juegos de internet y otros factores relacionados con la edad influían en la composición corporal y el comportamiento adictivo[21]. Sobre el IMC, tampoco se mostró una asociación significativa con el sexo en este estudio. Esto contrasta con el hallazgo de Pacheco et al. en Chile, donde un IMC más alto se asoció con comportamientos de alimentación descontrolada y emocional[15]. Sin embargo, el estudio de Medrano et al. en México no reportó una relación directa entre el IMC y la adicción al internet, sugiriendo que el IMC puede no ser un indicador significativo en todos los contextos[18].

Por el lado del pliegue escapular, tampoco mostró una asociación significativa con el sexo. Este resultado difiere del estudio de González en España, que destacó la importancia de los pliegues cutáneos en la evaluación de la composición corporal[19]. Sin embargo, el estudio de Bueno et al. en Lima no encontró una relación significativa entre el uso de redes sociales y el pliegue escapular, apoyando los resultados del presente estudio[20]. Finalmente, por el lado del pliegue bicipital mostró una asociación significativa con el sexo. Este resultado no es similar al hallazgo de Panea et al. en España, donde no se encontró una relación significativa entre los trastornos alimentarios y la adicción a internet en mujeres[17]. Por otro lado,

el estudio de Pérez et al. en Chiclayo encontró una relación significativa entre el uso de internet y medidas de composición corporal, sugiriendo que diferentes pliegues cutáneos pueden estar influenciados por factores[23].

Adicional a ello, el resultado tiene respaldo en la teoría de la adiposidad diferencial entre géneros, donde se reconoce que las mujeres tienden a acumular más grasa subcutánea, especialmente en áreas como el perímetro abdominal y el pliegue tricipital, en comparación con los hombres[24]; y según los estudios de Ramos P et al., los hombres eran más activos que las mujeres porque tenían más masa muscular esquelética que la masa grasa corporal[27]. Además, Moreno et al. mencionan que la distribución de grasa corporal está asociada a comportamientos adictivos, lo cual se refleja en la asociación significativa observada en este estudio[22]. Este hallazgo es crucial, ya que destaca la necesidad de intervenciones específicas que aborden las diferencias de género en la composición corporal y los riesgos asociados con la adicción al internet. Los profesionales de la salud pueden utilizar esta información para desarrollar programas de educación y prevención personalizados teniendo en cuenta que, para los estudiantes universitarios, estos resultados subrayan la importancia de adoptar hábitos de vida saludables que incluyan una dieta equilibrada y actividad física regular y puedan ayudar a los estudiantes a gestionar mejor su salud y a reducir los riesgos asociados con el uso excesivo de internet.

Limitaciones: Muestro no probabilístico, falta de representatividad en la población. Potencial sesgo de conformidad (mencionar que garantizaron el anonimato). Sesgo de medición en el diagnostico de TAI (mencionar que la encuesta fue validada, peso).

CONCLUSIONES

Se determinó que el 52.4% de los estudiantes de la UNCP padecen adicción al internet, un hallazgo significativo que resalta la necesidad de implementar programas de prevención y tratamiento a nivel institucional para mitigar sus efectos negativos en la salud y rendimiento académico. Además, se encontró una asociación significativa entre el trastorno de adicción al internet y la mayoría de medidas de composición corporal. Los factores relacionados con la adicción incluyeron sexo, IMC, perímetro abdominal, pliegue escapular, pliegue iliaco, pliegue tricipital y presión arterial. No se encontraron asociaciones significativas con la edad, perímetro braquial, pliegue bicipital, porcentaje de grasa corporal y nivel de glucosa. Tanto hombres como mujeres de la UNCP mostraron un alto contenido de grasa en varias medidas corporales, incluyendo el perímetro abdominal, perímetro braquial, pliegue iliaco, pliegue tricipital y porcentaje de grasa corporal. Esto subraya la importancia de intervenciones específicas para mejorar la salud y bienestar de los estudiantes.

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Red guava (*Psidium guajava L*) juice increases hemoglobin levels in female adolescent

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ABSTRACT

Background: One nutritional issue Indonesian adolescents face is micronutrient deficiency, with approximately 12% of male adolescents and 23% of female adolescents experiencing anemia, predominantly due to iron deficiency. Anemia in adolescent girls is particularly concerning as they are future mothers who will conceive and give birth, thereby increasing the risk of maternal mortality, preterm birth, and low birth weight. An initial survey of 7 female students revealed that 4 were anemic. This study aims to determine the effect of red guava juice on hemoglobin levels in female adolescents at a junior high school of SMP N 2 Belang, Belang District.

Methods: This quasi-experimental study employed a pretest-posttest with control group design, involving a total sampling of 30 respondents divided into 15 respondents in the treatment group and 15 in the control group. Data were collected through observation sheets and analyzed using paired sample t-tests.

Results: The paired sample t-test results indicated a significant effect of red guava juice on increasing hemoglobin levels in female adolescents, with a p-value of 0.002 and a mean value of 11.46 during the pretest and 12.58 during the posttest in the treatment group. In contrast, the control group did not receive any treatment and had a p-value of 0.334, indicating no significant increase in hemoglobin levels during the posttest. After consuming red guava juice, there was a considerable change from anemia to non-anemia.

Conclusion: Consuming red guava (*Psidium guajava* L.) juice demonstrates potential as a non-pharmacological intervention for increasing hemoglobin levels in adolescent females, with research findings indicating a significant improvement in the treatment group compared to the control group. Nevertheless, further studies with larger sample sizes and extended durations are necessary to validate red guava juice's efficacy in managing anemia among the general population of adolescent females.

KEYWORDS

Anemia, Adolescent Health, Functional Drinks, Preventive Nutrition.

INTRODUCTION

Adolescence is a transitional period from childhood to adulthood. According to the WHO (2024)[1], adolescents or young people are between 10 and 24 years old. Age is considered a poor indicator because growth and development vary among individuals. Physiologically, adolescence is defined as the period when physiological development begins, specifically the maturation of reproductive organs[2].

One nutritional issue Indonesian adolescents face is micronutrient deficiency, with approximately 12% of male adolescents and 23% of female adolescents experiencing anemia, predominantly due to iron deficiency (iron deficiency anemia)[3]. The prevalence of anemia is higher among female adolescents compared to their male counterparts. Anemia in

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adolescents adversely affects immunity, concentration, academic performance, fitness, and productivity[4]. Additionally, anemia in female adolescents is particularly concerning as they are future mothers who will conceive and give birth, thereby increasing the risk of maternal mortality, preterm birth, and low birth weight[5].

The factor influencing hemoglobin levels in the blood is the adequacy of iron in the body. Adolescents suffering from anemia may experience suboptimal growth, such as osteoporosis, in later life[6,7]. Osteoporosis can occur rapidly if adolescents experience eating disorders and reduced cognitive abilities[8]. Furthermore, female adolescents with anemia may experience decreased concentration, lack of enthusiasm in activities due to fatigue, and deficiencies that can affect attention, intelligence, and academic performance at school[9–11].

Research by Sulistiyowati (2016)[12] Sulistiowaty found that red guava juice can aid in iron absorption and treat anemia. Iron in food is absorbed with the help of vitamin C. Vitamin C can increase the pH in the stomach, thereby enhancing iron absorption by up to 30%. Research by Prasetyanti & Putri (2017)[13] demonstrated that hemoglobin levels can increase significantly with the consumption of iron tablets, and factors such as the consumption of vitamin C-rich fruits also influence the absorption of iron tablets.

Based on the number of students at a junior high school of SMP N 2 Belang, totaling 362 students, an initial survey was conducted on 11 February 2019. Among the 7 female students surveyed, 4 were identified to be anemic. Thus, many female adolescents still suffer from anemia. Anemia can be defined as a deficiency in hemoglobin levels. This study aims to analyze the effect of red guava juice on changes in hemoglobin levels in female adolescents at a junior high school of SMP N 2 Belang, Belang District.

METHOD

This study used a quasi-experimental design with a pretest-posttest control group design. The main variable to be compared in this study was hemoglobin levels in female adolescents. Hemoglobin levels were measured before and after the intervention in both groups (treatment and control). This study was conducted on adolescent girls aged 12-15 years at Junior High School 2 Belang, Belang District, Southeast Minahasa Regency, North Sulawesi, Indonesia. The research design involved two stages of observation: before the administration of red guava juice (pretest) and after the administration of red guava juice (posttest). The red guava juice was made from 100 g of red guava fruit, 10 g of granulated sugar, and 150 ml of water, blended and strained. The composition included 228 mg of vitamin C, 0.73 mg of vitamin E, 49 µg of folate, 0.26 mg of iron, 0.23 mg of zinc, and 5204 µg of lycopene. The juice was administered for 7 days. The respondents' hemoglobin levels were measured before and after 7 days of consuming the red guava juice. The population in this study consisted of 30 female students, using a total sampling technique, which included the entire population of 30 respondents divided into 2 groups: 15 respondents in the treatment group and 15 respondents in the control group.

The intervention involved administering red guava juice to the treatment group for 7 days, consumed in the morning, while the control group did not receive any treatment. Data analysis was performed using the paired t-test.

Ethical Approval Number: 301/Kepk/Vii/2019 from Health Research Ethics Committee, Manado Health Polytechnic Ministry of Health.

RESULTS

Hemoglobin Levels Pretest and Posttest in the Treatment Group.

Based on Table 1, there were 6 non-anemic respondents in the pretest, which increased to 13 non-anemic respondents in the posttest in the treatment group. In contrast, in the control group, there were 6 non-anemic respondents in the pretest, with no increase in non-anemic respondents in the posttest.

Normality Test

This test was conducted to determine whether there were changes in hemoglobin levels before and after the adminis-

Table 1. Distribution of respondents based on hemoglobin levels in the pretest and posttest of the treatment and control groups at a junior high school of SMP N Belang

Hemoglobin Levels	Category	Treatment Group		Control Group	
		Pretest	*Posttest*	*Pretest*	*Posttest*
≥ 12 g/dl	Non-Anemic	6	13	6	6
< 12 g/dl	Anemic	9	2	9	9
Total		15	15	15	15

tration of red guava juice in the treatment group and in the control group without any treatment. The results of the paired sample t-test for changes in hemoglobin levels before and after treatment in the treatment group are shown in Table 2.

Based on Table 2, the difference in hemoglobin levels between the pretest and posttest in the treatment group was 1.12. The paired sample t-test in the treatment group showed a p-value of 0.002 < 0.05, whereas the difference in hemoglobin levels between the pretest and posttest in the control group was 0.01. The paired sample t-test in the control group showed a p-value of 0.334. It can be concluded that there was a significant change in hemoglobin levels between the pretest and posttest in the treatment group, whereas there was no significant change in hemoglobin levels between the pretest and posttest in the control group.

Table 2. Results of the paired sample t-test for changes in hemoglobin levels before and after treatment in the treatment and control groups

Hemoglobin Levels	Treatment Group			Control Group		
	Mean	**Standard Deviation**	***P value***	**Mean**	**Standard Deviation**	***P value***
Pretest	11.46	0.882	0.02	11.77	1.052	0.334
Posttest	12.58	0.882		11.78	1.050	

DISCUSSION

The characteristics of respondents based on age, as indicated by the research data, show that respondents in both the treatment and control groups fall within the range of 13 years. The research results indicate a significant increase in hemoglobin levels with a p-value of 0.002 < 0.05. The mean pretest hemoglobin level was 11.46 g/dl, which increased to 12.58 g/dl in the posttest for the treatment group. The mean increase in hemoglobin levels from the pretest was 1.12 g/dl, indicating a significant change in hemoglobin levels. In contrast, the control group, which did not receive any treatment, had a p-value of 0.334 > 0.05, with a mean pretest hemoglobin level of 11.77 g/dl, which increased to 12.78 g/dl in the posttest. The mean increase in hemoglobin levels from the pretest was 1.01 g/dl, indicating no significant difference in the control group during the posttest. Univariate analysis showed that 6 respondents were not anemic and 9 respondents were anemic during the pretest, which increased to 13 respondents not anemic and 2 respondents anemic during the posttest. In the control group, 6 respondents were not anemic and 9 were anemic during the pretest, with no increase in non-anemic and anemic respondents during the posttest.

This study aligns with research conducted at the Rusdi et al. (2018)[14] Orphanage in Padang Panjang City on 34 anemic adolescents selected through simple random sampling. Subjects were divided into two groups: control and treatment. The treatment group was given 100 grams of red guava processed into juice for 7 days. Data analysis used the dependent t-test with a significance level of α=0.05. The mean pretest Hb level was 10.26 g/dl (control) and 10.50 g/dl (intervention), and the mean serum ferritin level was 33.63 µg/L (control) and 36.63 µg/L (intervention). The mean posttest Hb level was 10.98 g/dl (control) and 12.48 g/dl (intervention), and the mean serum ferritin level was 40.35 µg/L (control) and 57.40 µg/L (intervention). Statistical tests showed that red guava juice significantly affected hemoglobin and serum ferritin levels in anemic adolescent girls, with a p-value of <0.001.

This study is consistent with the research by Winarni et al. (2020)[15], which found that the increase in hemoglobin levels after administering red guava juice with Fe tablets was 2.96 g/dl, red guava alone was 2.89 g/dl, red guava juice with honey was 1.21 g/dl, a combination of spinach and red guava juice was 0.96 g/dl, Fe tablets with orange juice was 0.40 g/dl, orange juice alone was 0.63 g/dl, and Fe-Folate with orange juice was 0.47 g/dl. Thus, among all these studies, the combination of red guava juice with Fe tablets was the most effective in increasing hemoglobin levels in anemic pregnant women compared to orange juice.

This study is also consistent with the research by Yuviska & Armiyanti (2019)[16], which found that the average hemoglobin (Hb) level in adolescents before consuming mung bean juice was 10.107 with a standard deviation of 1.0278. The average Hb level in mothers after consuming mung bean juice was 10.813, with a standard deviation of 1.0460. The average Hb level in mothers before consuming guava juice was 10.040, with a standard deviation of 1.2403. The average Hb level in mothers after consuming guava juice was 10.507, with a standard deviation of 1.3456. There is a difference in the effect of mung bean juice and red guava juice on the increase in hemoglobin levels in RISMA in Desa Maja. This study is in line with the research by Carolin et al. (2021)[17], which found a difference in the effect of red guava juice and beet juice on hemoglobin levels in pregnant women. The average hemoglobin level before and after consuming red guava juice was 8.4 g/dl and 11.5 g/dl, respectively, and the average hemoglobin level before and after consuming beet juice was 8.5 g/dl and 10.2 g/dl, respectively, with a p-value of 0.001.

Red guava juice has shown promising effects on increasing hemoglobin levels in female adolescents, according to several studies. In one study, the mean hemoglobin level in the treatment group receiving Fe tablets and guava juice increased from 10.7 g/dL to 11.4 g/dL, while the control group receiving only Fe tablets increased from 10.2 g/dL to 10.6 g/dL[18]. Another study found a significant effect of red guava juice on hemoglobin levels during menstruation in adolescent girls ($p=0.000$)[19]. Interestingly, the combination of red guava pudding and green bean juice showed an even greater increase in hemoglobin levels, with an average increase of 3.6 g/dL ($p<0.05$) compared to green bean juice alone (2.2 g/dL increase)[20]. This suggests that combining red guava with other iron-rich foods may enhance its effectiveness in increasing hemoglobin levels. Red guava juice is an effective non-pharmacological intervention for increasing hemoglobin levels in female adolescents. Its high vitamin C content likely plays a crucial role in enhancing iron absorption[18,19].

The limitations of this study include a small sample size and a lack of information regarding the participants' previous dietary patterns and physiological conditions. Additionally, the relatively short duration of the study may have limited the ability to observe long-term effects of red guava juice intervention on hemoglobin levels in adolescent girls. These implications highlight the need for future studies with larger sample sizes, longer durations, and more comprehensive data collection to address these limitations and provide more robust evidence on the effects of red guava juice on hemoglobin levels in adolescent girls.

CONCLUSION AND RECOMMENDATIONS

This study suggests that red guava juice may have a positive effect on hemoglobin levels in adolescent females. Daily consumption of red guava juice for 7 consecutive days was associated with a significant increase in hemoglobin levels in the treatment group, while no significant changes were observed in the control group. These findings indicate the potential of red guava juice as a natural alternative for addressing anemia in adolescent females. Further research with larger sample sizes and longer durations is recommended to confirm the long-term effectiveness of red guava juice in improving hemoglobin levels.

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Relación de los marcadores bioquímicos con factores sociodemográficos en pacientes con neoplasias hematológicas. Análisis de correspondencias múltiples

Relationship of biochemical markers with sociodemographic factors in patients with hematological neoplasms. Multiple correspondence analysis

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RESUMEN

Introducción: Las neoplasias hematológicas son un grupo de enfermedades cancerígenas que pueden involucrar sistemas y órganos, estas patologías representan diferentes vías de tratamiento y mediciones de pronóstico, como son valores bioquímicos y datos demográficos.

Objetivos: Investigar la relación entre los marcadores bioquímicos y los factores sociodemográficos en pacientes con neoplasias hematológicas.

Materiales y Métodos: Se realizó un estudio transversal en 62 participantes de 17 a 70 años que forman parte del servicio de hematología del Hospital Luis Vernaza de la ciudad de Guayaquil, Ecuador. Los datos fueron analizados por análisis de correspondencia múltiple.

Resultados: Del total de participantes el 68% eran de sexo masculino. Donde se evidencia que un total del 46,78% pierden peso ya sean hombres o mujeres y que el grupo etario más afectado es la población adulto joven con un 29,03%. Los adultos mayores presentan una ganancia de peso, pero al mismo tiempo pueden presentar niveles alterados de marcadores bioquímicos relacionados con el metabolismo proteico y la función renal.

Conclusiones: Los marcadores bioquímicos tienen una relación positiva con los factores socio demográficos en pacientes con neoplasias hematológicas.

PALABRAS CLAVES

Oncohematología, biomarcadores, epidemiología, pronóstico clínico.

ABSTRACT

Introduction: Hematologic neoplasms are a group of cancerous diseases that can involve systems and organs. These pathologies represent different treatment approaches and prognostic measurements, such as biochemical values and demographic data.

Objectives: To investigate the relationship between biochemical markers and sociodemographic factors in patients with hematologic neoplasms.

Materials and Methods: A cross-sectional study was conducted with 62 participants aged 17 to 70 years who are part of the hematology service at Luis Vernaza Hospital in Guayaquil, Ecuador. The data were analyzed using multiple correspondence analysis.

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Results: Of the total participants, 68% were male. It was observed that 46.78% experienced weight loss, regardless of gender, with the most affected age group being young adults, representing 29.03%. Older adults showed weight gain but also presented altered levels of biochemical markers related to protein metabolism and renal function.

Conclusions: Biochemical markers have a positive relationship with sociodemographic factors in patients with hematological neoplasms.

KEYWORDS

Oncohematology, biomarkers, epidemiology, clinical prognosis.

LISTA DE ABREVIATURAS

ACM: Análisis de Correspondencia Múltiple.

ESPEN: Sociedad Europea de Nutrición Clínica y Metabolismo.

INTRODUCIÓN

Las neoplasias hematológicas son un grupo de enfermedades cancerígenas que pueden involucrar sistemas y órganos[1]. Este grupo de patologías afectan a todas las personas de todos los grupos de edades[2]. Entre los tipos más comunes se incluyen la leucemia, el linfoma y mieloma múltiple, todos los cuales son heterogéneos en características genéticas, moleculares y clínicas, lo que lleva a graves dificultades en el tratamiento individualizado[1]. Estas patologías representa diferentes vías de tratamiento y mediciones de pronóstico[3]. Las investigaciones han revelado que los marcadores bioquímicos juegan un papel crucial en la evaluación y el pronóstico de estas enfermedades[4,5].

La medición de los marcadores bioquímicos está aumentando para el diagnóstico temprano y el seguimiento de las neoplasias hematológicas[6]. Las pruebas bioquímicas pueden ser medidas en sangre, orina o tejidos[7]. Los marcadores que se estudian incluyen las proteínas séricas, vitaminas, minerales, enzimas y perfil lipídico.

Los factores sociodemográficos, como la edad, sexo, influyen en la incidencia y el pronóstico de las neoplasias hematologías[8], las tasas de incidencia están aumentando, en parte debido al envejecimiento de a la población a nivel mundial[9]. Estudios previos han demostrado que estos factores pueden afectar tanto la presentación clínica como la respuesta al tratamiento en los pacientes[7,10]. Estudios de calidad de vida en esta población han identificado afectaciones en las funciones físicas y disminución del bienestar emocional[10].

La pérdida de peso en los pacientes con cáncer es un signo característico que se puede deberse a diferentes factores como edad, tratamiento, factores sociales y económicos. Esta pérdida de peso puede ocasionar un desgaste proteico-calórico y afecta la calidad de vida de los pacientes[11,12]. Mediante diversas pruebas bioquímicas se puede medir esa malnutrición.

Los hallazgos del actual estudio serán fundamentales para llevar a cabo una vigilancia periódica de los marcadores bioquímicos y los factores sociodemográficos de las personas con neoplasias hematológicas. Por lo tanto, el objetivo de este estudio es investigar la relación entre los marcadores bioquímicos y los factores sociodemográficos en pacientes con neoplasias hematológicas, utilizando un análisis de correspondencias múltiples. Este análisis estadístico permite identificar patrones y asociaciones entre múltiples variables, proporcionando una más completa compresión de como interactúan estos factores en relación con las neoplasias hematológicas.

MATERIALES Y MÉTODOS

Diseño y participantes

El enfoque de esta investigación se centra en examinar la relación entre marcadores bioquímicos y factores sociodemográficos en pacientes con neoplasia hematológica. Se utiliza un enfoque cuantitativo para analizar datos categóricos, con el objetivo de identificar posibles asociaciones entre las variables de interés.

En este estudio, se considera un total de 62 pacientes diagnosticados con neoplasia hematológica. Se recopilaron datos de forma individual y posteriormente se realizó el análisis de variables bioquímicas y factores sociodemográficos.

Aspectos éticos

El estudio fue aprobado por el Comité de Ética, garantizando el cumplimiento de los principios éticos y de confidencialidad en el manejo de la información de los participantes.

Técnicas de recolección

Se recolectaron datos de manera retrospectiva de los expedientes clínicos de los pacientes. Se registraron variables categóricas, incluyendo sexo (H: Hombre, M: Mujer) y edad fue categorizada como: adolescente < 18 años, adulto joven 18 a 64 años y adulto mayor > 65 años, junto con marcadores bioquímicos como glucosa, urea, creatinina, proteínas, albúmina sérica, prealbúmina, vitamina D, fósforo, magnesio, TGO, GPT, colesterol, HDL, triglicéridos, hemoglobina, hematocrito, y hierro. Estas variables se clasificaron en categorías específicas para facilitar los análisis estadísticos.

Procesamiento y análisis de la información

Los datos recopilados se procesaron utilizando técnicas estadísticas, centrándose en el análisis de correspondencias múltiples (ACM)[13]. El ACM es una técnica específica para

analizar datos categóricos que permite explorar las relaciones entre múltiples variables visualizarlas en un espacio de dimensiones reducidas. Se utilizaron pruebas de independencia basadas en el estadístico Chi-cuadrado para evaluar la asociación entre las variables. Además, se llevó a cabo un análisis descriptivo para resumir las características de la población. Se utilizó R Studio para el procesamiento de la información.

RESULTADOS

Las características sociodemográficas de los participantes se detallan en la Tabla 1, donde se aprecia una predominancia del sexo masculino (68%) en relación el femenino. Se observa también, una predominancia de adultos jóvenes (65%) en comparación de adolescentes y adultos mayores.

Tabla 1. Datos basales30

Variables	Total	
	n	%
Edad (Media; DE)	51,51; 19,05	
Sexo		
Femenino	20	32
Masculino	42	68
Grupo etario		
Adulto Mayor	18	29
Adolescente	4	6
Adulto Joven	40	65

La Tabla 2, presenta información sobre los cambios de peso corporal según el sexo en los participantes. Donde se evidencia que un total del 46,78% pierden peso ya sean hombres o mujeres y que la categoría etaria más afecta con esta pérdida es la población adulto joven con un 29,03%.

Dentro del análisis de correspondencias de múltiples como primer paso consiste en establecer el número de dimensiones para indicar la distribución de la varianza explicada a través de los valores propios, ya que son ejes que sintetizan la información contenida en el conjunto de datos multidimensionales. Cada dimensión refleja una gradiente que explica una proporción específica de la variabilidad de datos.

En la Tabla 3, la primera dimensión explica aproximadamente el 10.32% de la varianza en los datos, seguida de manera similar por las siguientes dimensiones. El porcentaje acumulado de varianza explicada muestra que, hasta la sexta dimensión, alrededor del 47.5% de la varianza total en los datos ha sido explicada por el modelo. Esto su-

Tabla 3. Dimensiones, valores propios, varianza y varianza acumulada

Dimensicon	eigenvalue	variance. percent	cumulative. variance. percent
Dim.1	0,14	10,32	10,32
Dim.2	0,13	9,35	19,66
Dim.3	0,12	8,51	28,18
Dim.4	0,10	7,17	35,35
Dim.5	0,09	6,51	41,85
Dim.6	0,08	5,65	47,5

Tabla 2. Variación del peso de la población de estudio con respecto a los datos sociodemográficos

		Variación del peso					
		GANANCIA		MANTIENE		PERDIDA	
Datos Sociodemográficos		n	%	n	%	n	%
Sexo	FEMENINO	1	1,61	5	8,06	14	22,59
	MASCULINO	18	29,03	9	14,52	15	24,19
Edad	ADOLESCENTE	1	1,61	2	3,24	1	1,61
	ADULTO JOVEN	14	22,58	8	12,90	18	29,03
	ADULTO MAYOR	4	6,45	4	6,45	10	16,13

giere que las primeras dimensiones capturan la mayoría de la estructura subyacente en los datos, con una disminución gradual en la importancia relativa de las dimensiones adicionales.

En la Figura 1, se observa que el grupo de adultos mayores presentan una ganancia de peso, pero al mismo tiempo pueden presentar niveles bajos de pre albúmina. Los individuos y las categorías de forma simultánea generan un mapa de factores, donde los individuos son representados por puntos azules y las categorías por triángulos rojos.

La Figura 2, permite identificar las variables que están más correlacionadas con cada dimensión. Las correlaciones cuadradas entre variables y las dimensiones son usadas como coordenadas. Donde se observa que las proteínas totales y pre albúmina representan factores que se relación con el metabolismo proteico y que los cambios en estos parámetros bioquímicos pueden estar relacionados con las características sociodemográficas de cada participante.

La Figura 3, permite establecer la relación y asociación entre las categorías de las variables, las variables con un perfil similar están agrupadas, las variables correlacionadas negativamente se ubican en cuadrantes opuestos por el origen de la gráfica, mientras más alejada se encuentre una categoría del origen, esta se encuentra mejor representada. Se observa que los adolescentes no presentan cambios en sus pruebas bioquímicas, en cambio, los adultos mayores presentan valores de urea, magnesio y transaminasa glutámico-oxalacética (TGO) elevadas, esto sugiere que existe una diferencia clara en los perfiles nutricionales y bioquímicos entre estos grupos etarios.

La calidad de la representación se llama el coseno cuadrado (Cos2), el cual mide el grado de asociación entre las categorías de las variables y un eje en particular. Si la categoría de una variable está bien representada por dos dimensiones, la suma del cos2 es cercana a uno.

En la Tabla 4, se observaron que los valores de prealbúmina baja tienen una predominancia sobre los niveles de

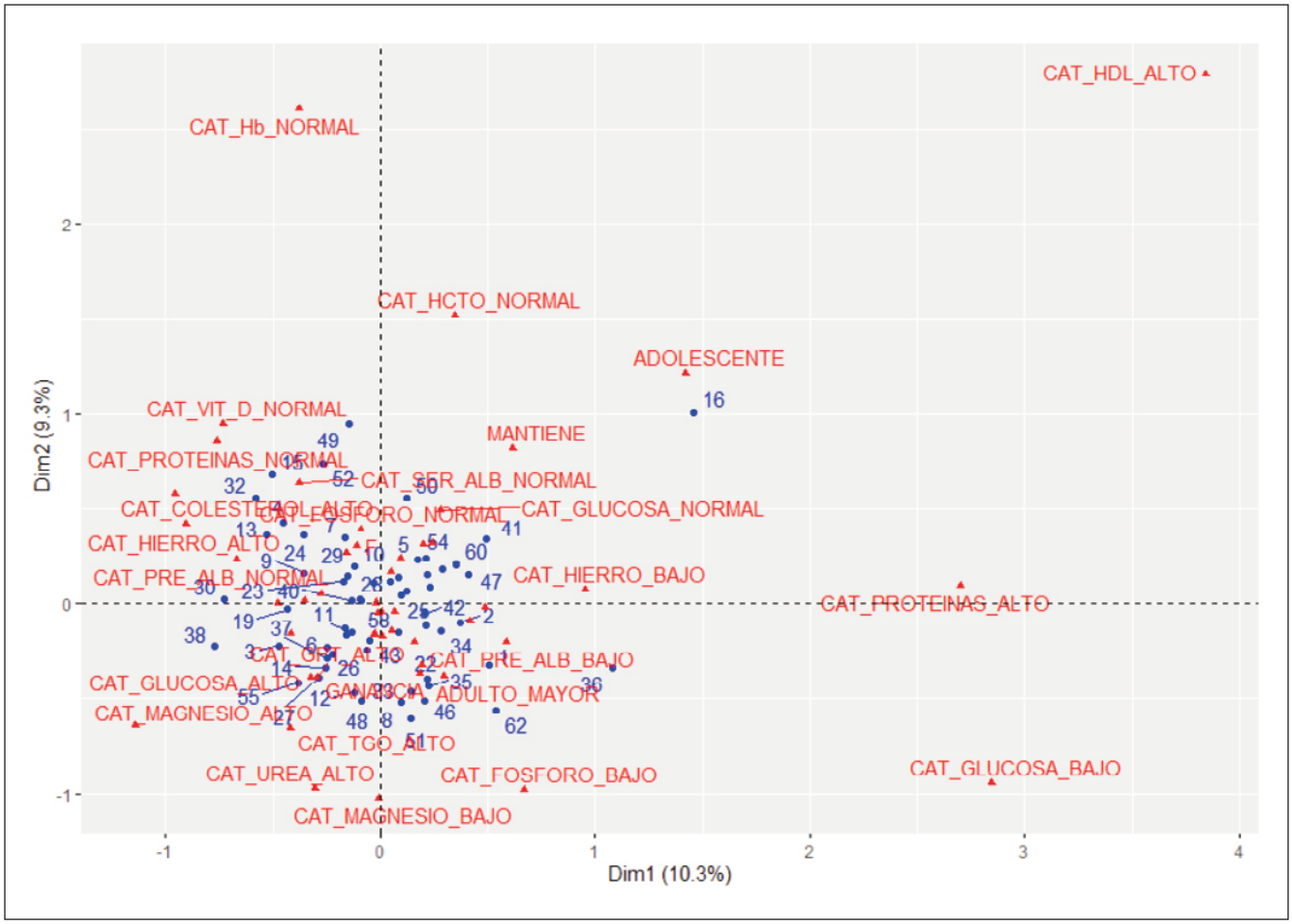

Figura 1. Representación simultanea de individuos y categorías

Figura 2. Correlación de las variables con cada una de las dimensiones

proteínas totales y que la población que presenta niveles altos de proteínas y prealbúmina son los adolescentes. En cambio, los adultos mayores presentan niveles elevados de creatinina lo que se relaciona con su función renal y la edad avanzada.

Todas las categorías de las variables requieren más de una dimensión para estar mejor representadas, considerando que la suma de las dos primeras dimensiones no se acerca a uno. Las categorías que tienden a tener una mejor representación son albúmina baja y normal.

DISCUSIÓN

El presenta estudio revela asociaciones entre las variaciones de peso, marcadores bioquímicos y factores sociodemográficos, aportando información sobre las posibles interacciones fisiológicas en pacientes con neoplasias hematológicas.

Con base a los resultados observados en la muestra de pacientes. Podemos destacar que el 30,65% de los pacientes presentó una ganancia de peso, lo que podría estar relacionado con los efectos positivos de los tratamientos como a cambios

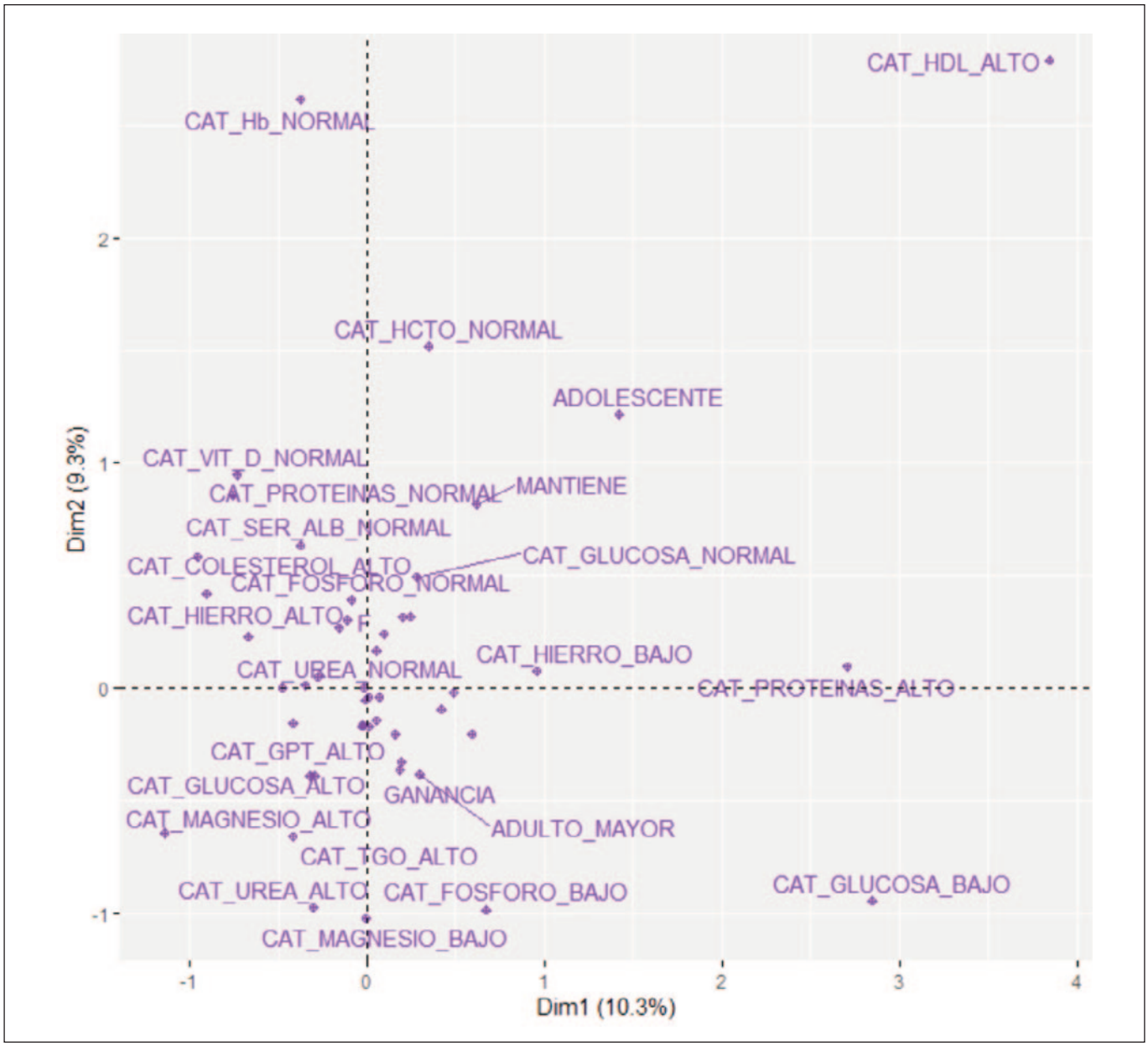

Figura 3. Nube de puntos variables y categorías

metabólicos. Las guías de práctica clínica ESPEN para el manejo nutricional en pacientes con cáncer, recomienda cubrir sus requerimientos nutricionales para lograr una ganancia de peso[18], por lo que demuestra que el porcentaje de nuestro estudio donde se observa a pacientes incrementando su peso es debido a un aporte adecuado de sus necesidades nutricionales, además, de su mejora metabólica y un eficaz tratamiento.

En la tabla 1, se observa que los hombres (29,03%) tienen una mayor tendencia a ganar peso en comparación de las mujeres (1,61%). Estos resultados demuestran que existe una relación en la variación de peso según el género. Además, los adultos jóvenes tienen una mayor ganancia y pérdida de peso (22,58% y 29,03% respectivamente) a comparación de los adultos mayores y adolescentes. Como lo menciona, Bossi, P. et al mencionan que la variación del peso corporal en los pacientes con cáncer se caracteriza por diferentes factores como edad, factores sociales, comorbilidades, tratamientos y se puede evidenciar por el porcentaje de pérdida de peso y marcadores bioquímicos[19].

En el análisis de correspondencia múltiple podemos observar en las dimensiones 1 y 2 que existe una correlación fuerte entre el fósforo, proteínas totales y la variación del peso ob-

Tabla 4. Coordenadas de variables en dimensiones del análisis de correspondencias múltiples

Variables	Dim 1	Dim 2	Dim 3	Dim 4	Dim 5
FEMENINO	0,01	0,04	0,22	0,11	0,20
MASCULINO	0,01	0,04	0,22	0,11	0,20
ADOLESCENTE	0,14	0,10	0,14	0,00	0,04
ADULTO JOVEN	0,14	0,00	0,04	0,15	0,00
ADULTO MAYOR	0,04	0,06	0,00	0,19	0,00
GLUCOSA ELEVADA	0,12	0,17	0,02	0,04	0,03
GLUCOSA BAJA	0,13	0,01	0,01	0,05	0,05
GLUCOSA NORMAL	0,06	0,20	0,03	0,02	0,05
UREA ELEVADO	0,02	0,16	0,01	0,06	0,15
UREA NORMAL	0,02	0,16	0,01	0,06	0,15
CREATININA ELEVADA	0,01	0,00	0,08	0,40	0,02
CREATININA NORMAL	0,01	0,00	0,08	0,40	0,02
PROTEINAS ELEVADA	0,37	0,00	0,08	0,03	0,00
PROTEINAS BAJAS	0,00	0,11	0,15	0,20	0,00
PROTEINAS NORMAL	0,10	0,12	0,07	0,15	0,00
ALBÚMINA SÉRICA BAJA	0,07	0,21	0,16	0,06	0,02
ALBÚMINA SÉRICA NORMAL	0,07	0,21	0,16	0,06	0,02
PREALBÚMINA BAJA	0,39	0,05	0,00	0,05	0,03
PREALBÚMINA NORMAL	0,39	0,05	0,00	0,05	0,03
VITAMINA D BAJA	0,12	0,19	0,00	0,05	0,03

servado en los pacientes con neoplasias hematológicas, por lo cual, estos nutrientes desempeñan un papel importante en el mantenimiento, pérdida o ganancia de peso. Esto puede deberse a diferentes factores como consecuencia de la enfermedad o tratamiento. Peiró-Valgañón, V. et al observaron que el tratamiento con fósforo combinado con la quimioterapia tiene un efecto positivo en la recuperación de los pacientes con cáncer[20]. Por lo cual se relaciona con los resultados observados en nuestro estudio y la fuerte relación de fósforo en la variación del peso corporal.

En la figura 1 se observa una asociación entre la variación de peso en el adulto mayor y marcadores bioquímicos como pre albúmina y albúmina. Adicional, nos explica que un 10,3% que la complejidad de la varianza influye de forma alta en la variación del peso. Parodi, A. et al menciona la importancia de la albúmina para la presión osmótica coloidal y transporte de ácidos grasos de cadena corta, nutrientes y minerales. Adicional, la albúmina es sintetizada en el hígado de las personas y los pacientes con neoplasias hematológicas tienen nivel inferiores y estos afectan en el mantenimiento del peso, principalmente de la masa muscular[21]. Xu, M. et al menciona que los niveles de albúmina se ve alterado también por los diversos tratamientos que se utiliza para los pacientes con neoplasias hematológicas[22].

Además, en la figura 3 se establece que los adolescentes mantienen su peso, pero presentan niveles bajos de glucosa que pueden estar relacionados con los procesos metabólicos que experimentan por su estado fisiopatológico.

Este estudio muestra que los marcadores bioquímicos como las proteínas totales, albúmina y fósforo tienen un papel importante en las diferentes variaciones del peso corporal en los pacientes con neoplasias hematológicas. Debido a que estos marcadores formar parte esencial en los procesos metabólicos de la población en estudio y estos cambios se pueden dar por la propia enfermedad o el tratamiento que se esta aplicando en el paciente.

CONCLUSIONES

Se concluye, que los marcadores bioquímicos relacionados con la función renal y metabolismo proteico tienen una relación positiva con los factores socio demográficos en pacientes con neoplasias hematológicas.

Futuros estudios de análisis de correspondencia múltiple son necesarios para confirmar las asociaciones observadas.

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Multi nutrient functional biscuits "Tumiz" improve nutritional status and growth of children; A clinical trial in malnourished rats

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ABSTRACT

Background: The main cause of malnutrition in Indonesia is insufficient nutrient intake, necessitating efforts to supplement nutrients through supplementary feeding. Conversely, Indonesia possesses a variety of local food ingredients that remain underutilized, thus requiring processing to enrich the nutrient content of snacks for combating malnutrition. Previously, we have developed flour-fortified biscuits from local food ingredients that contain complete nutrients (Tumiz). Objectives. This study aims to assess the impact of Tumiz functional biscuits on the nutritional status and growth malnourished Wistar rats.

Methods: Employing a randomized control group pretest-posttest design, male Wistar rats divided into four groups, each comprising 6 samples. These groups included K1: normal rats fed standard food, K-2: malnourished rats given biscuits from the Ministry of Health program, K-3: malnourished rats fed normal food, and K-4: malnourished rats given Tumiz biscuits. The intervention spanned eight weeks, during which body weight, body length, albumin, and IGF-1 levels were measured before and after the intervention.

Results: Significant increases in body weight were observed between pretest-posttest in all groups: K1 (p=0.003), K2 (p=0.006), K3 (p=0.003), and K4 (p=0.003). The greatest increase in body weight over two months was found in group K4. The albumin levels increased in the rats, there was no statistically significant difference in albumin levels before and after the intervention acrossall groups: K1 (p=0.336), K2 (p=0.297), K3 (p=0.191), and K4 (p=0.466). All intervention groups experienced a significant increase in body length ($p<0.05$), including groups K1 ($p<0.001$), K2 (p=0.003), K3 ($p<0.001$), and K4 ($p<0.001$). The increase in body length of group K4 did not differ from group K1. IGF-1 levels of Wistar rats significantly increased in group K4 (p=0.006) and group K2 (p=0.026), while groups K1 and K3 experienced a decrease in IGF-1 levels.

Conclusion: Tumiz biscuits can increase body weight, body length, and IGF-1 levels but have not been able to increase albumin levels in malnourished Wistar rats.

KEYWORDS

Animal models, biochemical markers, food supplementation, experimental research.

INTRODUCTION

Malnutrition, especially in children under five in the global including Indonesia, remains a significant public health problem requiring serious attention. The Nutrition Status Survey of Indonesia (SSGI) 2022 reported a prevalence of underweight of 17.7%, stunting of 29.9%, and wasting of 10.2%[1]. The primary cause of malnutrition is inadequate nutrient intake. Malnutrition during toddlerhood can lead to linear growth deficit, which has short and long term consequences for physical abilities and productivity[2]. Children experiencing growth deficit since in utero and continuing into the postnatal period are at risk of developing various degerative diseases[3]. Malnourished children under five (U5) commonly exhibit increased metabolism, leading to elevated oxidative stress[4].

Intervention strategies to address nutritional deficiencies in U5 children through balanced nutrition and supplementary

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foods may help prevent malnutrition and reduce oxidative stress[5]. Numerous prior studies demonstrated the benefits of utilizing local food sources[6], such as sago worms[7], soybeans, green beans[8,9], and vegetable like carrots[10] in tackling malnutrition. The advancements in food processing technology have facilitated the creation of nutritionally complete flour products, such as multi-nutrient flour (Tumiz)[11].

Tumiz is a functional food flour made from local food ingredients, namely soy bean flour, mung beans, carrots and sago worms so that it contains complete nutrients (multi nutrition). We have developed biscuits through Tumiz fortification so that it has more complete nutrients. Each piece of Tumiz functional biscuit contains 67 kcal energy, 2 g protein, 3.2 g fat, 2.2 mg vitamin A, 0.8 mg iron, 58 mg calcium, 3 mg zinc, 80%DPPH antioxidant[11,12]. Drawing upon the the positive outcomes of previous studies[14], we hypothesized that this biscuit could serve as a valuable nutritional intervention to improve the nutritional status of malnourished children.

Prior to implementation as intervention program to human, preclinical testing involving animal trials, specifically Wistar rat, is conducted. The outcome of this preclinical trial is expected to elucidate the effects of Tumiz biscuits on the growth dan nutritional status of experimental animals. The hypothesis posits that intervention with Tumiz biscuits can enhance growth and nutritional status in children under five. Looking ahead, multi-nutritional snacks hold promise as an alternative for enhancing nutritional status and combating nutritional challenges, especially among children under five.

METHOD

Research Design

This study was conducted with preclinical trials using a randomized controlled group pretest-posttest design, comprising four treatment groups. The intervention lasted for 8 weeks.

Sample

The experimental animals used as samples were Wistar white rats meeting the following criteria: Male sex, aged 5-8 weeks, weighing 100-160 grams, and exhibiting physical health characterized by smooth and clean fur, clear eyes and ears, and good appetite. The rats were procured from the Pharmacology Laboratory of the Faculty of Medicine, Hasanuddin University.

The sample size was calculated based on Freder's formula: $(t-1)(n-1) \geq 15$, where (t=number of groups, n=size of each group, 15=general degrees of freedom). Therefore, the sample size was determined to be 6 rats in each group. Accounting for a 10% estimated mortality rate, the sample size for each group was set 7 rats, resulting in a total sample size of 28 rats.

The sample was divided into four groups. Selection of malnourished rats was conducted through simple random sampling, utilizing a lottery system. Group-1 (K1), consisted of normal rats fed standard food; group-2 (K2) comprised malnourished rats fed biscuits from the Ministry of Health program; group-3 (K3) involved malnourished rats fed standard food; and group-4 (K4) consisted of malnourished rats fed Tumiz biscuits.

This study was conducted in accordance with the ethical guidelines for animal research, as outlined in the Animal Research: Reporting of In Vivo Experiments (ARRIVE) guidelines and the International Guiding Principles for Biomedical Research Involving Animals. The research protocol was approved by the Health Research Ethics Commission (KEPK) of the Faculty of Medicine, Hasanuddin University (266/UN4.6.4.5.31/PP36/2023). All procedures involving animals adhered to the principles of 3Rs (Replacement, Reduction, Refinement) to minimize suffering and enhance animal welfare. The handling of rats was performed by trained personnel following standard operating procedures[15].

Research Treatment

Pre-treatment

Before initiating treatment, all Wistar rat samples underwent weighing and were acclimatized for one week. During the adaptation period, the rats were housed in cages measuring 40 x 20 x 10 cm^3, with a maximum of four rats per cage. The cage temperature was maintained at room temperature. Throughout the adaptation period, the rats were provided with 20 grams of pellets daily and drinking water was available ad libitum.

Pretreatment

Pretreatment was conducted to induce malnutrition conditions in the rats, characterized by a minimum weight loss of 5-10% of their normal body weight. Malnutrition conditions were induced by providing food with low protein content, specifically gogek made from grated cassava. Gogek, similar in size to cassava but smaller, was provided ad libitum at a dosage of 20 grams per day for 14 days. On the 14th day, weight, body length, and blood collection were measured for all samples.

Implementation of the Intervention

The intervention spanned eight weeks, during which the respective food regimens were administered according to group assignments. Feeding was conducted twice daily via a sonde for groups K2 and K4. Groups K1 and K3 were given standard food (AD I Super brand) equivalent to 10% of their body weight. Group K2 received biscuits from the government program (Ministry of Health), while group K4 was provided with Tumiz functional biscuits twice daily at a dosage of 5 grams per administration. The biscuits were initially pulverized using a blender, diluted to a concentration of 1:10, and administered via sonde.

Tumiz functional biscuits are made through the addition of Tumiz flour. The complete composition of Tumiz biscuit ingredients is as follows: 35% multi nutrition flour (Tumiz), wheat flour, powdered sugar, margarine, liquid milk, honey and baking powder[11,12].

Data Collection

Blood serum was collected for albumin and Insulin-like Growth Factor 1 (IGF-1) levels the day before the intervention (pretest) and at the end of week 8 (posttest). Body weight and body length measurements were taken at the beginning of the intervention (pre-test), week 4 (mid-test), and the end of week 8 (post-test). Body length was measured using a Kruuse brand animeter with a scale of 0.1 cm. Body weight was measured using Electronic Weighing Scale PCB model A-007 with a scale of 0.01 kg. Examination of albumin and IGF-1 levels were conducted using the ELISA method at the Hasanuddin University Medical Research Center (HUM-RC) Laboratory.

Albumin levels

Plasma was collected using EDTA or heparin as an anticoagulant. After mixing for 10-20 minutes, samples were centrifuged for 20 minutes at a speed of 2000-3000 RPM to collect the supernatant. Reagent preparation involved several stages: standard reconstitution, wash buffer dilution, and analysis steps, including the addition of standards and samples, incubation, washing, addition of substrate and stop solution, and measurement of optical density (OD) at 450 nm.

Insulin-like Growth Factor 1 (IGF-1) Level

Plasma was collected using EDTA or heparin as an anticoagulant. After centrifugation, samples were either tested immediately or stored at -20°C or -80°C. Reagent preparation involved dilution of standard, detection reagents A and B, wash solution, and TMB substrate. Analysis steps included the addition of standards and samples, incubation, washing, addition of detection reagents, washing, addition of substrate, addition of stop solution, and measurement of OD at 450 nm.

Data processing and analysis

Data from the study were inputted and processed through the IBM SPSS Statistics for Windows, Version 16.0 (IBM Corp, Armonk, New York, United States). Descriptive analysis was applied, and data was presented in mean and standard deviation. Data analysis was performed using a paired two-sample t-test to assess the effect of the intervention on body weight, body length, albumin, IGF-1, and MDA levels between before and after the intervention in each group, and a one-way ANOVA test to analyze differences in changes in body weight, body length, albumin, IGF-1 and MDA levels between groups. Data analysis used a significant level of 5% (α=0.05).

RESULTS

Nutritional Status

During the malnutrition stage, there was a decrease in body weight in groups K2, K3, and K4 of 23.40 kg, 23.98 kg, and 23.54 kg, respectively. No physical changes were observed in

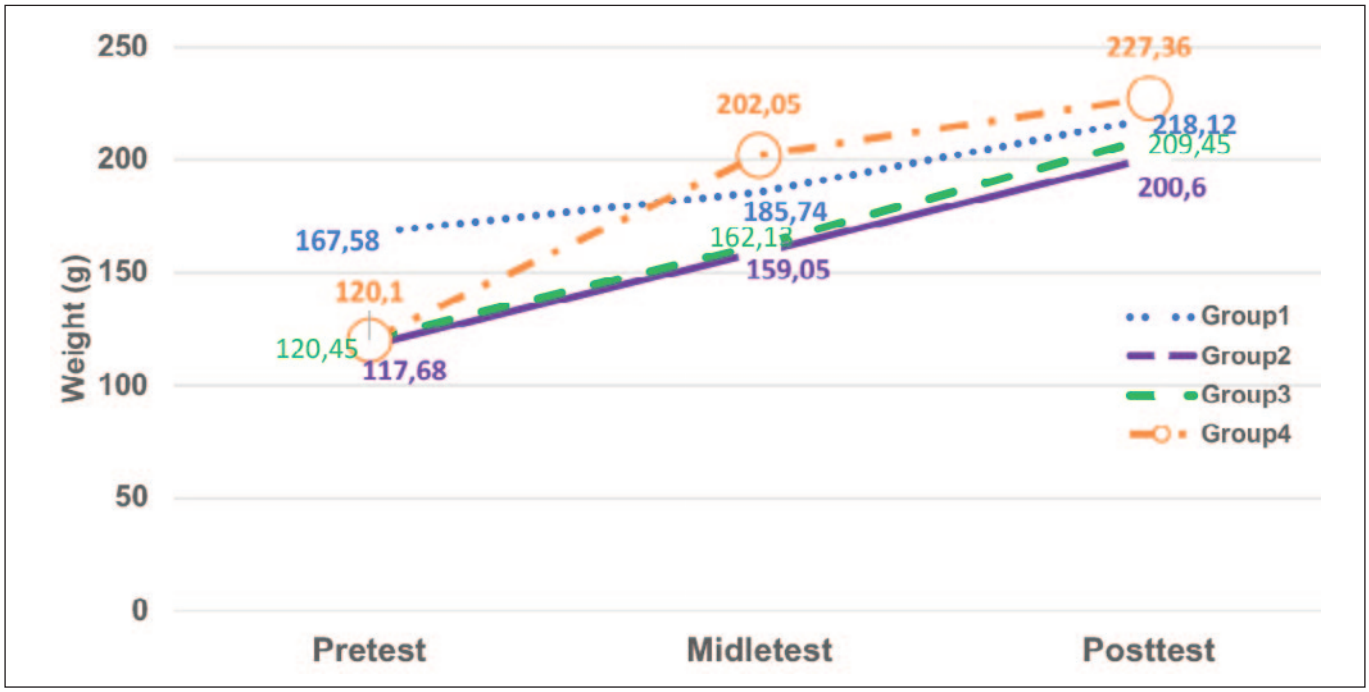

Figure 1. Mean body weight of Wistar rats during the intervention

the rats' fur during this stage, but they appeared less active and exhibited reduced movement. Conversely, rats in group K1 experienced an increase in body weight by 21.4 kg and appeared more agile and active.

The average body weight of K1 rats at the beginning of the intervention was higher than the other groups. However, in terms of weight gain, it can be seen that K4 had a higher weight gain at that stage, and was able to pass the weight of the normal rat group in the fourth week. The average body weight after 1 month of intervention in rats of group K1 = 185.74 g, K2 = 159.05 g, K3 = 162.13 g and K4 = 202.05 g.

After two months of intervention, each group had an average body weight as follows K1 = 218.12 g, K2 = 200.60 g, K3 = 209.45 g and K4 = 227.36 g, respectively. All groups increased during the intervention but Group K3 had a higher body weight.

The body weight of Wistar rats at pretest showed that group K1 weighed significantly higher than group K2 (p=0.002), K3 (p=0.002), and K4 (p<0.001). After one month of intervention, group K1 had an not insignificant weight gain (p=0.098). However, the other intervention groups experienced a significant increase in body weight: both groups K2 (p<0.001), K3 (p=0.005), and K4 (p<0.000). The highest weight gain after one month of intervention was found in group K4, significantly different from group K1 (p=0.009), but not significant from groups K2 and K3.

All intervention groups experienced an increase in body weight in the second month of intervention, but the amount of weight change in each group did not differ significantly between groups (p=0.827). Statistical analysis showed a significant increase in body weight of rats between pretest and posttest in K1 (p=0.003), K2 (p=0.006), K3 (p=0.003), and K4 (p=0.003). The greatest weight gain over two months was found in group K4, and the least in group K1.

Table 2 presents the albumin levels (mean ± standard deviation) of Wistar rats during the intervention. Group K2 exhibited higher final albumin levels (posttest), followed by group K4. Judging from the average increase in albumin levels during the first month of intervention (midtest), it appears that group K4

Table 1. Weight (g) of wistar rats between before and after intervention

Group	Before	Midle test	After	Δ	p-value[1]	p-value[2]
K1 (n=6)	167.58 ± 25.6	185.74 ± 31.8	218.1 ± 37.8	50.58 ± 21.9a	0.098	0.002**
K2 (n=6)	117.68 ± 14.9	159.05 ± 17.7	200.6 ± 30.3	82.70 ± 32.9ab	<0.001***	0.002**
K3 (n=6)	120.45 ± 11.4	162.13 ± 18.8	209.4 ± 35.1	89.00 ± 44.6ab	0.005**	0.002**
K4 (n=6)	120.10 ± 04.3	202.05 ± 23.3	227.4 ± 34.0	105.15 ± 43.2b	<0.001***	<0.001***
p-value[3]	0.000[ttt]	0.236	0.543	0.025[t]		

Description: Before, Midle test and After measurement results are mean ± standard deviation values; Δ = change in weight (g) between pre- and post-intervention; [1]Paired two-samples t-test with significant differences between pre- and midle-intervention at *p<0.05, **p<0.01, ***p<0.001; [2]Paired two-samples t-test with significant differences between pre- and post-intervention at *p<0.05, **p<0.01, ***p<0.001; [3]One-way ANOVA test with significant differences between group at [t]p<0.05, [tt]p<0.01, and [ttt]p<0.001.

Table 2. Albumin level (g/dL) of wistar rats between before and after intervention

Group	Before	After	Δ	p-value[1]
K1 (n=6)	31.528 ± 11.35	27.857 ± 4.69	-3.671 ± 8.44	0.336
K2 (n=6)	30.428 ± 8.12	41.925 ± 20.42	11.49 ± 26.22	0.297
K3 (n=6)	25.071 ± 6.31	20.694 ± 2.34	-4.376 ± 7.085	0.191
K4 (n=6)	25.768 ± 10.48	29.510 ± 6.23	3.741 ± 11.60	0.466
p-value[2]	0.649	[t]0.025[t]	0.226	

Description: Before, Midle test and After measurement results are mean ± standard deviation values; Δ = change in albumin between pre- and post-intervention; [1]Paired two-samples t-test with significant differences between pre- and midle-intervention; One-way ANOVA test with significant differences between group at [t]p<0.05.

experienced a greater increase in albumin levels. Conversely, groups K1 and K3 actually experienced a decrease in albumin levels during the first month of intervention. According to the results of statistical analysis, there was no difference in albumin levels between before and after the intervention in any of the groups: K1 (p=0.336), K2 (p=0.297), K3 (p=0.191), and K4 (p=0.466).

Growth

Graph 2 depicts a consistent increase in the body length of Wistar rats across all groups. Malnourished Wistar rats from group K4 exhibited a slightly higher body length gain compared to the other groups, although the difference was minimal.

Regarding the body length of Wistar rats at pretest, all groups had relatively similar body length (p=0.600). After one month of intervention, all groups experienced a significant increase in body length (p<0.05), including groups K1 (p=0.003), K2 (p=0.019), K3 (p<0.001) and K4 (p=0.015). The magnitude of change in body length of malnourished rats (K2, K3, K4) did not differ significantly from that of the normal rat group (K1).

Table 3. Body length (cm) status of wistar rats at the before and after intervention

Group	Before	Midletest	After	Δ	p-value[1]	p-value[2]
K1 (n=6)	17.9 ± 1.20	20.0 ± 0.70	21.85 ± 1.00	21.85 ± 1.00	0.001**	<0.001***
K2 (n=6)	18.0 ± 0.71	18.75 ± 0.90	21.75 ± 1.00	21.75 ± 1.00	0.016*	0.001**
K3 (n=6)	17.3 ± 0.26	20.13 ± 0.70	21.12 ± 1.00	21.12 ± 1.00	0.013*	<0.001***
K4 (n=6)	18.1 ± 0.20	21.5 ± 0.70	22.50 ± 0.60	22.50 ± 0.60	0.002**	<0.001***
p-value[3]	0.285	0.579	0.251	0.251		

Description: Before, Midle test and After measurement results are mean ± standard deviation values; Δ = change in body length (cm) between pre- and post-intervention. [1]Paired two-samples t-test with significant differences between pre- and midle-intervention at *p<0.05, **p<0.01, ***p<0.001. [2]Paired two-samples t-test with significant differences between pre- and post-intervention at *p<0.05, **p<0.01, ***p<0.001. [3]One-way ANOVA test with significant differences between group.

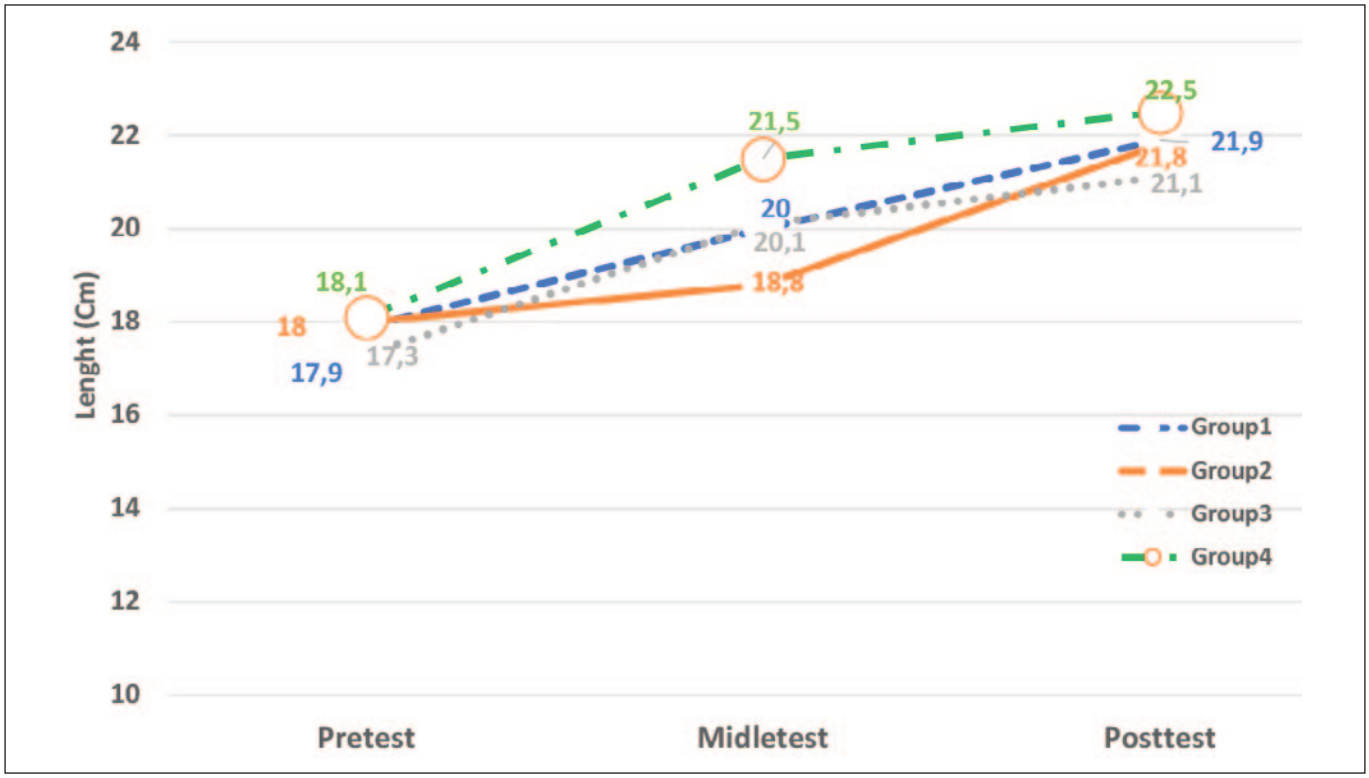

Figure 2. Mean body length (cm) of Wistar rats during intervention

After two months of intervention, all intervention groups experienced a significant increase in body length ($p<0.05$), including groups K1 ($p<0.001$), K2 ($p=0.001$), K3 ($p<0.001$), and K4 ($p<0.001$). The increase in body length of group K4, which received the Tumiz biscuits intervention, did not differ siginifcantly from that of the normal Wistar rat group (K1).

Table 4 presents the IGF-1 levels of Wistar rats during the intervention. Initial IGF-1 levels (pretest) indicated that group K1 rats had significantly higher IGF-1 levels than other groups ($p=0.002$). After completion of the intervention, it was observed that K4 had significantly higher final IGF-1 levels (post-test) than the other groups ($p=0.005$). IGF-1 levels of Wistar rats increased significantly in group K4 ($p=0.006$) and group K2 ($p=0.026$). Conversely, the K1 and K3 groups experienced a decrease in IGF-1 levels.

Similarly, interventions using biscuits made from pumpkin seeds have been shown to increase the body weight of malnourished Wistar rats[17]. Some research on toddlers also yielded similar results. Providing Mama Rani biscuits to undernourished toddlers contributed to an increase in their body weight[18]. We attribute the higher weight gain in the group of malnourished Wistar rats fed Tumiz biscuits to the complete nutritional content of the product, especially its energy, protein, and fat content.

Nutrients like carbohydrates and fats provide energy and building blocks for the body, while protein plays a crucial role in tissue formation. Consumption of foods rich in fat, carbohydrates, and protein can lead to an increase in body weight[19]. The administration of Tumiz biscuits also increased the albumin levels of malnourished Wistar rats. We observed that the

Table 4. IGF-1 level (µg/ml) of wistar rats between before and after intervention

Group	Before	After	Δ	p-value[1]
K1 (n=6)	4.597 ± 0.976	2.575 ± 1.701	-2.021 ± 1.384	0.016**
K2 (n=6)	1.857 ± 1.044	4.220 ± 1.176	2.360 ± 2.058	0.026**
K3 (n=6)	2.155 ± 1.708	2.034 ± 0.815	-0.121 ± 1.626	0.862
K4 (n=6)	2.198 ± 0.641	4.251 ± 0.726	2.052 ± 1.096	0.006*
p-value[2]	0.002[tt]	0.005[tt]	<0.000[ttt]	

Description: Before and After measurement results are mean ± standard deviation values; Δ = change IGF-1 between pre- and post-intervention; [1]Paired two-samples t-test with significant differences between pre- and post-intervention at *p<0.05, **p<0.01, ***p<0.001; [2]One-way ANOVA test with significant differences between group at [t]p<0.05, [tt]p<0.01, and [ttt]p<0.001.

DISCUSION

Nutritional Status

The average body weight of K1 rats at the beginning of the intervention was higher than the other groups. This discrepancy arose because Wistar rats in groups K2, K3, and K4 experienced a weight loss of about 23 grams during the malnutrition process. However, after the 8-week intervention, there was an increase in body weight in all groups. Notably, the increase in body weight of the K4 group, which received Tumiz biscuit intervention, was higher than the other groups. Feeding Tumiz biscuits demonstrated the capacity to increase the body weight of malnourished Wistar rats, effectively restoring their nutritional status. Furthermore, the body weight of K4 rats that received Tumiz biscuits intervention exceeded that of the normal rat group (K1), indicating the superior effects of Tumiz biscuits in increasing the body weight of malnourished Wistar rats compared to government PMT biscuits. Our findings surpass those of interventions using Moringa leaf flour, where the trend of weight gain in the intervention group was lower than the normal rat group[16]. increase in albumin levels in the intervention group was higher than in the two control groups that did not receive the biscuit supplementation intervention, namely groups K1 and K2. Both control groups experienced decreased albumin levels. However, compared to the Ministry of Health biscuit intervention group, the increase in albumin levels in the Tumiz biscuit intervention group was still lower than the results of the government program biscuit intervention. Our findings align with several previous studies, both in animal and human subjects. Rahmawaty (2009) reported that the intervention of tempebrutul biscuits fortified with iron (Fe) and zinc (Zn) could increase body weight and albumin levels in experimental rats suffering from malnutrition[20]. However, providing moringa cookies increased protein intake and body weight but did not been able to increase albumin in undernourished children[21]. Additionally, while the infertvention of tempe bengkuang formula improved nutritional status, it did not increase albumin levels in undernourished toddlers. Conversely, a significant increase in albumin levels occurred in the intervention group of the Kemenkes biscuit program. Providing additional food in the form of multigrain nutritious biscuits was shown to increase

body weight and reduce the prevalence of wasting in malnourished children[22].

Growth

We observed consistent growth in body length of Wistar rats across all groups. Group K4 exhibited a higher growth rate compared to the normal rats in group K1. Likewise, group K2, which received the biscuit intervention program, showed growth patterns resembling those of normal rats, albeit slightly lower than group K4. On the other hand, group K3 which received normal food intervention, experienced slower growth towards the end of the intervention, though this did not significantly affect the increase in body length.

The change in body length of malnourished Wistar rats in group K4 and group K2 during the 8-week intervention was 5.5 cm and 4.25 cm, respectively. This increase in body length for the two groups was greater than that observed in the normal rat group (K1) and control group K3, which measured 3.93 cm and 3.68 cm, respectively. We also noted the elevation of IGF-1 levels in groups K4 (2.052 µmol/L) and K2 (2.360 µmol/L). Different result were shown in the group K1 (-2.021 µmol/L) and K3 (-0.121 µmol/L) where experienced a decrease in IGF-1 levels. These findings suggest that the feeding intervention in the form of functional multigrain biscuits (Tumiz) can enhance the body length growth of malnourished rats. Although the difference in body length increase was not statiscally significant, the body length growth rate of the Tumiz biscuit intervention group was higher than that of the normal rat group. Malnutrition leads to decreased growth, as reflected by lower IGF-1 levels. Malnourished rats typically exhibited lower IGF-1 levels compared to normal rats, as observed at the beginning (pretest) of our study. Our finding is supported by the finding of a study in Burkina Faso that shows low IGF-1 levels in malnourished children. This study suggested that differences in food intake may contribute to variations in IGF-1 levels. IGF-1 concentration is positively correlated with the growth and nutritional status of children[23].

The Tumiz biscuit intervention can gradually increase IGF-1 levels and body length in rats. The effect of our intervention mirrored that of the Ministry of Health's program biscuits, resulting in a growth rate of rats at the end of the study higher than that of normal rats. We attribute this effect to the comprehensive nutritional content of Tumiz biscuits, including protein, fat, vitamin A, calcium, and zinc. These nutrients play crucial role in linear growth. Tumiz, made from local functional foods such as soybean, green bean, and sago worm, contains essential amino acids and fatty acids vital for growth[24,13]. The content of these nutrients in the Tumiz biscuits resemble the nutrients in the Ministry of Health program biscuits, which have been shown to increase children's body length in the previous study[25]. This finding corroborates previous research indicating that processed ingredients and products, such as fish, can mitigate impaired height growth in stunted children[26]. Tumiz biscuits also possess high micronutrient potential, particularly zinc, calcium, phosphorus, and iron, essential for supporting children's height growth[27].

Rats supplemented with Tumiz biscuits exhibited increased linear growth, as reflected by changes in height during the intervention. These results aligned with previous findings in toddlers through the intervention of local snacks enriched with shellfish flour[26]. The high micronutrient levels in Tumiz biscuit supplements are believed to support this growth. Micronutrients, especially zinc, play a crucial role in growth. Zinc-enriched diets have been shown to enhance linear growth and reduce the prevalence of growth disorders in children under five years old[17]. Another important nutrient contained in the Tumiz biscuits is β-carotene, which is beneficial for supporting infant growth. Although we did not measure retinol levels in this study, there is a positive correlation between serum retinol and IGF-1 levels[28]. Several previous studies have highlighted the role of vitamin A in growth indicators. Studies in healthy infants in Indonesia[29] and newborns in Canada[30], showed lower IGF-1 levels in vitamin A-deficient toddlers compared to normal children.

CONCLUSION AND RECOMMENDATIONS

Administration of Tumiz biscuits showed notable effects in increasing the body weight of malnourished Wistar rats; however, this did not lead to an increase in albumin levels. In contrast, intervention with Tumiz biscuits showed promising results in increasing body length and IGF levels in malnourished Wistar rats. Further research is needed in the form of clinical trials to determine the effectiveness of Tumiz biscuits in improving the nutritional status and growth of undernourished children.

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Comparative analysis of malnutrition screening tools in predicting mortality in critically ill patients: SGA, GLIM, and mNutric Score

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ABSTRACT

Introduction: Malnutrition is prevalent among critically ill patients and is associated with increased mortality, prolonged hospital stays, and higher rates of complications. Several malnutrition screening tools are available, including the Subjective Global Assessment (SGA), the Global Leadership Initiative on Malnutrition (GLIM), and the modified Nutrition Risk in Critically Ill (mNutric) Score. This study aims to compare the predictive ability of these three tools in determining mortality among critically ill patients.

Methods: A retrospective cohort study was conducted in the Intensive Care Unit (ICU) of RSUP Dr. Wahidin Sudirohusodo from April 2022 to March 2023. Patients aged 18 years and older were included. Nutritional status was assessed using SGA, GLIM, and mNutric Score. Statistical analyses were performed to compare groups (e.g., survivors vs. non-survivors) and to identify independent predictors of mortality. Multivariable logistic regression was conducted to determine the independent predictive value of each malnutrition screening tool.

Result: A total of 1,106 patients were included in the analysis. The overall ICU mortality rate was 23.1%. The mNutric Score was a significant independent predictor of mortality (OR = 6.601, 95% CI: 4.183–10.416, $p < 0.001$), while neither SGA nor GLIM were significant after adjustment for confounders.

Conclusion: The mNutric Score is a superior tool for predicting mortality in critically ill patients compared to SGA and GLIM. Its use should be considered in ICU settings to identify patients at nutritional risk and guide timely interventions.

KEYWORDS

Nutritional support, intensive care, medical prognosis.

INTRODUCTION

Malnutrition is a common concern in critically ill patients, particularly those admitted to the intensive care unit (ICU). The prevalence of malnutrition in this population is high, and it is associated with poor clinical outcomes, including increased mortality, prolonged hospital stays, and higher rates of complications[1,2]. Identifying patients at nutritional risk early in their ICU stay is critical for improving outcomes through timely nutritional interventions[3,4].

Several tools have been developed to assess nutritional status in critically ill patients, each with varying levels of accuracy and clinical utility[5]. The Subjective Global Assessment (SGA) is one of the oldest and most widely used tools, assessing patients' nutritional status based on clinical judgment[6,7]. The more recent Global Leadership Initiative on Malnutrition (GLIM) criteria offer a standardized approach to diagnosing malnutrition, incorporating phenotypic and etiologic factors[8,9]. Meanwhile, the modified Nutrition Risk in Critically Ill (mNutric) Score was specifically designed for ICU patients, considering factors such as comorbidities and disease severity to predict nutritional risk and outcomes[10].

Given the array of tools available, determining the most reliable and effective method for predicting clinical outcomes in

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critically ill patients is crucial[11]. This study compares the performance of the SGA, GLIM, and mNutric Score in predicting mortality among critically ill patients. By evaluating the predictive ability of each tool, this research aims to provide insights into which screening method is most suitable for guiding nutritional interventions in the ICU setting.

METHODS

Study Design and Population

This retrospective cohort study was conducted in the Intensive Care Unit (ICU) of RSUP Dr. Wahidin Sudirohusodo, Makassar, from April 2022 to March 2023. Patients aged 18 years and older who were admitted to the ICU during the study period were included in the analysis. Individuals with incomplete medical records or missing nutritional assessment data were excluded. The study was approved by the ethics committee of the university and hospital which ensure the confidentiality of all the patient's data throughout the research process.

Variable and Data Collection

For each patient, demographic information, including age, gender, and admission type was collected from electronic medical records. Nutritional status was assessed using the three screening tools mentioned above. The Subjective Global Assessment (SGA) categorized patients into three groups based on a combination of medical history (weight loss, dietary intake, gastrointestinal symptoms, functional status) and physical examination findings (muscle wasting, subcutaneous fat loss, and fluid retention). Patients were classified as well-nourished (SGA A), moderately malnourished (SGA B), or severely malnourished (SGA C)[12,13]. The Global Leadership Initiative on Malnutrition (GLIM) criteria diagnosed malnutrition based on the presence of one phenotypic and one etiologic criterion. Phenotypic criteria included weight loss greater than 5% within 6 months or more than 10% beyond 6 months, a body mass index (BMI) below 20 kg/m² for patients under 70 years or below 22 kg/m² for patients over 70 years, and reduced muscle mass determined through clinical assessment or imaging. Etiologic criteria included reduced food intake or assimilation of less than 50% of energy requirements for more than one week and the presence of acute or chronic disease-related inflammation. Patients were classified as having no malnutrition, moderate malnutrition if one phenotypic and one etiologic criterion were met, or severe malnutrition if severe phenotypic and one etiologic criterion were met[14,15]. The modified Nutrition Risk in Critically Ill (mNutric) Score assessed nutritional risk based on factors such as age, APACHE II score, SOFA score, comorbidities, and hospital length of stay before ICU admission. A score below 5 indicated low risk, whereas a score of 5 or above indicated high risk[16].

Statistical Analysis

Descriptive statistics were used to summarize the characteristics of the study population. Categorical variables were presented as frequencies and percentages, while continuous variables were summarized using means and standard deviations or medians with interquartile ranges, depending on the distribution of the data. The association between nutritional status and mortality was analyzed using bivariate methods, including chi-square tests for categorical variables and independent t-tests or Mann-Whitney U tests for continuous variables. To determine the independent predictive value of each malnutrition screening tool for mortality, multivariable logistic regression was performed. A p-value of less than 0.05 was considered statistically significant for all analyses, and SPSS 25.0 (IBM Corp., Armonk, NY) was used for data analysis.

RESULTS

In this study, a total of 1,189 patients were admitted to the ICU from April 2022 to March 2023 and initially considered for inclusion in the analysis is illustrated in Fig 1. However, after applying the exclusion criteria, 83 patients were excluded from the study because they were younger than 18 years old. This left 1,106 patients who met the inclusion criteria and were eligible for further analysis.

Baseline characteristic of the population was provided in Table 1. The median age of the patients was 55 years (IQR: 45–63), and 58% were male. Most patients were admitted for medical reasons (72%), while the remainder were surgical admissions (28%). The median body mass index (BMI) was 23.4 kg/m² (IQR: 21.0–26.5). Regarding nutritional status, the Subjective Global Assessment (SGA) classified 33.6% of patients as well-nourished (SGA A), 45.8% as moderately malnourished (SGA B), and 20.6% as severely malnourished (SGA C). Using the Global Leadership Initiative on Malnutrition (GLIM) criteria, 48.2% of patients were classified as not malnourished, 33.9% as moderately malnourished, and 17.9% as severely malnourished. The mNutric Score identified 37.2% of patients as having a low risk of malnutrition (mNutric score < 5) and 62.8% as high risk (mNutric score ≥ 5). In patients classified by the mNutric Score, those with a high risk of malnutrition (mNutric score ≥ 5) had a mortality rate of 36.5%, compared to 12.3% in the low-risk group ($p < 0.001$).

The multivariable logistic regression results were summarized in Table 2. In the multivariable logistic regression analysis, after adjusting for age, sex, BMI, and admission type, the mNutric score remained a significant independent predictor of mortality (OR = 6.601, 95% CI: 4.183–10.416, $p < 0.001$). Neither the SGA (OR = 1.058, 95% CI: 0.762–1.468, $p = 0.738$) nor the GLIM (OR = 0.946, 95% CI: 0.762–1.174, $p = 0.612$) were significant predictors of mortality after adjustment for confounders.

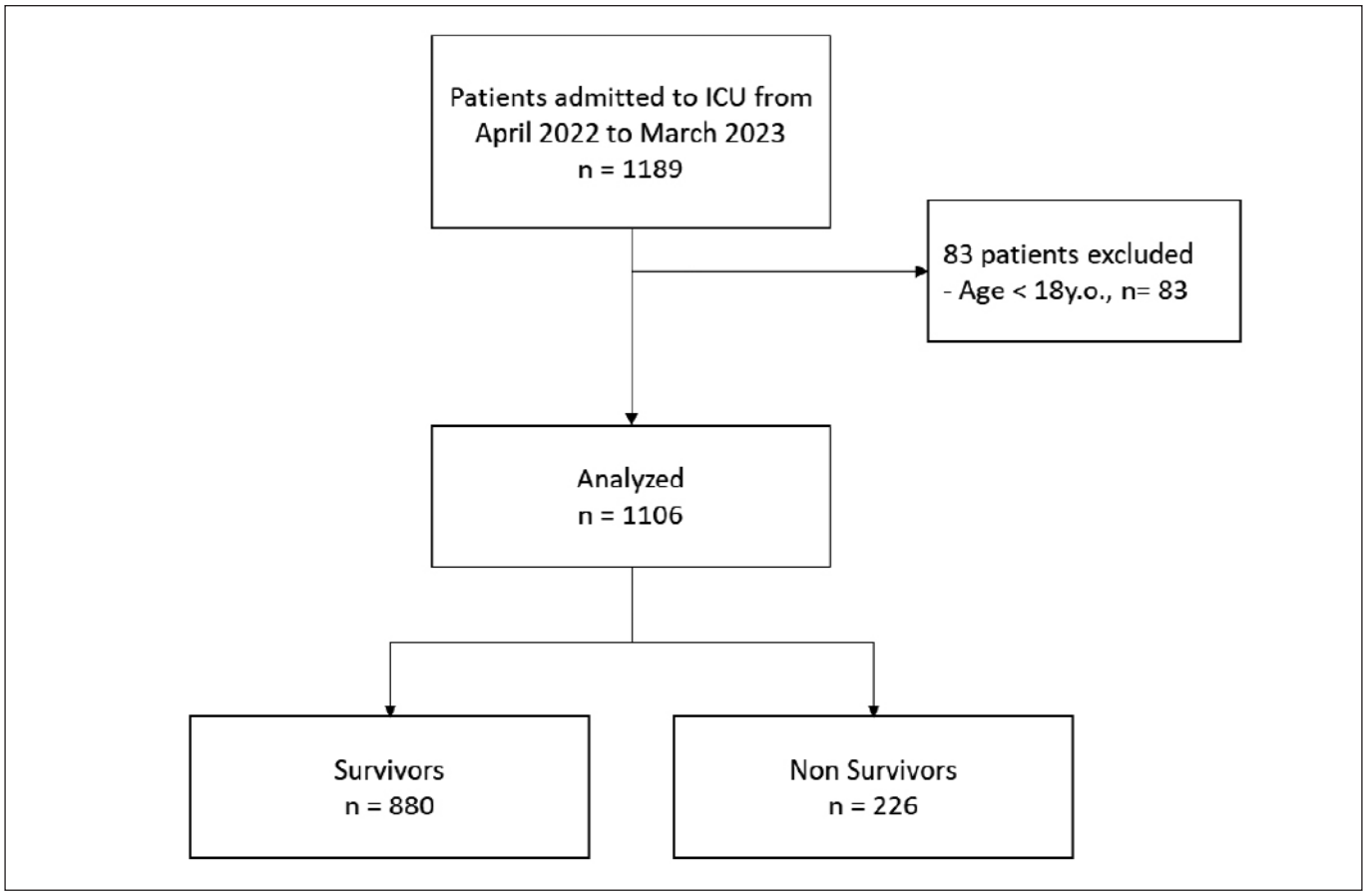

Fig. 1. Flowchart of the study patients

DISCUSSION

This study aimed to evaluate the predictive ability of three malnutrition screening tools—Subjective Global Assessment (SGA), Global Leadership Initiative on Malnutrition (GLIM), and the modified Nutrition Risk in Critically Ill (mNutric) Score—in determining mortality in critically ill patients. Our findings show that the mNutric score is a superior predictor of mortality compared to both SGA and GLIM, with significantly higher discriminatory power as demonstrated by the ROC curve analysis. These results highlight the importance of using ICU-specific tools for assessing malnutrition in critically ill patients[17,18].

The mNutric score emerged as the strongest independent predictor of mortality. This is consistent with previous studies that have validated the mNutric score as a reliable tool for critically ill populations, where the risk of malnutrition is closely tied to disease severity, organ dysfunction, and inflammation[10,16,19]. In contrast, the SGA and GLIM tools, though widely used in general hospital settings, showed moderate predictive ability for mortality in the ICU. The SGA tool, which is based on clinical judgment and subjective criteria such as weight loss and physical examination findings, may lack sensitivity in detecting malnutrition in the critically ill, where rapid changes in nutritional status and the impact of acute illness are not fully captured[6,7]. Similarly, the GLIM criteria, while standardized and widely applicable, may not fully account for the metabolic and inflammatory alterations that occur in critical illness[8,9,15].

While this study provides valuable insights, there are limitations that should be acknowledged. First, the retrospective nature of the study may introduce selection bias, and the use of electronic medical records may result in incomplete or missing data. Additionally, the study was conducted in a single center, which may limit the generalizability of the findings to other ICU settings. Future studies should consider prospective, multicenter designs to validate the findings and explore the use of the mNutric score in other critically ill populations, including patients with specific diseases such as sepsis or trauma.

CONCLUSION

In conclusion, the mNutric score is a superior tool for predicting mortality in critically ill patients compared to SGA and GLIM. Given its strong predictive ability, the mNutric score should be considered for routine use in ICU settings to

Table 1. Baseline characteristics of the study patients

	Survivors (n=880)	Non Survivors (n=226)	p Value
Age, year	50.0 [37.0, 60.0]	55.5 [41.0, 67.0]	<0.001
Sex			<0.001
Men	401 (45.6)	131 (58.0)	
Woman	479 (54.4)	95 (42.0)	
Height, cm	160.0 [155.0, 165.0]	160.0 [155.0, 165.0]	0.105
Weight, kg	60.0 [50.0, 63.0]	60 [50.0, 64.0]	0.235
BMI, kg/m2	22.22 [20.56, 24.61]	22.22 [20.81, 23.92]	0.690
BMI Category			0.921
<18.5	94 (10.7)	21 (9.3)	
18.5 - 22.9	412 (46.8)	102 (45.1)	
23 - 24.9	192 (21.8)	53 (23.5)	
25 - 29.9	165 (18.8)	46 (20.4)	
>30	17 (1.9)	4 (1.8)	
Admission Type			<0.001
Medical	84 (37.2)	123 (14)	
Surgical	142 (62.8)	757 (86)	
mNutric Score			<0.001
Low Risk	830 (94.3)	150 (66.4)	
High Risk	50 (5.7)	76 (33.6)	
SGA			0.655
A	158 (17.9)	40 (17.7)	
B	538 (61.2)	135 (50.7)	
C	184 (20.9)	51 (22.6)	
GLIM			0.763
Not Malnourished	231 (26.3)	64 (28.3)	
Moderate	439 (49.9)	107 (47.3)	
Severe	210 (23.9)	55 (24.3)	

Data are presented as n (%) or median (interquartile range).
BMI, Body Mass Index; mNutric Score, modified Nutrition risk in critically ill; SGA, Subjective Global Assessment; GLIM, Global Leadership Initiative on Malnutrition.

Table 2. Regression Analysis of Malnutrition Tools Predicting Mortality

	OR	95% CI	p Value
mNutric Score	6.601	4.183 - 10.416	<0.001
SGA	1.058	0.762 - 1.468	0.738
GLIM	0.946	0.762 - 1.174	0.612

Adjusted for age, sex, BMI, Admission Type.
BMI, Body Mass Index; mNutric Score, modified Nutrition risk in critically ill; SGA, Subjective Global Assessment; GLIM, Global Leadership Initiative on Malnutrition.

identify patients at nutritional risk and guide timely nutritional interventions.

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Ingesta de alimentos asociados a la desnutrición crónica en niños peruanos menores de 5 años con y sin lactancia materna

Food intake associated with chronic malnutrition in Peruvian children under 5 years of age with and without breastfeeding

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RESUMEN

Objetivo: Determinar la ingesta de alimentos asociados a la desnutrición crónica en niños peruanos menores de 5 años con y sin lactancia materna.

Material y métodos: El diseño de la investigación es no experimental, enfoque cuantitativo, observacional, descriptivo y transversal. La muestra fue de 11.583 niños menores de 5 años, siendo el estudio un análisis secundario de la base de datos de la Encuesta Nacional Demográfica y Salud Familiar del 2022. Se utilizó el modelo estadístico de regresión logística binaria, la variable dependiente es desnutrición crónica (no/si) y las variables predictoras fueron los alimentos que brindaron al niño el día de ayer durante el día o la noche (no/si).

Resultados: Los niños que no reciben lactancia materna, tienen mayor riesgo de padecer desnutrición crónica si no consumen: agua (p=0,001, OR=1,269), jugo de fruta (p=0,001, OR=1,256), cualquier comida hecha de cereales (p=0,015, OR=1,279), carne de res, hígado, otras vísceras (p=0,008, OR=1,209), Carne de pollo, pescado, mariscos, mondongo, otras carnes (p=0,009, OR=1,206) y vegetales de hoja verde oscuro (p=0,029, OR=1,156), además los que no consumieron bebidas gaseosas y caldo (p=0,011, OR=0,850) tienen menos riesgo de presentar desnutrición crónica. Los niños amamantados tienen menor riesgo de desnutrición crónica si no ingieren té o café (p=0,013, OR=0,860) y las papillas de los programas sociales (p=0,028, OR=0,612).

Conclusiones: Los niños sin lactancia materna que no consumieron bebidas gaseosas y caldo tienen menos riesgo de presentar desnutrición crónica, sin embargo, los niños con lactancia materna que no ingieren té o café y las papillas de los programas sociales del gobierno peruano presentan menor riesgo de desnutrición crónica.

PALABRAS CLAVE

Desarrollo infantil; Crecimiento físico; Consumo proteico; Carencias nutricionales.

ABSTRACT

Objective: To determine food intake associated with chronic malnutrition in Peruvian children under 5 years of age with and without breastfeeding.

Material and methods: The design of the research is non-experimental, quantitative, observational, descriptive and cross-cutting. The sample included 11.583 children under the age of 5 and the study was a secondary analysis of the 2022

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National Demographic and Family Health Survey database. The binary logistic regression statistical model was used, the dependent variable is chronic malnutrition (no/yes) and the predictor variables were the foods given to the child yesterday during the day or night (no/yes).

Results: Children who are not breastfed have a higher risk of suffering from chronic malnutrition if they do not consume: water (p = 0.001, OR = 1.269), fruit juice (p = 0.001, OR = 1.256), any food made from cereals (p = 0.015, OR = 1.279), beef, liver, other viscera (p = 0.008, OR = 1.209), chicken meat, fish, shellfish, tripe, other meats (p = 0.009, OR = 1.206) and dark green leafy vegetables (p = 0.029, OR = 1.156), in addition those who did not consume soft drinks and broth (p = 0.011, OR = 0.850) have a lower risk of presenting chronic malnutrition. Breastfed children have a lower risk of chronic malnutrition if they do not consume tea or coffee (p=0.013, OR=0.860) and porridge from social programs (p=0.028, OR=0.612).

Conclusions: Non-lactating children who did not consume soft drinks and broth are less likely to develop chronic malnutrition, however, breast-feeding children who do not drink tea or coffee and are influenced by the Peruvian government's social programs have a lower risk of chronic undernourishment.

KEYWORDS

Child development; Physical growth; Protein consumption; Nutritional deficiencies.

INTRODUCCIÓN

Para garantizar el crecimiento y desarrollo del niño durante la infancia y los primeros años de vida, es fundamental una nutrición adecuada. Además, una nutrición adecuada y el acceso a alimentos saludables, constituyen derechos fundamentales en los niños con la finalidad de que estos puedan alcanzar una óptima salud[1]. La Organización Mundial de la Salud (OMS) y el Fondo de las Naciones Unidas para la Infancia (UNICEF) recomiendan la lactancia materna exclusiva hasta los 6 meses de edad y una lactancia materna continua hasta los 2 años de edad o más. Alrededor del 44% de los niños de 0 a 6 meses en todo el mundo fueron amamantados exclusivamente durante el período 2015-2020[2].

Por ello, los primeros 1.000 días de la vida de un niño es considerado una etapa crítica de desarrollo para prevenir el retraso del crecimiento infantil, sin embargo, a pesar de varios programas de intervención, esta prevalencia global sigue siendo alta[3]. Asimismo, la OMS refiere que la desnutrición está asociada al 45% de las muertes infantiles y estimó que, a nivel mundial, en el año 2022, 149 millones de niños menores de 5 años tenían retraso del crecimiento (talla baja para la edad)[2].

Por tanto, la lactancia materna exclusiva durante los primeros 6 meses es beneficiosa para el desarrollo del peso de los bebés en la infancia[4], protege a los bebés contra la diarrea, la neumonía y otras enfermedades infecciosas, además, es fuente principal de energía y nutrientes durante las enfermedades y reduce la mortalidad infantil principalmente en niños desnutridos[5].

Por otro lado, se ha reportado que pocos niños reciben alimentos complementarios nutricionalmente adecuados y seguros, menos de una cuarta parte de los bebés de 6 a 23 meses de edad cumplen los criterios de diversidad dietética y frecuencia de alimentación apropiados para su edad[2]. Algunos estudios han demostrado que, independientemente del tipo y duración de la lactancia materna, esta se asocia con un riesgo reducido a la mitad de aumento rápido de peso o crecimiento acelerado[6,7]. Por lo que, si no se introducen alimentos complementarios o no se proporcionan de forma adecuada, el crecimiento del niño puede verse afectado.

Por lo expuesto, el objetivo del estudio fue determinar la ingesta de alimentos asociados a la desnutrición crónica en niños peruanos menores de 5 años con y sin lactancia materna.

MATERIALES Y MÉTODOS

El diseño de la investigación es no experimental, enfoque cuantitativo, observacional, descriptivo y transversal. Este estudio es un análisis secundario de la base de datos de la Encuesta Nacional Demográfica y Salud Familiar (ENDES) del año 2022[8].

Población y muestra

La población del estudio fue 18616 niñas/os menores de 5 años de madres de 12 a 49 años de edad, nacidos desde enero del 2019 y que viven con la madre. Se empleó la base de datos de la ENDES del año 2022, que fue desarrollado en los meses de enero a diciembre del año 2022[8].

La muestra se caracteriza por ser bietápica, probabilística de tipo equilibrado, estratificada e independiente, a nivel departamental, por área urbana y rural[8].

Para el estudio se eliminaron 7033 casos entre ellos datos perdidos, respuestas no sabe/no recuerda, por lo que se obtuvo una muestra de 11583 niños menores de 5 años.

Variable e Instrumentos

El cuestionario consta de 167 variables de las cuales se eligieron aquellas sobre ingesta de alimentos que dio al niño ayer durante el día o la noche[9]. Las otras variables a considerar se refirieron a sí fueron amamantados o no y la talla para la edad según Desviación Estándar establecido por la OMS: (DE: <-3= Desnutrición crónica severa, -3 a-2= Desnutrición crónica, -2 a -1= Riesgo de desnutrición crónica, -1 a 3= normal y >3= Talla alta)[10].

Recopilación de los datos

La ENDES es una encuesta nacional anual, realizada por el Instituto Nacional de Estadística e Informática (INEI). La base de datos se obtuvo en la sección «consulta por encuestas» de la encuesta ENDES del año 2022, microdatos, código módulo 1634 encuesta de salud sobre inmunización y salud, del portal web del Instituto Nacional de Estadística e Informática (INEI)[8]. Luego se exportó la data al programa SPSS y finalmente se seleccionó las variables del estudio para su análisis descriptivo e inferencial, de aquellos que resultaron significativos. La base de datos fue tomada de una fuente secundaria del INEI-ENDES 2022 de acceso libre y que autoriza el uso de la información.

Análisis estadístico

Se utilizó el Software SPSS 26 para el desarrollo del análisis de datos y se realizó un análisis descriptivo de los mismos. Se empleó la prueba de Chi cuadrado para relacionar el diagnóstico de talla para la edad con la lactancia materna (no/si) y la prueba de U de Mann-Whitney para determinar si existe diferencia en la talla para la edad según lactancia materna. También se utilizó el modelo de regresión logística binaria, en el cual la variable dependiente es desnutrición crónica (no/si) y las variables independientes o predictoras fueron los alimentos que brindaron al niño el día de ayer durante el día o la noche (no/si). Se aplicó un nivel de significancia $p<0.05$.

RESULTADOS

En la tabla 1, se muestra que la mayoría de los niños con o sin lactancia materna toman agua sola y no beben jugos de fruta. Y los niños sin lactancia materna en su gran mayoría consumen carne de pollo, pescado, mariscos o mondongo, además de productos elaborado a base de harina o cereales (pan, fideos, galletas, etc); pero no ingieren vegetales de hoja verde oscuro, carne de res, hígado u otras vísceras, ni tampoco toman bebidas gaseosas o caldos. Mientras que, la mayor parte de los niños con lactancia materna no consumen fórmulas maternizadas, papillas de programas sociales y no beben té o café.

En la tabla 2, existe diferencia y relación entre la talla para la edad y la lactancia materna (p=0,001), el 37,4% de los niños sin lactancia materna presentaron más riesgo de desnutrición crónica, así como un 50,7% de desnutrición crónica, comparado con los niños que fueron amamantados que obtuvieron una prevalencia del 34,7% y 46,9% respectivamente. Por otro lado, el 53,1% de los niños amamantados y el 49,3% de niños que no fueron amamantados presentaron talla adecuada respectivamente.

Respecto a los niños que no reciben lactancia materna, tienen mayor riesgo de padecer desnutrición crónica si no consumen: agua, jugo de fruta, cereales, carne de res, hígado, otras vísceras, carne de pollo, pescado, mariscos, mondongo, otras carnes y vegetales de hoja verde oscuro. Sin embargo, en aquellos niños sin lactancia materna que no consumieron bebidas gaseosas y caldo tienen menor riesgo de presentar desnutrición crónica (Tabla 3).

Tabla 1. Ingesta de alimentos que le brindó al niño durante el día o la noche de ayer

Ayer durante el día o la noche que consumió el niño		Niños sin lactancia materna		Niños con lactancia materna	
		n	%	n	%
Agua sola	No	1084	26,2	3161	42,5
	Sí	3053	73,8	4285	57,5
Jugo de fruta	No	2657	64,2	5466	73,4
	Sí	1480	35,8	1980	26,6
Otro líquido como bebidas gaseosas, caldo	No	2363	57,1	-	-
	Sí	1774	42,9	-	-
Harina, pan, fideos, galletas u cualquier comida hecha de cereales	No	462	11,2	-	-
	Sí	3675	88,8	-	-
Carne de res, hígado, otras vísceras	No	2795	67,6	-	-
	Sí	1342	32,4	-	-
Carne de pollo, pescado, mariscos, mondongo, otras carnes	No	1296	31,3	-	-
	Sí	2841	68,7	-	-
Cualquier vegetal de hoja verde oscuro (espinaca, acelga etc.)	No	2603	62,9	-	-
	Sí	1534	37,1	-	-
Té o café	No	-	-	6110	82,1
	Sí	-	-	1336	17,9
Leche en polvo (fórmulas maternizadas)	No	-	-	6453	86,7
	Sí	-	-	993	13,3
Papillas de programas sociales	No	-	-	7361	98,9
	Sí	-	-	85	1,1
Total		**4137**	**100**	**7446**	**100,0**

Por otro lado, los niños que reciben lactancia materna, evidenciaron que aquellos que no ingieren: agua, jugo de fruta, leche en polvo (fórmulas maternizadas) tienen mayor riesgo de padecer de desnutrición crónica. Asimismo, este grupo al no ingerir té /café y las papillas de los programas sociales del gobierno peruano evidenciaron menor riesgo de desnutrición crónica (Tabla 4).

Tabla 2. Relación entre la lactancia materna y la talla para la edad

Talla para la edad	Lactancia materna				p-valor
	NO		SI		
	%	n	%	n	
Desnutrición crónica severa	13,3	552	12,2	905	0,001
Desnutrición crónica	37,4	1545	34,7	2590	
Riesgo de desnutrición crónica	34,8	1441	32,4	2414	
Normal	14,5	599	20,7	1537	
Total	**100**	**4137**	**100**	**7446**	

(p=0,001), al respecto, Taboada et al.[9],, encontraron que los niños menores de cinco años con cardiopatía congénita que recibieron lactancia materna tuvieron menor riesgo de padecer retardo en el crecimiento. No obstante, Dharod et al.[11], manifestaron que los lactantes amamantados más allá de los 6 meses tuvieron un crecimiento significativamente más bajo que los lactantes amamantados durante 0 a 2 meses (p = 0,001).

La lactancia materna es un factor importante para combatir la desnutrición, porque proporciona los nutrientes necesarios para el desarrollo infantil durante los primeros meses de vida, además un niño con desnutrición y sin lactancia en la primera infancia tendrá una tasa de crecimiento más lenta[12].

El estudio evidenció que los niños con o sin lactancia materna, tienen más riesgo de padecer desnutrición crónica si no consumen: agua, jugo de fruta y leches maternizadas, cereales, carnes y vegetales de hoja verde oscura (p<0,05). Actualmente, existe poca evidencia sobre el tema; sin embargo, algunos estudios sostienen que los malos hábitos alimentarios afectan el crecimiento de los niños de varias maneras, incluyendo la reducción de la inmunidad y la capacidad del cuerpo para luchar contra las enfermedades, la reducción de la aptitud física y el aumento del riesgo de varias condiciones carenciales como la anemia por falta de hierro[13,14]. Otro estudio reportó que, aquellas madres con acceso a información sobre nutrición, la exposición de las madres a los medios de comunicación y el buen conocimiento de

Tabla 3. Ingesta de alimentos asociados a la desnutrición crónica en Niños sin Lactancia Materna

Niños sin lactancia materna									
Ayer durante el día o la noche qué consumió el niño:		B	Error estándar	Wald	gl	Sig.	Exp(B)	95% C.I. para EXP(B)	
								Inferior	Superior
Agua sola	No/Si	0,238	0,072	10,966	1	0,001	1,269	1,102	1,461
Jugo de fruta	No/Si	0,228	0,067	11,499	1	0,001	1,256	1,101	1,434
Otro líquido como bebidas gaseosas y caldo	No/Si	-0,163	0,064	6,457	1	0,011	0,850	0,750	0,963
Cualquier comida hecha de cereales, harina, pan, fideos, galletas.	No/Si	0,246	0,101	5,970	1	0,015	1,279	1,050	1,558
Carne de res, hígado, otras vísceras	No/Si	0,190	0,072	7,010	1	0,008	1,209	1,051	1,391
Carne de pollo, pescado, mariscos, mondongo, otras carnes	No/Si	0,187	0,072	6,828	1	0,009	1,206	1,048	1,388
Cualquier vegetal de hoja verde oscura (espinaca, acelga etc.)	No/Si	0,145	0,066	4,773	1	0,029	1,156	1,015	1,317
Constante		-0,426	0,118	12,987	1	0,001	0,653		

DISCUSIÓN

Los primeros años de vida constituyen una oportunidad crucial para garantizar el crecimiento y el desarrollo adecuados de los niños, siempre y cuando tengan una alimentación adecuada.

Los resultados evidenciaron que existe diferencia y relación entre la talla para la edad entre niños con la lactancia materna

Tabla 4. Ingesta de alimentos asociados a la desnutrición crónica en Niños con Lactancia Materna

Niños con lactancia materna									
Ayer durante el día o la noche qué consumió el niño:		B	Error estándar	Wald	gl	Sig.	Exp(B)	95% C.I. para EXP(B)	
								Inferior	Superior
Agua sola	No/Si	0,212	0,048	19,463	1	0,001	1,236	1,125	1,359
Jugo de fruta	No/Si	0,152	0,054	7,991	1	0,005	1,165	1,048	1,295
Té o café	No/Si	-0,151	0,061	6,143	1	0,013	0,860	0,763	0,969
Leche en polvo (fórmulas	No/Si	0,275	0,069	15,800	1	0,001	1,317	1,150	1,508
Papillas de programas sociales	No/Si	-0,491	0,223	4,853	1	0,028	0,612	0,396	0,947
Constante		-0,090	0,039	5,353	1	0,021	0,914		

la misma está asociado a una dieta mínima aceptable[15]. Las familias y los niños que se encuentran en circunstancias difíciles requieren atención especial y apoyo práctico, permanecer juntos y recibir el apoyo que necesitan para elegir la opción de alimentación más adecuada disponible[2].

Por otro lado, la investigación encontró menos riesgo de presentar desnutrición crónica en niños sin lactancia materna, si no consumieron bebidas gaseosas y caldo ($p<0,05$). Para Yang et al.[16], los padres y los cuidadores pueden dar ejemplo, al seguir un estilo de vida con actividad física y alimentación saludable, y evitando alimentos altamente procesados y densos en energía con alto contenido de azúcares y grasas. Esto debido a que, las malas prácticas de alimentación en los niños, tienen una variedad de causas entre ellos los factores sociodemográficos y económicos, tales como, tener un padre con un nivel educativo secundario o superior, ser ama de casa, ser madres a temprana edad, hijos a edades tardías, tener hogares con riqueza de clase media y alta, tener madres casadas, madres educadas, tener antecedentes de seguimiento posnatal, tener visitas de atención prenatal, la exposición a los medios, tener un buen conocimiento sobre la práctica de alimentación infantil, entre otros[17-21].

La desnutrición crónica es una enfermedad multicausal en los niños menores de 5 años, entre ellos tenemos factores como: los servicios completos de atención prenatal, niños sin inmunización, tamaño pequeño al nacer, padres sin educación, pobreza[22], la lactancia materna durante los primeros seis meses, disposición de agua potable para el consumo en el hogar y el nivel educativo de la madre que influencian en el estado nutricional infantil[23-25], la desnutrición materna y la nutrición inadecuada durante el embarazo, la infancia y la primera infancia; son capaces de conducir al retraso del crecimiento[26].

Por otro lado, la investigación tuvo como resultado que los niños con lactancia materna si no ingieren té o café y las papillas de los programas sociales presentan menor riesgo de desnutrición crónica ($p<0,05$). Esto debido a que, el consumir té y café con las comidas interfieren con la absorción de hierro, la ingesta insuficiente de vitaminas y minerales (micronutrientes) que no permiten que el cuerpo produzca suficientes enzimas, hormonas y otras sustancias esenciales para el crecimiento adecuado del niño[27]. La desnutrición crónica infantil afecta la vida y la salud de los niños, con efectos en la edad adulta, ocasionando un círculo vicioso de pobreza y desnutrición[23].

Respecto a los programas sociales, el estudio de Francke y Acosta[28], evaluó el programa Qali Warma del gobierno peruano y sus evidencias refieren que no tendría efectos significativos sobre la anemia ni sobre la desnutrición crónica en niños menores de 3 a 5 años. Otro estudio de Antezana[29], en el que evaluaron el programa Chispitas, basado en la suplementación con hierro, sostienen que no hay un efecto en la disminución de la desnutrición y anemia en niños menores de 5 años.

Entre las limitaciones del estudio podemos mencionar que existen pocos estudios sobre las variables, la información de la data del ENDES sobre las edades de los niños no fue segmentada por grupos de edad.

CONCLUSIÓN

Nuestros resultados proyectados resaltan la necesidad urgente de políticas nacionales y regionales e intervenciones de múltiples niveles para incrementar la lactancia materna exclusiva y así reducir el retraso del crecimiento y el sobrepeso/obesidad infantil. Haciéndose necesarias las intervenciones específicas, ya que la prevalencia del retraso del crecimiento constituye aún un tema pendiente por resolver.

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Risk of hospital malnutrition, inflammatory markers, and medical nutrition therapy in digestive surgery patient: a retrospective cohort study from eastern indonesia

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ABSTRACT

Introduction: The prevalence of hospital malnutrition in Indonesian 23.9% - 60.5%. It is important to evaluate nutritional status of patients at admission to prevent malnutrition and to identify the need for nutritional therapy. Nutrition, immunity, and the gastrointestinal tract are closely interrelated. Malnutrition is widely reported in surgical patients, especially those who have undergone major surgery, and is a particular risk in patients undergoing surgery for upper gastrointestinal cancer or colorectal cancer. Studies show a high prevalence of malnutrition or high nutritional risk during hospital admission, but this is rarely assessed in the clinical setting, especially for patients undergoing elective surgery. There has been no study on digestive surgery patients receiving medical nutritional therapy (MNT).

Method: A retrospective cohort study was conducted, including 353 digestive surgery patients who were admitted between January 2022 and January 2024. This study used medical record data with a total sample of digestive surgery patients. Nutritional status was assessed using the Malnutrition Universal Screening Tool (MUST). This study identified the MUST modified scores of digestive surgery patients, with albumin, Neutrophil-to-Lymphocyte Ratio (NLR), and Total Lymphocyte Count (TLC) values. Statistical analyses were performed using chi-square tests for categorical variables and t-tests or Mann-Whitney U tests for continuous variables, with a p-value of <0.05 considered statistically significant.

Result: The most common diagnosis is rectal cancer. Moderate MUST score in 144 patients (40.7%), low MUST score in 140 patients (39.6%) and high MUST scores in 69 patients (19.5%). 96 patients (27%) received medical nutrition therapy, 71% with severe protein energy malnutrition diagnosis, 29% with moderate protein energy malnutrition diagnosis.

Conclusion: Malnutrition is common among digestive surgery patients and is associated with impaired immune function, as evidenced by hypoalbuminemia and higher NLR in malnourished patients. MUST modified score directly correlated with hypoalbuminemia, increased of NLR, and patient mortality in RSUP. Dr. Wahidin Sudirohusodo Makassar, South Sulawesi.

KEYWORDS

Inflammatory status, nutritional assessment, retrospective studies, immune function, surgical complications, clinical recovery.

INTRODUCTION

Hospital Malnutrition often under-recognized condition among hospitalized patients in Asia. Poor nutritional status is associated with an increased risk of adverse clinical outcomes, including infectious and non-infectious complications, increased length of stay and increased mortality[1].

The prevalence of malnutrition in Indonesian hospitals varies between 23.9% and 60.5%. This may be due to variability in the patient population as well as the parameters used. Malnutrition in hospitals can be caused by individual and/or institutional factors[2].

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The prevalence of malnutrition in hospitals varies according to the patient population, screening and assessment methods, and hospital setting; however, it is generally estimated that 20 to 50% of hospitalized patients are malnourished on admission, and approximately one-third of patients who are not malnourished on admission may become malnourished during hospitalization. Certain patient populations, including surgical patients, critically ill patients, geriatrics and cancer patients are known to be particularly susceptible to malnutrition[3].

Disease-related malnutrition is a common condition but is often underestimated or even unrecognized in chronic diseases. Malnutrition negatively impacts clinical outcomes and increases mortality through impaired wound healing, increased rates of infection and other complications, increased duration and intensity of treatment, and increased length of hospital stay[4].

Malnutrition is widely reported in surgical patients, especially those who have undergone major surgery, and is particularly at risk in patients undergoing surgery for upper gastrointestinal cancer or colorectal cancer. Pre-operative malnutrition has been shown to increase length of hospital stay, higher rates of infection and mortality at the surgical site, and is associated with higher post-operative complications, increased costs, poorer quality of life and lower survival rates. Studies show a high prevalence of malnutrition or high nutritional risk during hospital admission, but this is rarely assessed in the clinical setting, especially for patients who will undergo elective surgery[5].

Malnutrition is common in surgical patients and between 16 - 67% of surgical patients are malnourished before surgery. Estimates vary depending on the population examined and the diagnostic instruments used[6].

Approximately 44% of all patients hospitalized for elective surgical procedures are at risk of malnutrition. However, this prevalence varies depending on the criteria for malnutrition and the screening tools used. In surgical patients, preoperative malnutrition is associated with an increased risk of postoperative complications, increased mortality and medical costs, and longer hospital stays[7].

Patients undergoing gastrointestinal surgery have decreased oral intake, tumor cachexia, impaired absorption due to intestinal obstruction, or reduced intestinal length which affects their nutritional status. Other surgical parameters such as preoperative sepsis, American Society of Anesthesiology (ASA) score of more than 3, emergency surgery, open surgery, long duration of surgery, and massive intraoperative blood loss contribute to poor postoperative outcomes. In addition, low socioeconomic status, Indian customs, restrictions on intake of certain foods pose additional risks[8].

Medical Nutritional Therapy (MNT) involves the use of specific nutritional interventions to manage medical conditions. For instance, Enteral Nutrition (EN) is preferred for patients who can tolerate it, as it maintains gut integrity and function. For patients unable to use their gastrointestinal tract, Parenteral Nutrition (PN) provides essential nutrients intravenously. MNT is tailored to each patient's needs, ensuring they receive the right balance of macronutrients and micronutrients[9].

There has been no study on hospital malnutrition, especially digestive surgery patients at RSUP. Dr. Wahidin Sudirohusodo, so the novel of this study is to identify problems related to hospital malnutrition in digestive surgery patients at RSUP. Dr. Wahidin Sudirohusodo Makassar for the period January 2022 - January 2024.

MATERIAL AND METHODS

Study Design and Participants

This study utilized a retrospective cohort design to assess the prevalence of malnutrition and its association with clinical outcomes in digestive surgery patients.

This study used medical record data with a total sample of digestive surgery patients. The population of this study were inpatients at the RSUP. Dr. Wahidin Sudirohusodo Makassar period January 2022 - January 2024 according to the inclusion criteria. The sample size in this study was determined using the total sampling method.

Inclusion criteria were patients diagnosed with digestive surgery disease, aged > 18 years, hospitalized ³ 7 days. Patients were excluded if they had incomplete medical records or were above the age of 59, and hospitalized < 7 days.

Nutritional Assessment

Malnutrition risk was evaluated using the Malnutrition Universal Screening Tool (MUST). MUST applied at Wahidin Sudirohusodo Hospital:

1. Adult patients with BMI score with standard:
   a. BMI 20 (>30 Obese) : 0
   b. BMI 18, - 20 : 1
   c. BMI < 18,5 : 2
2. Nutritional status classification for children with graphic standard CDC, weight for height:
   a. >90 – 110% : 0
   b. 70–90% : 1
   c. <70% : 2
3. Score of unplanned weight loss in the last 3-6 months:
   a. Weight loss <5% : 0
   b. Weight loss 5-10% : 1
   c. Weight loss>10% : 2
4. Nutritional intake score for acute patients:
   a. Nutritional intake>5 days : 0
   b. No nutritional intake>5 days : 2

5. If the patient cannot be weighed, then do upper arm circumference measurement, upper arm circumference classification for adults:
   a. >85% : 0
   b. 70.1 – 84.9% : 1
   c. <70% : 2

TOTAL SCORES =

Interpretation of scores:

- Low risk (0) = Monitoring after 7 days.
- Medium risk (1 – 2) = Monitoring intake for 3 days, continued every 7 days if no change. Treatment plan can be changed as needed.
- High risk (³3) = Collaborate with Nutrition Support Team.

Data Collection

Data on patient demographics, nutritional status, inflammatory markers, length of stay, and mortality were collected from the hospital's medical records. The primary outcomes measured were LOS, inflammatory response (Albumin, NLR, TLC), and mortality. Data were analysed to determine the correlation between malnutrition risk and these outcomes.

Statistical Analysis

Descriptive statistics were used to summarize patient characteristics. Categorical variables were analysed using chi-square tests, while continuous variables were analysed using t-tests or Mann-Whitney U tests, depending on the distribution of the data. A p-value of <0.05 was considered statistically significant.

RESULT

This study involved 353 patients. The study obtaining ethical approval from the Health Research Ethics Committee of the Faculty of Medicine, Hasanuddin University with number: 313/UN4.6.4.5.31/PP36/2024.

This study involved 353 samples with mean age 43.4 ± 11 years old. Gender was dominated by 212 males (60%) and 141 females (40%). The highest MST score was a moderate MST score of 144 patients (40.7%), a low MST score of 140 patients (39.6%) and a high MST score of 69 patients (19.5%). There were 50 patients who died during hospitalization (14%) and 303 patients survived (86%). 27% patients with clinical nutrition collaboration, the most diagnoses 71% with severe protein energy malnutrition, and 29% with moderate protein energy malnutrition.

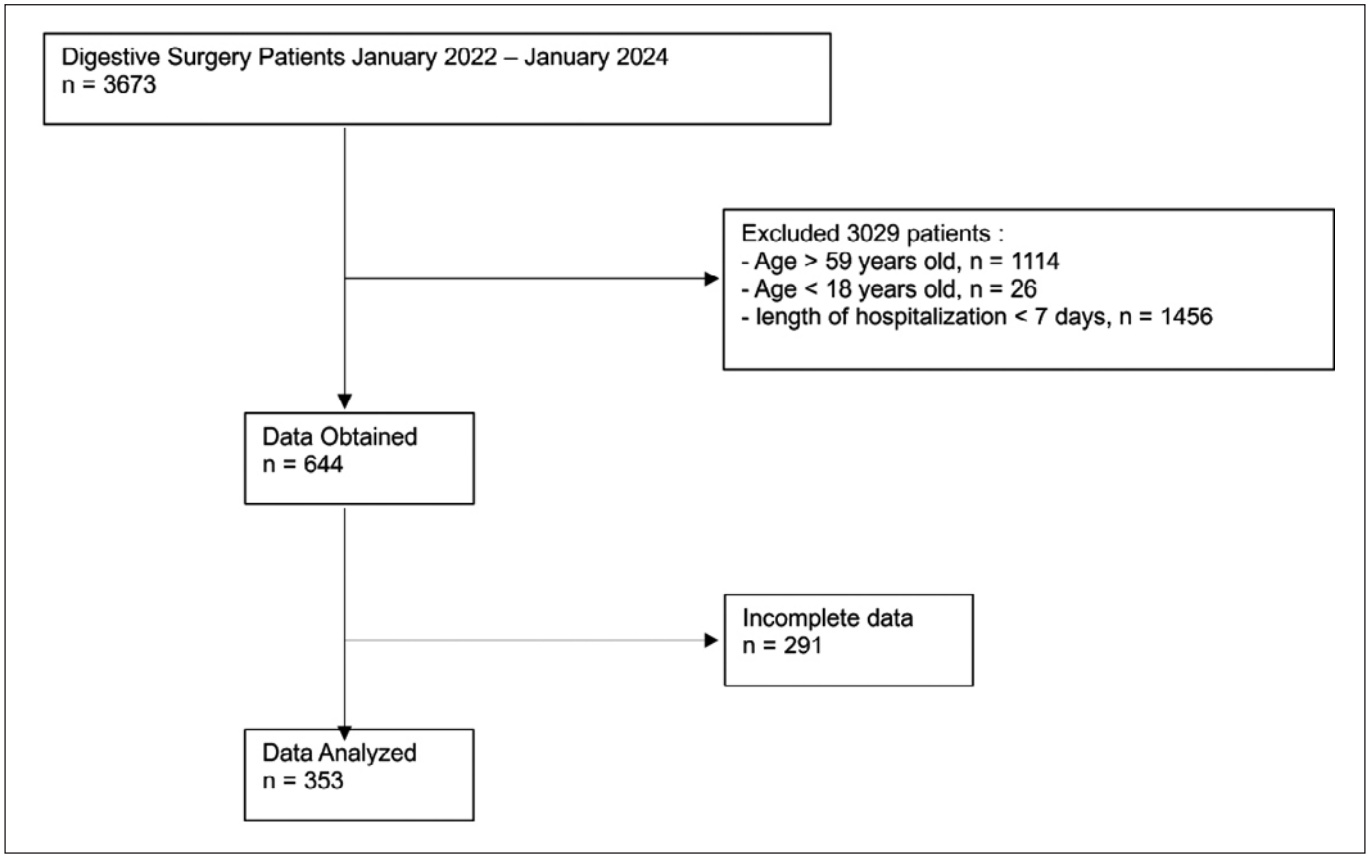

Figure 1. Flow chart of trail

Table 1. Basic characteristics of patients

Basic Characteristics		n	%
Sex	Men	212	60
	Woman	141	40
Age	18 – 59 y.o	43.4 ±11	
Education status	No education	37	10,5
	Elementary	41	11,6
	Secondary	55	15,5
	High School	150	42,4
	Bachelor	70	19,8
Marital Status	Married	301	85,2
	Unmarried	42	11,8
	Widowed	10	2,8
Occupation Status	Employee	213	60,5
	Unemployed	140	39,5
MUST modified Score	Low risk	140	39,6
	Moderate risk	144	40,7
	High risk	69	19,5
Mortality	Yes	50	14
	No	303	86
Medical Nutrition Therapy	Yes	96	27
	No	257	73
Medical Nutrition Diagnosis	Moderate PEM	28	29
	Severe PEM	68	71

The table 3 shows a significant MST modified score and albumin level (p = 0.000), MST scores and NLR (P = 0.027).

The table 5 shows a significant MST modified score and mortality rates (P= 0.006).

The table 7 shows a significant MST modified score, MNT and non MNT, p = 0.000.

The table 8 shows a higher mortality rate in patients who received medical nutrition therapy. This may be influenced by the diagnosis, severity of the disease, complications, and the length of time the patient was consulted to clinical nutrition.

Tabla 2. Most common diagnoses in subjects

Digestive surgery patients	n	%
Rectal cancer	38	24
Colon cancer	34	21
Intra-abdominal tumor	15	9.3
Choledocholithiasis	13	8
Cholelithiasis	12	7.4
Hepatoma	12	7.4
Rectal tumor	12	7.4
Colon tumor	11	7.4
Colorectal cancer	8	5
GIST	6	3.7

DISCUSSION

The aim of this study was to determine the association of the hospital malnutrition risk score, Malnutrition Universal Screening Tools (MUST) modified score, with inflammatory biomarkers, length of hospitalization, mortality, MNT and non MNT.

This study found that 60.4% of digestive surgery patients were at moderate and high risk of malnutrition.

Surgical trauma elicits a series of events that generate an immune response with activation of the cytokine cascade in the postoperative period. Cytokines play an important role in regulating the inflammatory response at the site of injury, thereby facilitating the wound healing process. However, excessive cytokine production can have systemic consequences leading to postoperative complications and death[10].

Malnutrition is a major problem in the gastrointestinal perioperative setting, as only 40% of malnourished patients are ultimately treated. Malnutrition can be defined as a condition that occurs when the body does not receive enough essential nutrients to maintain healthy growth and function. This can result from insufficient nutrient intake and/or the inability to absorb nutrients properly, or an unbalanced diet. Malnutrition has been associated with poor clinical outcomes, as it has been shown that malnourished patients have a relative mortality risk of 1.6-1.9 and remain hospitalized for 1.5-1.7 times longer. Thus, up to 80% of patients who present with compromised nutritional status on admission will further deteriorate if no nutritional regimen is provided[11].

It has been observed that patients who are malnourished at the time of admission also appear to be at a higher risk of

Table 3. Correlation of MUST modified score and inflammatory biomarkers

Inflammation biomarkers			MUST Modification Score			Total	p value
			Low	Moderate	High		
Albumin	Normal	n	51	34	9	94	0.004*
		%	54.3%	36.2%	9.6%	100%	
	Mild hypoalbuminemia	n	44	39	21	104	
		%	42.3%	37.5%	20.2%	100%	
	Moderate hypoalbuminemia	n	22	39	22	83	
		%	26.5%	47%	26.5%	100%	
	Severe hypoalbuminemia	n	23	32	17	72	
		%	31.9%	44.4%	23.6%	100%	
TLC	Normal	n	73	66	27	166	0.464
		%	44%	39.8%	16.3%	100%	
	Mild depletion of immunity	n	20	22	16	58	
		%	34.5%	37.9%	27.6%	100%	
	Moderate depletion of immunity	n	22	24	14	60	
		%	36.7%	40%	23.3%	100%	
	Severe depletion of immunity	n	25	32	12	69	
		%	36.2%	46.4%	17.4%	100%	
NLR	Normal	n	48	44	11	103	0.028*
		%	46.6%	42.7%	10.7%	100%	
	Mild increase of NLR	n	34	31	28	93	
		%	36.6%	33.3%	30.1%	100%	
	Moderate increase of	n	24	28	9	61	
		%	39.3%	45.9%	14.8%	100%	
	Severe increase of	n	34	41	21	96	
		%	35.4%	42.7%	21.9%	100%	

Values are n (%). Significant if $p<0.05$.
Comparison was performed using Chi square test.

poor nutritional intake during hospitalization. Surgery can exacerbate malnutrition through a systemic inflammatory response, which in turn increases metabolic activity, increases energy consumption, impairs organ function, and compromises immunity. In addition, undernourished patients may develop infections at the surgical site; therefore, they have a greater chance of morbidity[11].

The metabolic response to surgery triggers various metabolic and endocrine changes and the perioperative catabolic response is characterized by a period of negative nitrogen balance leading to increased muscle and fat breakdown, sympathetic nervous system stimulation and insulin resistance. Increased metabolic activity leads to an increase in body temperature and respiratory rate: in patients undergoing elective surgery, there can be a 10-15% increase in basal energy expenditure and in the absence of complications, it can take 3-8 days to transition from catabolism to anabolism. Therefore, it is common for patients to experience weight

Table 4. Correlation of MUST modified score and length of stay (LOS) in hospital

LOS			MUST Modification Score			Total	P value
			Low	Moderate	High		
LOS	7-14 days	n	39	36	19	94	0.847
		%	41.5%	38.3%	20.2%	100%	
	> 14 days	n	101	108	50	259	
		%	39%	41.7%	19.3%	100%	

Table 5. Correlation of MUST modified score and mortality

Mortality			MUST Modification Score			Total	P value
			Low	Moderate	High		
Mortality	Yes	n	10	27	14	51	0.006*
		%	19.6%	52.9%	27.5%	100%	
	No	n	130	117	55	302	
		%	43%	38.7%	18.2%	100%	

Table 6. Length of stay (LOS) and length of consulted to clinical nutrition

	Mean	SD	Median	Minimum	Maximum
LOS	20.2	8.9	18	7	53
Length of consulted	7.5	7.8	5	0	30

Table 7. Assosiation of MUST modified score and Medical Nutrition Therapy (MNT), Non Medical Nutrition Therapy (Non - MNT)

MUST Modified Score			Nutrion therapy		Total	p value
			MNT	Non MNT		
MUST	Low	n	20	120	140	0.000*
		%	21.1%	46.5%	39.7%	
	Moderate	n	46	98	144	
		%	48.4%	38%	40.8%	
	High	n	29	40	69	
		%	30.5%	15.5%	19.5%	

Table 8. Analysis of MUST modified score, mortality rates, and MNT

			MNT		Jumlah	Nilai p
			With MNT	Non MNT		
Outcome	Death	n	27	23	50	0.000*
		%	28.4%	8.9%	14.2%	
	Survive	n	68	235	303	
		%	71.6%	91.1%	85.8%	

loss after gastrointestinal surgery. It has been found that 50% of patients lose more than 10% of their body weight a year after upper gastrointestinal surgery and half of patients undergoing colorectal surgery fail to reach their calorie intake targets, and almost no patients reach their protein intake targets after hospital discharge[12].

This study found that 73.4% of digestive surgery patients were admitted with hypoalbuminemia. 44.4% of patients with moderate MUST modified score had severe hypoalbuminemia.

Hypoalbuminemia is prevalent in hospitalized and critically ill patients. Critical illness is associated with hypoalbuminemia through various mechanisms. It can alter the distribution of albumin between the intravascular and extravascular compartments resulting in decreased albumin synthesis and increased albumin degradation and clearance. The reduction in albumin synthesis results from increased transcription of genes for positive acute phase proteins (such as C-reactive protein) and decreased transcription rate of albumin messenger RNA. However, the increased degradation and clearance of albumin is due to an increase in capillary leakage, which is influenced by several cytokines in the inflammatory process such as TNF-alpha, interleukin-6, and prostaglandins[8].

Plasma albumin has three main functions: osmotic, transport, and nutritional, and accounts for more than 75-80% of the total plasma osmotic pressure (25 mmHg). During physiological stress, a decrease in serum albumin levels to hypoalbuminemia levels leads to a decrease in oncotic pressure, which in turn causes interstitial oedema[6].

Albumin, a very important protein, transports hormones, fatty acids and exogenous drugs and regulates plasma oncotic pressure. As albumin levels decrease during injury and infection, albumin is referred to as a negative active phase protein. The maintenance protein called serum albumin is rapidly upregulated by inflammatory signals. Low serum albumin levels are mostly caused by inflammatory conditions, by high levels of the cytokine's interleukin-6 (IL-6) and tumor necrosis factor-alpha (TNF-alpha). A common finding in both acute and chronic diseases is hypoalbuminemia. Although new data suggest that increased catabolism is the more frequent reason, hypoalbuminemia in chronic diseases, is associated with decreased albumin synthesis due to wasting and cachexia. The mechanism that causes hypoalbuminemia in acute conditions differs from that in chronic diseases because capillary leakage into the interstitial space due to inflammatory processes is the main source of hypoalbuminemia in acute conditions. In addition, reduced synthesis, dilution of blood due to fluid administration, renal and intestinal losses due to congestion, and increased catabolism also play a role[6].

Historically, serum albumin concentration was considered a marker of nutritional status and clinicians monitored albumin concentration in patients during hospital stays. It was based on the pathophysiological rationale that albumin concentrations reflect circulating proteins in plasma, with lower concentrations indicating nutritional deficiencies[13].

In this study, 71% of digestive surgery patients were admitted to the hospital with increased NLR. 46% of patients with a moderate MUST modified score had a moderate increase in NLR.

Neutrophils are one of the first responders at sites of infection and injury and as such are powerful mediators of acute inflammation[14].

The neutrophil to lymphocyte ratio, calculated as a simple ratio between neutrophil and lymphocyte counts measured in peripheral blood, is a biomarker that reflects the balance between two aspects of the immune system: acute and chronic inflammation (as indicated by neutrophil counts) and adaptive immunity (lymphocyte counts). In cancer patients, higher NLR has been associated with poor prognosis. Nutrition, immunity, inflammation, and cancer are closely linked, which in turn can affect the survival prognosis of cancer patients. Gastric cancer patients often experience symptoms such as weight loss, hypoproteinemia, anemia and malabsorption, which are associated with inhibition of humoral and cellular immune function, altered inflammatory response and wound healing. In radical distal gastrectomy, a large part of the stomach, including tumor and normal tissue, is removed, resulting in malnutrition,

which greatly increases the risk of tumor recurrence. Surgical trauma can inhibit the body's fluid and cellular immune function and stimulate the body to produce inflammation and traumatic changes, resulting in poor nutrition[6].

The neutrophil to lymphocyte ratio (NLR) has been extensively evaluated and shown to be associated with outcomes and predict disease course among patients with various medical conditions including ischemic stroke, cerebral hemorrhage, major cardiac events, as well as sepsis and infectious diseases. Moreover, in cancer patients, higher NLR has been associated with poor prognosis. This adverse association may reflect the contribution of severe inflammation and poor immune function to the development of these diseases[15].

Recent studies have demonstrated the usefulness of NLR in assessing the extent of the systemic inflammatory response. Lee et al. reported that elevated NLR can predict length of hospital stay in patients undergoing surgery for severe cholecystitis, while Xie et al. applied NLR to predict gastrointestinal resection in inguinal hernia caused by ischemia[16].

This study revealed that 53% of digestive surgery patients were admitted with immune depletion. At moderate MUST modified scores, 46.4% of patients had severe immune depletion. Indicating that nutrition affects immunity.

Both of nutritional status and systemic inflammatory response have been shown to play an important role in the development and progression of various diseases and the survival rate of hospitalized patients. Inflammatory processes can lead to energy wastage and increased daily requirements for calories and protein. Total lymphocyte count (TLC) is recognized as a biomarker of a patient's nutritional status, as well as a prognostic factor in several clinical conditions[15].

Lower TLC increases the frequency and severity of infections. Nutritional or immune status not only affects the patient's prognosis, but also affects the effectiveness of chemotherapy and the risk of surgery[14].

This study found that 73.3% of digestive surgery patients were hospitalized for more than 14 days. No significant difference was found between MUST modified score and length of hospitalization.

A significant association between MUST modified score and mortality was found. Mortality rate was 39% in patients with moderate MUST modified score, 20% with high MUST modified score. Low MUST scores had a mortality rate of 7%. For digestive surgery patients, clinical nutrition cooperation had a mortality rate of 29.2% compared to didn't received medical nutrition therapy patients, with a mortality rate of 8.9%.

The strength of this study is using a specific total sample of digestive surgery patients who are vulnerable to malnutrition, before and after surgery and or chemotherapy. This study also used Malnutrition Universal Screening Tool (MUST) to assess the risk of malnutrition and was applied at the RSUP. Dr. Wahidin Sudirohusodo Makassar.

This study has limitations that need to be considered. This study used an observational design, which means that the findings are correlational and cannot be used to determine direct correlation. Other factors may influence the results so interventional studies are needed for further confirmation.

CONCLUSSION

In conclusion, this study underscores the high prevalence of hospital malnutrition among digestive surgery patients and its association with weakened immune function. MUST modified score directly correlated with hypoalbuminemia, increased of NLR, and patient mortality in RSUP. Dr. Wahidin Sudirohusodo Makassar, South Sulawesi. The findings highlight the importance of early nutritional screening and intervention in this population. Addressing malnutrition through timely and targeted nutritional therapy may improve immune function and reduce the risk of complications, ultimately contributing to better outcomes for digestive surgery patients.

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Comparison between patients who have undergone cancer surgery based on MST value: a retrospective study

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ABSTRACT

Introduction: Malnutrition is a prevalent concern in oncologic surgery patients, often exacerbated by the effects of cancer and its treatments. Malnutrition is associated with poor clinical outcomes, including higher mortality rates, longer hospital stays, and increased complications. The Malnutrition Screening Tool (MST) is a valuable method for identifying malnutrition risk at hospital admission. This study aims to assess the prevalence of malnutrition using the MST and evaluate its prognostic value in relation to clinical outcomes, such as length of stay (LOS), inflammatory markers, and mortality in oncologic surgery patients.

Methods: A retrospective cohort study was conducted at Dr. Wahidin Sudirohusodo Hospital in Makassar, Indonesia, from January 2022 to January 2024. Nutritional status was assessed using the MST, by comparing MST scores of less than 2 and MST score of 2 or higher were considered at risk of malnutrition, and key clinical outcomes—LOS, inflammatory markers (Neutrophil-to-Lymphocyte Ratio [NLR]), serum albumin, total lymphocyte count (TLC), and Prognostic Nutritional Index (PNI)—were analyzed. Statistical comparisons were performed using chi-square tests and t-tests, with statistical significance set at $p < 0.05$.

Results: Among the 284 patients, 33.8% were classified as malnourished (MST ≥2). Patients with higher MST scores had significantly worse clinical outcomes, including higher mortality (33.3% vs. 12.3% for MST <2, $p < 0.001$). Malnourished patients exhibited poorer inflammatory and nutritional markers, with higher NLR (6.13 vs. 4.68, $p = 0.05$), lower albumin (3.0 g/dL vs. 3.3 g/dL, $p = 0.004$), and lower PNI (36.4 vs. 41.8, $p < 0.001$). No significant difference was found in LOS between the two groups (median 10 days vs. 9 days, $p = 0.732$).

Conclusion: Malnutrition, as identified by the MST, is strongly associated with increased mortality and worsened inflammatory and nutritional markers in oncologic surgery patients. These findings underscore the need for routine nutritional screening and timely interventions to improve clinical outcomes in this high-risk population.

KEYWORDS

Surgical recovery, health, immunological impact, nutritional risk, clinical recovery.

INTRODUCTION

Hospital malnutrition is a prevalent issue, particularly among oncologic surgery patients, where the effects of cancer and its treatments can exacerbate nutritional decline[1,2]. Malnutrition in this population is associated with poor clinical outcomes, including increased risk of postoperative complications, longer hospital stays, and higher mortality rates. Despite the well-documented impact of malnutrition, it often goes undiagnosed and untreated in clinical settings, which can significantly impair recovery and overall prognosis[3-6].

The Malnutrition Screening Tool (MST) has emerged as a valuable and straightforward method to screen patients for malnutrition risk upon hospital admission. Its use allows for the early identification of patients who may benefit from nu-

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tritional interventions, potentially improving their clinical outcomes[7-9].

This study focuses on evaluating the prevalence of malnutrition in oncologic surgery patients using the MST as a screening tool. The study also aims to explore the prognostic value of MST in relation to key clinical outcomes, including length of stay, inflammatory markers, and mortality. By examining the relationship between malnutrition and patient outcomes, we are able to underscore the importance of routine malnutrition screening and timely nutritional interventions in surgical oncology.

METHODS

Study Design and Study Population: This retrospective cohort study was conducted at Dr. Wahidin Sudirohusodo Hospital, Makassar, Indonesia, covering the period from January 2022 to January 2024.The study population consisted of patients who had undergone oncologic surgery at the hospital during the study period. Eligible participants were adults aged 18 years or older, who had a minimum hospital stay of 14 days and had complete clinical and laboratory data, including routine blood tests and MST scores. Patients who did not undergo MST screening or whose medical records were incomplete were excluded from the analysis. After applying the inclusion and exclusion criteria, a total of 284 patients were included in the final analysis.

Variables and Data Collection: Nutritional status was assessed using the Malnutrition Screening Tool (MST), a widely used instrument for identifying patients at risk of malnutrition. Patients with an MST score of 2 or higher were considered at risk of malnutrition. In addition to MST, key nutritional and inflammatory markers were evaluated, including the Prognostic Nutritional Index (PNI), serum albumin levels, and the Neutrophil-to-Lymphocyte Ratio (NLR). The PNI was calculated based on the following formula: albumin concentration (g/L) plus five times the total lymphocyte count (TLC). Serum albumin levels were used to categorize patients into mild, moderate, or severe hypoalbuminemia, and the NLR was derived by dividing the neutrophil count by the lymphocyte count. Data collection was carried out by reviewing patients' medical records. Variables of interest included demographic information, laboratory results, and clinical outcomes such as length of stay and mortality. The length of stay was measured in days, while mortality was assessed by the outcome at discharge.

Research Permission and Ethical Clearance: This research was conducted with approval from the Ethical Committee of Dr. Wahidin Sudirohusodo Hospital. Ethical clearance was obtained to ensure patient confidentiality, and no identifying patient information was disclosed. All data used were anonymized and stored securely, in compliance with hospital regulations and ethical standards.

Statistical analysis: Descriptive statistics were used to summarize patient characteristics, and results for continuous variables were presented as medians with interquartile ranges, while categorical variables were expressed as frequencies and percentages. Comparisons between groups were performed using the chi-square test for categorical variables and t-tests or Mann-Whitney U tests for continuous variables, depending on the distribution of the data. Statistical significance was defined as a p-value of less than 0.05.

RESULTS

A total of 3881 oncologic surgery patients were initially identified during the study period at Dr. Wahidin Sudirohusodo Hospital. After applying exclusion criteria, including age over 59 years and length of hospital stay less than seven days, 505 patients remained. Further exclusions were made due to incomplete data, leaving 284 patients in the final analysis.

Table 1. Baseline characteristics of the study patients

Age, year	45 [37, 52]
Sex	
Men	84 (29.6)
Woman	200 (70.4)
Height, cm	155 [150, 160]
Weight, kg	50 [44, 59]
BMI, kg/m2	20.8 [18.3, 23,6]

Education Status	
No Education	19 (6.7)
Elementary	65 (22.9)
Secondary	56 (19.7)
High School	106 (37.3)
Diploma	4 (1.4)
Bachelor	34 (12)

Data are presented as n (%) or median [interquartile range].
BMI, Body Mass Index; MST, Malnutrition Screening Tool; MNT, Medical Nutrition Therapy; LOS, Length of Stay; NLR, Neutrophil to Lymphocyte Ratio; TLC, Total Lymphocyte Count; PNI, Prognostic Nutritional Index.

Table 1 continuation. Baseline characteristics of the study patients

Occupation Status	
Unemployed	169 (59.5)
Student	5 (1.8)
Employee	42 (14.8)
Self-Employee	68 (23.9)
Marital Status	
Unmarried	37(13)
Married	235 (82.7)
Widowed	12 (4.2)
MST	
<2	187 (65.8)
≥2	96 (33.8)
Type of Cancer	
Head Cancer	54 (19)
Lymphoma	40 (14.1)
Thyroid Cancer	46 (16.2)
Breast Cancer	100 (35.2)
Orthopaedic	44 (15.5)

Metastasized	
No.	264 (93)
Yes	20 (7.0)
Surgery	
No.	264 (93)
Yes	20 (7.0)
Chemotherapy	
No.	229 (80.6)
Yes	55 (19.4)
MNT	
No.	227(79.9)
Yes	57 (20.1)
LOS	10 [7,16]
Mortality	
No.	229 (80.6)
Yes	55 (19.4)
NLR	5.08 [2.47,9.97]
Albumin	3.2 [2.8, 3.6]
TLC	1505 [1008, 2139]
PNI	40.4 [34.1, 45.4]

Data are presented as n (%) or median [interquartile range].
BMI, Body Mass Index; MST, Malnutrition Screening Tool; MNT, Medical Nutrition Therapy; LOS, Length of Stay; NLR, Neutrophil to Lymphocyte Ratio; TLC, Total Lymphocyte Count; PNI, Prognostic Nutritional Index.

The median age of the patients was 45 years (IQR: 37-52 years), with a majority being female (70.4%). The median body mass index (BMI) was 20.8 kg/m² (IQR: 18.3-23.6), and the median length of stay (LOS) was 10 days (IQR: 7-16 days). Of the total, 65.8% of patients had an MST score below 2, indicating a lower risk of malnutrition, while 33.8% had an MST score of 2 or higher, suggesting a higher risk of malnutrition. Among the cancers present, breast cancer was the most common (35.2%), followed by head and neck cancers (19%), and thyroid cancer (16.2%).

Among patients with an MST score of 2 or higher, there was a significantly higher prevalence of lymphoma (24%, compared to 9.1% in those with MST <2) and a notably higher mortality rate (33.3% vs. 12.3% for MST <2) ($p < 0.001$). Furthermore, patients with an MST score of 2 or higher were more likely to receive medical nutrition therapy (32.3% compared to 13.9% for MST <2). However, there was no significant difference in the length of stay between the two groups (median of 9 days for MST <2 vs. 10 days for MST ≥2, $p = 0.732$). In terms of laboratory parameters, patients with an MST score of 2 or higher had poorer outcomes in several markers, including a higher Neutrophil-to-Lymphocyte Ratio (NLR) (6.13 vs. 4.68, $p = 0.05$), lower albumin levels (3.0 g/dL vs. 3.3 g/dL, $p = 0.004$), and lower total lymphocyte counts (1221 vs. 1626, $p = 0.005$). The Prognostic Nutritional Index (PNI) was also lower in patients with an MST score of 2 or higher (36.4 vs. 41.8, $p < 0.001$), indicating a worse nutritional status and prognosis in this group.

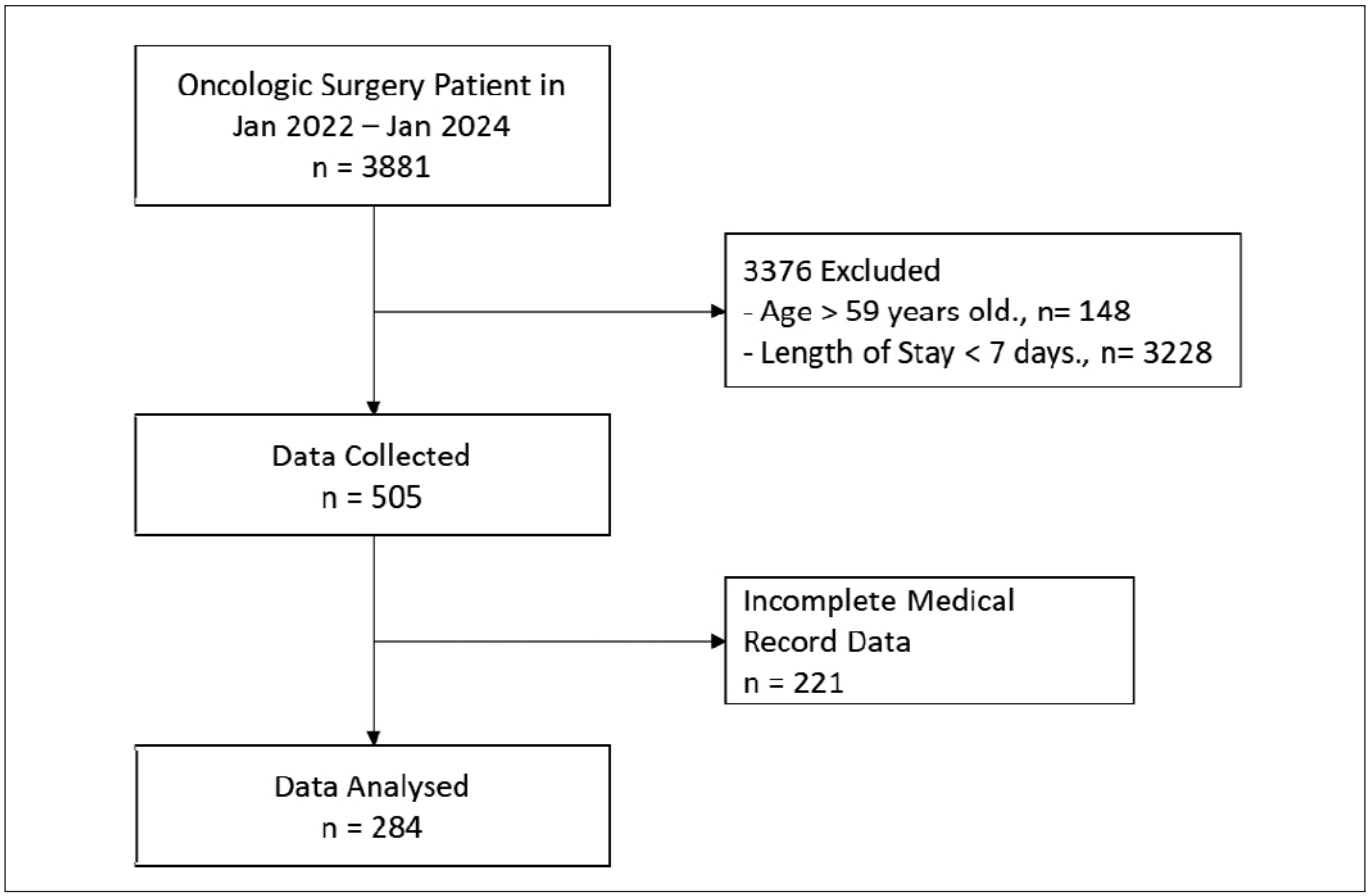

Figure 1. Flowchart of the Study

DISCUSSION

The findings from this study underscore the significant role of malnutrition in influencing clinical outcomes among oncologic surgery patients. Using the Malnutrition Screening Tool (MST), our study identified that 33.8% of the patients were at high risk of malnutrition (MST score ≥2), a prevalence consistent with previous studies that highlight malnutrition as a common issue in cancer patients undergoing surgery.

One of the most important outcomes of this study is the strong association between higher MST scores and increased mortality. Our results show that patients with an MST score of 2 or higher had a significantly higher mortality rate compared to those with lower scores. These findings align with earlier research, which demonstrates that malnutrition negatively impacts survival in cancer patients. The high mortality rate in malnourished patients could be attributed to several mechanisms, including impaired immune function, increased vulnerability to infections, and reduced tolerance to cancer therapies such as chemotherapy and radiation[1,10,11].

In addition to mortality, we observed significant differences in key nutritional and inflammatory markers between patients with higher and lower MST scores. Patients with MST scores ≥2 had higher Neutrophil-to-Lymphocyte Ratios (NLR), lower albumin levels, lower Prognostic Nutritional Index (PNI) and reduced total lymphocyte counts (TLC), all of which indicate a worsened inflammatory and nutritional status. These findings are consistent with prior studies that have identified NLR and albumin as important prognostic indicators in oncologic patients. High NLR is often associated with a systemic inflammatory response, which is a known contributor to cancer cachexia and poor outcomes in surgical patients. Meanwhile, hypoalbuminemia reflects both nutritional risk and systemic inflammation, further compromising the patient's ability to recover[12-17].

Interestingly, our study did not find a significant relationship between MST scores and length of stay (LOS). This result diverges from existing literature, which often suggests that malnourished patients have extended hospital stays due to complications such as delayed wound healing and infections[4,5,18]. One possible explanation for this discrepancy could be the intensive medical and nutritional support provided during hospitalization, which might have mitigated the length of stay, regardless of the patient's nutritional status at admis-

Table 2. Correlation between MST with type of cancer, clinical outcome, and laboratory parameters

	MST<2 (n=187)	MST ≥2 (n=96)	p Value
Type of Cancer			
Head Cancer	33 (17.6)	21 (21.9)	0.002
Lymphoma	17 (9.1)	23 (24)	
Thyroid Cancer	38 (20.3)	8 (8.3)	
Breast Cancer	68 (36.4)	31(32.3)	
Orthopaedic	31(16.6)	13 (13.5)	
MNT			
No	161 (86.1)	65 (67.7)	<0.001
Yes	26 (13.9)	31 (32.3)	
LOS	9 [7.15]	10 [7.16]	0.732
Mortality			
No	164 (87.7)	64 (66.7)	<0.001
Yes	23 (12.3)	32 (33.3)	
NLR	4.68 [2.25, 9.54]	6.13 [3.32, 11.58]	0.05
Albumin	3.3 [2.9,3.7]	3.0 [2.7, 3.5]	0.004
TLC	1626 [1141, 2168]	1221[834, 2089]	0.005
PNI	41.8 [35.9,46.9]	36.4 [31.9,43.5]	<0.001

Data are presented as n (%) or median [interquartile range].
BMI, Body Mass Index; MST, Malnutrition Screening Tool; MNT, Medical Nutrition Therapy; LOS, Length of Stay; NLR, Neutrophil to Lymphocyte Ratio; TLC, Total Lymphocyte Count; PNI, Prognostic Nutritional Index.

sion. Additionally, factors such as the type of surgery and post-operative care may have played a more decisive role in determining LOS in our cohort[1,3].

Another key finding from our study is the association between higher MST scores and the likelihood of receiving medical nutrition therapy (MNT). Patients with an MST score of 2 or greater were more likely to receive MNT, reflecting the proactive use of nutritional support in patients identified as malnourished or at risk. This emphasizes the importance of early screening using tools like MST to identify patients who would benefit from nutritional interventions[9,19]. However, despite receiving MNT, these patients still exhibited poorer clinical outcomes, suggesting that timely nutritional support is critical but may not fully mitigate the adverse effects of advanced malnutrition[1,3].

This study has several strengths. First, the use of the MST as a validated and simple screening tool ensures reliable identification of malnutrition risk. Second, the inclusion of key prognostic indicators, such as NLR, albumin, and PNI, provides a comprehensive view of the interplay between malnutrition and systemic inflammation. However, there are also limitations to consider. The retrospective nature of the study introduces potential biases, particularly in the completeness of medical records. Additionally, the lack of control over other variables, such as pre-hospital nutritional status and differences in cancer types and treatments, may limit the generalizability of the findings.

CONCLUSION

In conclusion, the results of this study highlight the critical need for routine malnutrition screening in oncologic surgery patients. Malnutrition, as identified by the MST, is strongly associated with increased mortality and worsened inflammatory and nutritional markers, underscoring its prognostic value. Early identification and intervention could potentially improve clinical outcomes, although further prospective studies are needed to validate these findings and explore more targeted nutritional interventions.

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Hospital malnutrition in gastro-entero-hepatology (GEH) patients and its relationship to clinical outcomes: a retrospective cohort study

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ABSTRACT

Background: Hospital malnutrition remains a significant global health burden, particularly among gastro-entero-hepatology patients. It adversely impacts clinical outcomes, prolongs hospital stays, and raises healthcare costs. Despite its relevance, recent data on malnutrition among Indonesia's gastro- entero-hepatology (GEH) patients are limited.

Objective: To determine the prevalence of malnutrition and its associated risk factors and clinical outcomes, inflammatory markers, and Prognostic Nutritional Index (PNI) in GEH patients at Wahidin Sudirohusodo General Hospital.

Methods: A retrospective cohort study was conducted among569 GEH inpatients aged 18–59 years with hospital stays exceeding 7 days. Nutritional risk was assessed using the Malnutrition Screening Tool (MST), while Neutrophil-Lymphocyte Ratio (NLR), Total Lymphocyte Count (TLC), and Prognostic Nutritional Index (PNI) were measured as inflammatory markers. Statistical analyses evaluated correlations between malnutrition risk, clinical outcomes, and laboratory values.

Results: Of the 569 patients, 7.4% were at high risk of malnutrition, 38.7% at moderate risk, and 54% at low risk. High-risk patients showed significantly elevated NLR ($p < 0.001$) and lower TLC ($p < 0.001$), reflecting an impaired immune response. These patients also had a lower PNI ($p < 0.001$) and more extended hospital stays ($p < 0.001$). No significant difference in mortality was found between different malnutrition risk groups.

Conclusion: Malnutrition is prevalent among GEH patients, particularly those with malignancies. Early nutritional screening and appropriate interventions are essential to improving clinical outcomes and reducinghospital stay durations. A multidisciplinary approach is necessary to optimize patient care.

KEYWORDS

Nutritional Status, Digestive Pathology, Clinical Malnutrition, Nutritional Intervention, Nutritional Support, Medical Prognosis.

INTRODUCTION

Hospital malnutrition is a significant global health burden, particularly among hospitalized patients. Malnutrition in hospitalized patients worsens prognosis, diminishes quality of life, and increases healthcare costs due to elevated mortality and morbidity rates, higher infection rates, prolonged hospital stays, reduced responses to medical treatment, and increased readmission rates.

[1]. The global prevalence of hospital malnutrition remains alarmingly high, ranging from 33% to 54%. In Indonesia, malnutrition data for hospitalized patients is limited, as not all hospitals conduct malnutrition risk screenings according to accreditation standards. The prevalence of hospital malnutrition in Indonesia ranges between 33% and 70%. In a 2010 study by Nurpudji et al. at Wahidin Sudirohusodo General Hospital, Makassar, mild-to-moderate malnutrition was 44%, while severe malnutrition affected 37% of inpatients. Moreover, two-thirds of patients with poor nutrition quality experience further deterioration during hospitalization if not

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promptly treated, while one-third of well- nourished patients may experience a decline in nutritional status[2].

Hospital malnutrition is caused by several factors, including inadequate intake and complex physiological and metabolic changes due to the disease process. The disease condition is often characterized by acute inflammatory responses that disrupt average nutrient utilization and promote catabolism or hypermetabolism. In some instances of disease-related malnutrition, nutritional support alone may be insufficient to prevent further nutritional decline, even when energy intake matches energy expenditure[3,4]. Therefore, it is recommended that a validated nutritional assessment be performed within the first 24 hours of admission and weekly thereafter during hospitalization, especially following changes in a patient's clinical condition. However, dietary assessments are sometimes overlooked due to competing clinical priorities, posing a significant challenge in reducing hospital-acquired malnutrition rates[4].

Although hospital malnutrition has been widely studied, research on the specific magnitude of malnutrition acquired during hospitalization and the institutional factors contributing to its worsening remains incomplete[5,6]. Malnutrition prevalence ranges between 6.1% and 69.7% among patients with GEH disorders. Disruption of digestive system function can impair nutrient digestion and absorption, leading to malnutrition. If not promptly addressed, malnutrition is expected to worsen the clinical outcomes of gastro-entero-hepatology patients[6]. Given the lack of recent data on malnutrition among gastro-entero-hepatology patients, particularly at Wahidin Sudirohusodo General Hospital, this study aims to fill that gap by investigating the prevalence and risk factors of hospital malnutrition in this patient population.

METHODS

Type of Study

This study is a retrospective cohort analysis conducted on patients diagnosed with GEH diseases hospitalized at Wahidin Sudirohusodo General Hospital, Makassar, between January 2022 and January 2024.

Subjects

The research subjects included all GEH inpatients at Wahidin Sudirohusodo General Hospital, Makassar, from January 2022 to January 2024, who met the inclusion criteria. The inclusion criteria for the study were as follows: patients diagnosed with GEH diseases as the primary diagnosis, confirmed by history, clinical examination, laboratory tests, and histopathology or endoscopy, regardless of consultation with the Clinical Nutrition Department. Eligible patients were aged between 18 and 59 years. Additionally, the availability of laboratory results, including a complete blood count (NLR, TLC) and serum albumin (PNI), was required, along with a hospital stay exceeding 7 days. The exclusion criteria included patients not meeting these conditions or those with GEH diseases in critical condition.GEH diseases under study encompassed conditions related to gastroenterology, such as chronic diarrhea, GERD, and hematemesis, as well as hepatology conditions like liver abscesses, biliary stones, and cirrhosis. Nutritional status and Hospital Malnutrition were assessed using the Malnutrition Screening Tool (MST), categorizing patients as low, moderate, or high risk[23]. Additional variables included the Prognostic Nutritional Index (PNI), calculated from serum albumin levels and total lymphocyte count (TLC), and the Neutrophil-Lymphocyte Ratio (NLR), determined by the ratio of absolute neutrophil count to absolute lymphocyte count. Other variables studied were total lymphocyte count (TLC), length of stay (LOS) in the hospital, mortality (death during hospitalization), complications arising during hospitalization, patient age, and the presence of comorbidities.

Ethical Clearance

This study was approved by the Ethics Committee of Wahidin Sudirohusodo General Hospital, and the hospital administration granted permission to access patient medical records. The research adhered to the ethical principles of confidentiality and patient anonymity.

Data Processing and Analysis

Descriptive statistics were used to present data in tables and graphs. Depending on data distribution, comparative analysis was performed using one-way ANOVA, T-tests, or Mann- Whitney tests. Correlation analysis was performed using Spearman's test. Significance levels were set at $p < 0.05$.

RESULTS

This study included 569 patients who met the inclusion and exclusion criteria. Data were collected and analyzed by comparing nutritional status with inflammatory markers (Neutrophil-Lymphocyte Ratio [NLR] and Total Lymphocyte Count [TLC]), Prognostic Nutritional Index (PNI), length of stay (LOS), and mortality.

Patient Characteristics

The average age of the participants was 47.0 ± 10.2 years. Most of the sample was male (62.9%, n=358), while 37.1% (n=211) were female. Most patients had completed formal education (94.7%, n=539), and 57.7% (n=328) were employed. Regarding marital status, 83.1% (n=473) were married, and 16.9% (n=96) were unmarried (Table 1).

The majority of patients had normal white blood cell (WBC) counts (51.8%, n=295) and platelets (58%, n=330). However, abnormal values were observed in hemoglobin (68.7%, n=391), neutrophil (50.6%, n=288), and lymphocyte counts (60.1%, n=342).

Table 1. Baseline Characteristics

Variables		Total (n = 569)
Age (yeay)		47.0 ± 10.2
Gender (n/percentage)	Male	358 (62.9%)
	Female	211 (37.1%)
Formal Education (n/percentage)	No	30 (5.3%)
	Yes	539 (94.7%)
Occupational Status (n/percentage)	Employed	328 (57.7%)
	Unemployed	241 (42.3%)
Marital Status (n/percentage)	Married	473 (83.1%)
	Unmarried	96 (16.9%)
White Blood Cell (WBC) (103/ul)		11.01±10.70
Hemoglobin (Hb) (gr/dl)		10.91±5.38
Platelet (PLT) (103/ul)		263.62±161.22
Neutrophil (%)		69.41±15.01
Lymposit (%)		18.57±10.50
Albumin (gr/dl)		3.06±1.47

Values are n (%) or means ± SD, unless otherwise stated.

Relationship Between Variables and MST

As shown in Table 2, Most patients (76.4%, n=435) had a hospital stay of fewer than two weeks, while 23.6% (n=134) stayed longer. The survival rate during hospitalization was 86.1% (n=490), with 13.9% (n=79) of patients dying during their stay.

The majority of patients had normal white blood cell (WBC) counts (51.8%, n=295) and platelets (58%, n=330). However, abnormal values were observed in hemoglobin (68.7%, n=391), neutrophil (50.6%, n=288), and lymphocyte counts (60.1%, n=342).

Malnutrition Screening Tool (MST) scores showed that 54% (n=307) of patients were at low risk of malnutrition, 38.7% (n=220) were at moderate risk, and 7.4% (n=42) were at high risk. Most patients (81.5%, n=464) did not receive medical nutrition therapy, while 18.5% (n=105) did.

Statistically significant relationships were observed between MST and several variables: NLR (p- value <0.001) and Spearman's correlation was positive (r=0.209), indicating a direct association; TLC (p-value <0.001), with a positive correlation (r=0.211); PNI (p- value <0.001 and a positive Spearman correlation (r=0.233) indicated a significant direct relationship; Length of stay (LOS) (p-value <0.001), with a positive correlation (r=0.179). No significant relationship was found between mortality and MST (p-value = 0.141, r = 0.062).

Table 2. Relationship Between Variables and MST

Variables			MST			Total	p-value
			Low Risk	Moderate Risk	High Risk		
NLR	Normal (≤3)	n	101	43	0	144	<0.001
		%	32.9%	19.5%	0.0%	25.3%	
	Abnormal (>3)	n	206	177	42	425	
		%	67.1%	80.5%	100.0%	74.7%	
TLC	Normal (≤1500)	n	126	55	4	185	<0.001
		%	41.0%	25.0%	9.5%	32.5%	
	Abnormal (>1500)	n	181	165	38	384	
		%	59.0%	75.0%	90.5%	67.5%	
PNI	Abnormal (>50)	n	246	167	6	419	<0.001
		%	80.1%	75.9%	14.3%	73.6%	
	Normal (≤50)	n	61	53	36	150	
		%	19.9%	24.1%	85.7%	26.4%	

*Chi-Square Test.

Table 2 continuation. Relationship Between Variables and MST

Variables			MST			Total	p-value
			Low Risk	Moderate Risk	High Risk		
Mortality	Alive	n	273	177	40	490	0.004
		%	88.9%	80.5%	95.2%	86.1%	
	Death	n	34	43	2	79	
		%	11.1%	19.5%	4.8%	13.9%	
Length of Hospitalization	<2 weeks	n	251	167	17	435	<0.001
		%	81.8%	75.9%	40.5%	76.4%	
	>2 weeks	n	56	53	25	134	
		%	18.2%	24.1%	59.5%	23.6%	
Medical utrition Therapy	Yes	n	0	63	42	105	<0.001
		%	0.0%	28.6%	100.0%	18.5%	
	No	n	307	157	0	464	
		%	100.0%	71.4%	0.0%	81.5%	
Total		n	307	220	42	569	
		%	100.0%	100.0%	100.0%	100.0%	

*Chi-Square Test.

DISCUSSION

According to the European Society for Parenteral and Enteral Nutrition (ESPEN), malnutrition is characterized by structural and functional changes in body composition. It is common in gastrointestinal diseases and carcinomas and is associated with prolonged hospital stays, increased infection rates, higher healthcare costs, and increased morbidity and mortality[7]. This study aligns with these findings, as most of the study subjects were at mild risk of malnutrition, according to the Malnutrition Screening Tool (MST). Previous research by Rizzi et al. showed that hospitalized patients are at higher risk of malnutrition than outpatients[4], and Cass and Charlton (2022) reported that 10% to 65% of patients experience nutritional decline during hospitalization[8].

Malnutrition and inflammation are closely linked in patients with gastrointestinal diseases, with inflammation affecting nutritional needs and intake. Inflammation triggers poor outcomes by inducing anorexia and altering metabolism, leading to increased energy expenditure and muscle catabolism[9]. In this study, most patients exhibited abnormal levels of inflammatory markers such as Neutrophil-Lymphocyte Ratio (NLR), Total Lymphocyte Count (TLC), albumin, and Prognostic Nutritional Index (PNI), which were significantly associated with MST. Patients with abnormal NLR, TLC, albumin, and PNI were categorized as being at mild nutritional risk based on MST. Inflammation due to acute or chronic illness leads to metabolic changes, affecting appetite, food intake, and gastrointestinal function at the cellular level, often through circulating cytokines like interleukin-6 (IL-6) and tumor necrosis factor-alpha (TNF-α)[10]. These cytokines contribute to low serum albumin levels, reflecting decreased synthesis and increased degradation during systemic inflammation[9].

NLR, an emerging marker of systemic inflammation, is a marker of inflammation and a significant prognostic predictor in various diseases. Kaya et al. demonstrated that NLR was significantly higher in malnourished or at-risk hospitalized patients than those with normal nutritional status[11]. This study also found a significant correlation between NLR and MST, which is consistent with prior research.

Albumin and TLC have long been recognized as predictors of postoperative complications. Rocha et al. found that when combined with nutritional assessments like subjective global

assessment (SGA), these parameters help identify patients at nutritional risk. Valero et al. also reported a positive association between serum albumin and lymphocyte counts and nutritional status, aligning with this study's findings[12].

PNI, developed initially to assess preoperative nutritional status and surgical risk in Japanese patients, has since been established as an independent prognostic indicator in a range of diseases[13]. This study found that most patients had abnormal PNI values, with a significant correlation between PNI and MST. These findings echo the work of Wu et al. (2023), who found low PNI to be associated with poor progression-free survival and overall survival in esophageal cancer patients.53 Similarly, Toya et al. (2021) and Xie et al. (2022) demonstrated that low PNI was linked to poor outcomes in elderly gastric cancer patients and those with decompensated liver cirrhosis, respectively[13,14].

Interestingly, this study found that most patients with malnutrition had less than two weeks of hospital stays, contrasting with research by Correia et al., which demonstrated an increase in malnutrition prevalence with more extended hospital stays.

[15]. Other studies, such as Beghetto et al., reported an increase in malnutrition rates from 40.2% at admission to 64.6% by the 14th day of hospitalization[16]. Malnourished patients typically have more extended hospital stays due to slower wound healing, higher complication rates, and increased mortality, which drive up healthcare costs.

[17]. Previous research has shown that 40% of patients are malnourished upon hospital admission and continue to experience nutritional decline during their stay[18].

In this study, there is a significant difference between patients who were given nutritional intervention and those who were not in terms of the risk of malnutrition and length of hospital stay. In line with a recent systematic review and meta-analysis by Gomes et al. (2022) of 27 clinical trials involving 6803 patients, nutritional support provided during hospitalization was associated with significantly lower rates of mortality and nonelective readmissions, as well as higher energy and protein intake and increased body weight[19].

Although malnutrition is associated with adverse outcomes, including immune depletion, impaired wound healing, muscle wasting, prolonged hospital stays, and higher mortality rates[20], this study found no significant association between mortality and MST. Most patients survived during hospitalization, which aligns with findings by Hormet et al. (2023), who reported no significant correlation between malnutrition and mortality using the Global Initiative on Malnutrition (GLIM) criteria[21]. This could be because most subjects in this study were classified as being at mild nutritional risk, excluding critically ill patients who might exhibit higher mortality rates.

Malnutrition is also linked to anemia and vitamin deficiencies. In this study, many patients had abnormal hemoglobin levels, indicative of iron deficiency, a common complication of malnutrition. Nutritional deficiencies have been associated with increased mortality in hospitalized and surgical patients[22], and malnutrition can further exacerbate mortality through mechanisms such as hypoglycemia and hypothermia. Malnutrition also increases the risk of infections due to impaired immune function, extending hospital stays and elevating healthcare costs.

In conclusion, malnutrition significantly affects outcomes in patients with gastroenterology-related diseases, a finding consistent with previous studies. Patel et al. (2023) found that malnourished patients with gastrointestinal diseases had higher risks of poor outcomes, including mortality, sepsis, deep vein thrombosis (DVT), and pulmonary embolism. Nutritional support should be considered when treating hospitalized patients who are malnourished or at nutritional risk since it is linked to improved nutritional and clinical outcomes[22].

This study had several limitations. First, as a retrospective cohort study, there is a risk of bias in the data. Second, the study was conducted in a single tertiary hospital, which may limit the generalizability of the findings to other settings. However, the large sample size and diverse patient population strengthen the external validity of the results. Finally, retrospective medical records may pose data quality issues, although standardized clinical measures and robust statistical analyses help mitigate these concerns.

CONCLUSION

This study revealed that 7.4% of GEH patients at Wahidin Sudirohusodo General Hospital were at high risk of malnutrition, 38.7% were at moderate risk, and 54% were at low risk. High malnutrition risk was more commonly observed in patients with malignancies compared to non- malignant cases. Additionally, GEH patients at high risk of malnutrition exhibited elevated lymphocyte ratio (NLR) and reduced Total Lymphocyte

Count (TLC), indicating that malnutrition impacts immune response. These patients also had lower Prognostic Nutritional Index (PNI), suggesting a poorer prognosis, and experienced more extended hospital stays. While no significant difference in mortality was found between patients at high, moderate, and low malnutrition risk, malnutrition remains a critical factor influencing clinical outcomes and quality of life.

These findings underscore the importance of early malnutrition screening and the implementation of appropriate nutritional interventions to improve nutritional status and clinical outcomes in GEH patients. A multidisciplinary approach is essential to ensure optimal patient care and management.

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Hospital malnutrition in chronic kidney disease: a retrospective cohort study from eastern Indonesia

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ABSTRACT

Background: Malnutrition in hospitalized patients, particularly those with chronic kidney disease (CKD), significantly impacts morbidity and mortality. This study addresses the prevalence and factors contributing to malnutrition in CKD patients at Dr. Wahidin Sudirohusodo Hospital (RSWS) Makassar, Indonesia.

Objective: This study aimed to examine the prevalence of malnutrition and its associated risk factors among hospitalized CKD patients from January 2022 to January 2024.

Methods: In a retrospective cohort analysis, 388 Chronic Kidney Disease Patients admitted between January 2022 and January 2024 were included. Key clinical outcomes such as LOS, inflammatory markers (Neutrophil-to-Lymphocyte Ratio [NLR]), serum albumin, total lymphocyte count (TLC), Prognostic Nutritional Index (PNI), and mortality were evaluated using the Malnutrition Screening Tool (MST) modified by Dr. Wahidin Sudirohusodo Hospital (RSWS), Makassar to determine nutritional status. Chi-square tests were used for categorical data, while t-tests or Mann-Whitney U tests were used for continuous variables. A p-value of less than 0.05 was deemed statistically significant.

Results: We found that 42% of CKD patients were at moderate to severe risk of malnutrition using the modified MST. Significant correlations were found between MST scores and inflammatory markers, particularly albumin ($p = 0.039$) and NLR ($p < 0.000$). Medical nutritional therapy improved these markers, leading to better outcomes. Higher MST scores were linked to longer hospital stays, while proper nutritional management reduced mortality and shortened hospitalization.

Conclusion: Early malnutrition screening and appropriate nutritional management in CKD patients improve outcomes by reducing inflammation and mortality, with NLR and albumin serving as key indicators of prognosis.

KEYWORDS

Clinical Malnutrition, Kidney Therapies, Chronic Disease, Medical Intervention, Medical Nutritional Intervention, Medical Nutrition Therapy, Retrospective Analysis, Kidney Failure.

INTRODUCTION

Malnutrition among hospitalized patients is a significant global health burden. It is well-documented that malnutrition in hospitalized patients worsens prognosis and quality of life by increasing mortality, morbidity, and infection rates, prolonging hospital stays, reducing responsiveness to medical treatments, and raising the rates of readmissions and healthcare costs[1]. Malnutrition has been identified as a key contributor to increased complications, leading to longer hospital stays, delayed recovery times, and higher mortality rates. In hospitals, malnutrition is particularly prevalent among elderly patients and those with chronic or acute diseases. The causes of malnutrition are often multifactorial, directly linked to poor nutrient intake, reduced nutrient bioavailability, and elevated nutritional needs, resulting in unmet requirements for energy, protein, and other vital nutrients[2,3].

Additional significant determinants of malnutrition include poor appetite, dysphagia, inflammation, malabsorption, age,

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polypharmacy (use of 6-9 medications), excessive polypharmacy (use of 10 or more medications), reduced mobility, and self-reported health status[2]. Malnutrition is recognized as a separate disease entity and has its own classification code in the International Classification of Diseases[4]. In hospitalized patients, malnutrition is often attributed to poor nutritional status (low BMI and muscle mass), while the risk of malnutrition is associated with various risk factors, typically linked to the progressive loss of lean body mass over time[5].

Data on hospital malnutrition in Indonesia remains limited, as not all hospitals conduct malnutrition risk screening in accordance with hospital accreditation standards. A study by Nurpudji et al, 2010 at Dr. Wahidin Sudirohusodo Hospital in Makassar, using the Subjective Global Assessment (SGA), reported mild to moderate malnutrition cases at 44.19% and severe malnutrition at 37.21%[6].

Chronic kidney disease (CKD) is a global public health concern, with increasing prevalence and incidence of renal failure, poor prognosis, and high costs. CKD is a condition affecting kidney function, often developing slowly and becoming chronic due to various factors[1]. The rise in metabolic and degenerative diseases has led to an increase in CKD cases. The growing prevalence of CKD worldwide has resulted in a higher number of patients with end-stage kidney disease (ESKD) requiring dialysis. In Indonesia, CKD is becoming a significant health issue, with its prevalence steadily rising year by year[7,8].

Protein Energy Wasting (PEW) is a common comorbidity among patients with acute or chronic kidney disease, particularly those in the later stages of CKD and those undergoing dialysis. PEW in CKD patients is associated with higher rates of hospitalization and mortality. The unique characteristics of CKD complicate reliable screening for PEW and the assessment of nutritional status, making the management of this comorbidity challenging. Several interventions can be implemented to prevent the progression of PEW in CKD by addressing etiological factors, such as ensuring adequate nutritional intake, avoiding the catabolic effects of renal replacement therapies, and treating systemic inflammation, metabolic acidosis, and hormonal imbalances[9].

Given the adverse impacts of malnutrition on patient outcomes, especially in those with chronic diseases like Chronic Kidney Disease (CKD), it is crucial to address this issue. This study aims to examine the prevalence and contributing factors of malnutrition in CKD patients hospitalized at Dr. Wahidin Sudirohusodo Hospital over the period of January 2022 to January 2024.

METHODS

Research Subjects: This study utilized a retrospective cohort analysis, focusing on chronic kidney disease (CKD) patients admitted to Dr. Wahidin Sudirohusodo Hospital (RSWS) in Makassar from January 2022 to January 2024. The study population included all hospitalized CKD patients who met the inclusion criteria were diagnosed with chronic kidney disease based on clinical and laboratory results (routine blood tests, albumin, and other blood chemistry), age between 18 - 59 years, hospitalized for ≥ 7 days and nutritional status assessment data available using the Malnutrition Screening Tool (MST) modified Dr. Wahidin Sudirohusodo Hospital, Makassar.

Exclusion criteria included incomplete medical records, missing data, or lack of nutritional screening using the MST. The sample size was determined using total sampling, meaning all CKD patients meeting the criteria within the study period were included.

Data collection: Data were collected from the medical records department of Dr. Wahidin Sudirohusodo Hospital. The information extracted included patient demographics, nutritional status (assessed using the modified MST), Prognostic Nutritional Index (PNI), laboratory results (such as blood chemistry, albumin, ureum, and creatinine), length of hospital stay (LOS), and patient outcomes (discharge or mortality). Malnutrition during hospitalization was defined as a deterioration in nutritional status based on specific criteria were MST score (Score 0 is low risk malnutrition, score 1 – 2 is moderate risk malnutrition, and score ≥ 3 is high risk malnutrition), hypoalbuminemia < 3.5 g/dL, TLC < 1500/mm³, and NLR) > 3. Albumin concentration (g/L) plus five times the total lymphocyte count (TLC) was the formula used to get the PNI. The NLR was calculated by dividing the neutrophil count by the lymphocyte count, and patients were classified as having mild, moderate, or severe hypoalbuminemia based on their serum albumin levels.

Research Permission and Ethical Clearance: This research was conducted with approval from the Ethical Committee of Dr. Wahidin Sudirohusodo Hospital (RSWS), Makassar. Ethical clearance was obtained to ensure patient confidentiality, and no identifying patient information was disclosed. All data used were anonymized and stored securely, in compliance with hospital regulations and ethical standards.

Data Processing and Analysis: The collected data were categorized according to the research objectives and processed for statistical analysis. Univariate analysis was used to describe baseline characteristics and frequency distributions, which were presented in tables and graphs. Bivariate analysis was conducted using One-Way ANOVA or T-Test for normally distributed data, and Chi-Square test for non-normally distributed data. Pearson or Spearman correlation tests were applied to evaluate relationships between quantitative and ordinal variables. Statistical significance was determined as follows: Not significant if p-value > 0.05, significant if p-value ≤ 0.05 and highly significant if p-value < 0.001.

RESULTS

Out of 388 chronic kidney desease patients, 52.8% (n=205) were male, and 47.2% (n=183) were female. Education levels varied, with 41.2% (n=160) having completed high school and 26.3% (n=102) having a tertiary education. A total of 57% (n=221) of patients were employed, while 43% (n=167) were unemployed. In terms of medical treatment, 33% (n=128) of patients were undergoing hemodialysis (HD), while 67% (n=260) were not. Only 11.1% (n=43) of patients were on continuous ambulatory peritoneal dialysis (CAPD). The most common comorbidities were hypertension (HT) in 47.4% (n=184) and diabetes mellitus (DM) in 14.9% (n=58). A small percentage (1.0%, n=4) had congestive heart failure (CHF). Malnutrition risk was assessed using the Malnutrition Screening Tool (MST) modified RSWS Makassar, with 69.3% (n=269) at mild risk, 28.4% (n=110) at moderate risk, and 2.3% (n=9) at severe risk. Among the patients, 85 (21.9%) received medical nutritional therapy (MNT), while 303 (78.1%) did not received medical nutritional therapy (MNT). Table 1 shows detailed patient characteristics.

Clinical Outcomes

The clinical outcomes of CKD patients in relation to nutritional status and medical care are presented in Table 2. Patients receiving medical nutrition therapy had a significantly longer length of stay (LOS) in the hospital (18.44 ± 13.80 days) compared to non-MNT patients (12.09 ± 6.93 days, p<0.001). Similarly, patients with MNT had higher white blood cell (WBC) counts (15.48 ± 11.39 vs. 12.26 ± 8.53, p=0.002) and lower albumin levels (2.86 ± 0.66 vs. 3.14 ± 0.67, p=0.001). A significant difference in neutrophil-lymphocyte ratio (NLR) was also observed (p=0.006), patients with MNT displaying higher inflammatory markers.

Inflammatory Markers Analysis

In the analysis of inflammatory markers (Table 3), shows significance in the albumin value with p = 0.039 and the NLR value with p < 0.000. This indicates that nutritional screening (MST modified RSWS, Makassar) and medical nutrition therapy can affect inflammatory markers in CKD patients, particularly albumin and NLR. The values of WBC, albumin, and NLR showed an increase; however, early nutritional screening conducted on CKD patients can reduce the risk of mortality through the provision of appropriate nutritional management according to the clinical condition of the patients, thereby improving inflammatory biomarkers and reducing mortality.

Medical Nutritional Therapy Analysis

Table 4, based on the research data, there is a significant result between MST scores in CKD patients who received medical nutrition therapy compared to those who did not receive medical nutritional therapy, with a p-value < 0.000.

Table 1. Baseline Characteristics

Variables		Total (n = 388)
Gender	Male	205 (52.8%)
	Female	183 (47.2%)
Age	18-59 years	44.28±11.04
Education	Elementary School	74 (19.1%)
	Middle School	52 (13.4%)
	Senior High School	160 (41.2%)
	University	102 (26.3%)
Occupational Status	Employed	221 (57.0%)
	Unemployed	167 (43.0%)
Haemodialysis	Yes	128 (33.0%)
	No	260 (67.0%)
Continuous Ambulatory Peritoneal Dialysis	Yes	43 (11.1%)
	No	345 (88.9%)
Congestive Heart Failure	Yes	4 (1.0%)
	No	384 (99.0%)
Hypertension	Yes	184 (47.4%)
	No	204 (52.6%)
Diabetes Mellitus	Yes	58 (14.9%)
	No	330 (85.1%)
Acute Kidney Injury	Yes	2 (0.5%)
	No	386 (99.5%)
Hypertensive Heart Disease	Yes	2 (0.5%)
	No	386 (99.5%)
Received MNT	Yes	85 (21.9%)
	No	303 (78.1%)

MNT = Medical Nutrition Therapy.

Table 2. Correlation Laboratory Parameters and Nutritional Status

	Received MNT		Non- Received MNT		p-value
	Mean ± SD	Median	Mean ± SD	Median	
LOS	18,44 ± 13,80	16,00	12,09 ± 6,93	10,00	0,000
Body Height (BH)	159,21 ± 6,78	160,00	158,83 ± 8,33	160,00	0,633
Actual Body Weight	53,65 ± 9,07	54,00	56,40 ± 12,36	55,00	0,116
Upper Arm Circumference (UAC)	24,69 ± 5,00	24,00	23,73 ± 4,20	23,35	0,397
BH:UAC	55,48 ± 17,41	58,65	62,05 ± 14,36	65,00	0,734
BMI	21,05 ± 2,94	20,66	22,19 ± 5,64	22,00	0,124
MST	1,35 ± 1,45	1,00	0,91 ± 1,02	1,00	0,044
Ureum	162,55 ± 102,08	143,00	185,25 ± 201,61	156,00	0,407
Creatinin	8,26 ± 7,83	5,93	10,38 ± 8,05	8,70	0,007
eGFR	28,6 ± 39,15	12,50	16,51 ± 16,17	12,00	0,498
WBC	15,48 ± 11,39	13,90	12,26 ± 8,53	10,04	0,002
Hb	9,19 ± 2,86	8,70	9,60 ± 12,70	8,50	0,331
PLT	278,16 ± 141,07	264,00	240,59 ± 120,75	218,00	0,021
Neutrofil	77,72 ± 15,20	80,30	76,37 ± 13,34	78,10	0,175
Lymfosit	12,27 ± 9,74	9,10	13,35 ± 8,83	11,20	0,154
Albumin	2,86 ± 0,66	2,80	3,14 ± 0,67	3,10	0,001
TLC	1139,04 ± 811,70	1014,00	1409,60 ± 1425,89	1072,00	0,328
NLR	15,11 ± 17,64	9,59	9,65 ± 9,11	6,37	0,006

MNT= Medical Nutrition Therapy; MST= Malnutrition Screening Tool Modified RSWS, Makassar. Hb= Hemoglobin. WBC= White Blood Count. PLT= Platelet; Egfr= Estimated Glomerular Filtration Rate. TLC= Total Lymphocyte Count; NLR= Neutrophil- Lymphocyte Ratio. PNI= Prognostic Nutrition Index.

Length of Stay (LOS) Analysis

Table 5 shows that there is no correlation between the modified MST score and LOS, with a p-value of 0.553.

Mortality Analysis

Based on the analysis of the research data, significant results were obtained in CKD patients who underwent nutritional screening, indicating an effect on mortality with a p-value of 0.000.

DISCUSSION

This study found that 42% of patients with Chronic Kidney Disease (CKD) are at moderate-to-severe risk of malnutrition using the modified Malnutrition Screening Tools (MST) of Dr. Wahidin Sudirohusodo General Hospital/ RSWS, Makassar. The MST, a quick and easy screening tool, includes questions on appetite, nutritional intake, and recent weight loss, with a score ≥2 indicating the need for further nutritional assessment or intervention. This finding is consistent with previous studies that highlight the effectiveness and sensitivity of the MST in identifying malnutrition risk in various clinical settings[10-12]. Similarly, Regina Corte-s-Aguilar et al. reported that the MST had a sensitivity of 0.81 and a specificity of 0.79, which makes it a reliable tool for rapid clinical assessment[13].

Malnutrition prevalence in CKD patients varies widely, with other studies reporting rates between 22.5% to 58.5%[11] and

Table 3. Correlation MST Scores and Inflamatory Markers in CKD Patients

Variable		MST Score			P-value
		Low	Moderate	High	
Albumin	Normal	77 (73.3%)	27 (25.7%)	1 (1.0%)	0.039
	Mild Hypoalbuminemia	91 (74.0%)	28 (22.8%)	4 (3.3%)	
	Moderate Hypoalbuminemia	77 (69.4%)	32 (28.8%)	2 (1.8%)	
	Severe Hypoalbuminemia	24 (49.0%)	23 (46.9%)	2 (4.1%)	
TLC	Normal	74 (60.7%)	44 (36.1%)	4 (3.3%)	0.180
	Mild Immune Depletion	33 (73.3%)	12 (26.7%)	0 (0.0%)	
	Moderate Immune Depletion	65 (75.6%)	18 (20.9%)	3 (3.5%)	
	Severe Immune Depletion	97 (71.9%)	36 (26.7%)	2 (1.5%)	
NLR	Normal	65 (91.5%)	5 (7.0%)	1 (1.4%)	0.000
	Mild NLR Increase	73 (69.5%)	31 (29.5%)	1 (1.0%)	
	Moderate NLR Increase	48 (64.0%)	25 (33.3%)	2 (2.7%)	
	Severe NLR Increase	83 (60.6%)	49 (35.8%)	5 (3.6%)	
Total		269 (69.3%)	110 (28.4%)	9 (2.3%)	0.000

MST = Malnutrition Screening Tool (modified RSWS Makassar); TLC = Total Lymphocyte Count; NLR = Neutrophil Lymphocyte Ratio; Statistical analysis.

Table 4. Correlation MST Scores of CKD Patients with Received MNT and Non-MNT

MST	Recived MNT		Total	p-value
	Yes	No		
Low	49	220	269	0.000
	57.6%	72.6%	69.3%	
Moderate	28	82	110	
	32.9%	27.1%	28.4%	
High	8	1	9	
	9.4%	0.3%	2.3%	
Total	85	303	388	
	100.0%	100.0%	100.0%	

MST = Malnutrition Screening Tool (modified RSWS Makassar); MNT = Medical Nutrition Therapy.

results from sixty-one studies that were eligible for quantitative analysis in the journal were reviewed by Ishfaq et al. The global prevalence of malnutrition associated with chronic renal illness was found to be 42.7%, with a range of 35.2% to 50.6%[14]. In this study, CKD patients in stages 1 – 3 constituted the majority, and the prevalence of malnutrition across all CKD stages 1 – 5 ranged from 13% to 33.3%. These results are comparable to those of Sewnet Getayeet et al, 2021 whose study involving 436 participants found a higher proportion of male CKD patients, with a mean age of 45 years[15] and the meta-analysis study by Behairy et al in 2022 included 60 non-dialysis CKD patients and 30 controls. Among the patients, there were 43 males (71.7%) and 17 females (28.3%), with an average age of 64.23 ± 7.99 years[16,17]. This demographic pattern aligns with our findings, where 52.8% of CKD patients were male, and the mean age was 44 years.

Inflammatory markers, specifically albumin and neutrophil-lymphocyte ratio (NLR), were closely associated with nutritional status in CKD patients. The decline in albumin levels ($p = 0.039$) and elevated NLR values ($p < 0.000$) in this study indicate a sig-

Table 5. Correlation MST Score of CKD Patients and LOS

LOS	MST Score			Total	p-value
	Low	Moderate	High		
< 7 day	8	1	0	9	0.553
	88.9%	11.1%	0.0%	100.0%	
7-14 day	180	79	5	264	
	68.2%	29.9%	1.9%	100.0%	
> 14 day	81	30	4	115	
	70.4%	26.1%	3.5%	100.0%	
Total	269	110	9	388	
	69.3%	28.4%	2.3%	100.0%	

MST = Malnutrition Screening Tool (modified RSWS, Makassar; LOS = Length of Stay.

Table 6. Correlation MST Score of CKD Patients and Mortality

Status	MST Score			Total	p-value
	Low	Moderate	High		
Dead	29	21	5	55	0.000
	52.7%	38.2%	9.1%	100.0%	
Alive	240	89	4	333	
	72.1%	26.7%	1.2%	100.0%	
Jumlah	269	110	9	388	
	69.3%	28.4%	2.3%	100.0%	

MST = Malnutrition Screening Tool (modified RSWS, Makassar).

nificant relationship between malnutrition and inflammation in CKD patients. These findings are consistent with prior research, where elevated NLR was identified as an independent risk factor for malnutrition in CKD patients[17]. NLR values ≥2.62 increased the likelihood of malnutrition in CKD patients by 3.86 times (95% CI: 1.344–11.104, P=0,012). This highlights the role of NLR as a critical inflammatory marker in monitoring malnutrition risk and its potential impact on mortality and patient outcomes.

Furthermore, medical nutritional therapy in CKD patients was shown to positively influence inflammatory markers such as leukocytes, albumin, and NLR, potentially improving patient outcomes. Adequate nutritional management significantly reduced mortality risk and hospital length of stay, consistent with studies suggesting that early malnutrition screening reduces mortality risk through timely nutritional interventions[17]. The relationship between NLR and chronic inflammation in CKD patients supports the notion that NLR, along with the platelet-to-lymphocyte ratio, could serve as valuable biomarkers for detecting malnutrition and inflammation severity in CKD.

Albumin, a key protein in maintaining osmotic pressure, also plays a significant role in patient outcomes. Hypoalbuminemia, identified as an independent risk factor for increased mortality in conditions such as septic shock, heart failure, and acute coronary syndrome, has been linked to poor CKD outcomes[17]. In this study, low albumin levels correlated with worse outcomes in CKD patients, which is consistent with research by

Xuqin Wang et al, 2023 who found that hypoalbuminemia before starting continuous renal replacement therapy (CRRT) was a significant predictor of early mortality in a meta-analysis involving over 5,000 patients[18].

Despite these findings, the results in table 5 did not show a statistically significant correlation MST scores and length of stay (LOS) in CKD patients, with a p-value of 0.553. However, MST scores were higher in patients with a hospital stay of 7–14 days. In table 6, the correlation malnutrition screening using MST modified RSWS Makassar and mortality was statistically significant (p = 0.000), reaffirming the importance of early nutritional assessment in reducing mortality risk in CKD patients[18].

Malnutrition remains a significant concern in CKD management, as it impacts patient quality of life, morbidity, hospital stay, and mortality[19]. Inflammation plays a central role in this, with systemic low-grade inflammation exacerbating CKD progression and increasing susceptibility to malnutrition through factors such as uremia, dyslipidemia, metabolic syndrome, and gut dysbiosis[20]. Therefore, early screening for malnutrition and timely nutritional interventions are essential to improving outcomes in CKD patients.

CONCLUSION

Early identification of malnutrition in CKD patients using the Malnutrition Screening Tools (MST) modified RSWS, Makassar is crucial for improving patient outcomes. The MST is a reliable, quick, and sensitive screening tool, with a significant correlation found between malnutrition and inflammatory markers, particularly albumin and neutrophil-lymphocyte ratio (NLR). Elevated NLR and low albumin levels are associated with higher malnutrition risk and worse outcomes in CKD patients. Medical Nutrition Therapy can help mitigate these effects, reducing hospital stay duration and mortality risk. Therefore, integrating nutritional management into the routine care of CKD patients, particularly those at high risk of malnutrition, is essential for reducing inflammation and improving overall prognosis.

RESEARCH LIMITATIONS

The limitations of this study include its relatively small sample size and single-center design, which may limit the generalizability of the findings. Additionally, the focus on short-term outcomes, without long-term follow-up, restricts conclusions about the sustained impact of nutritional therapy. Potential confounding factors such as varying CKD severity, comorbidities, and medication use were not fully controlled, which could influence the results. The study also relied on a limited set of biomarkers, which may not capture the full complexity of malnutrition and inflammation in CKD patients. Finally, if the study was retrospective, it may be prone to biases, further limiting the ability to establish clear causal relationships.

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Efecto del consumo de polifenoles sobre biomarcadores de inflamación y endotoxemia en personas con obesidad: una revisión sistemática

Effect of polyphenol consumption on biomarkers of inflammation and endotoxemia in people with obesity: a systematic review

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RESUMEN

Introducción: las enfermedades crónicas han aumentado a nivel mundial debido al estilo de vida y otros factores como el tabaquismo, el alcohol, la obesidad, la comida ultraprocesada baja en fibra, carente de frutas y verduras, etc. La evidencia científica respalda el uso de polifenoles dietarios como agentes preventivos y terapéuticos que podrían ayudar con la carga de estas patologías modulando la respuesta inflamatoria y la endotoxemia.

Objetivo: evaluar los efectos del consumo de polifenoles sobre parámetros relacionados con la obesidad, como los biomarcadores inflamatorios y de endotoxemia, los perfiles glucémicos y peso en personas con esta condición.

Metodología: Se realizó búsqueda de ensayos clínicos aleatorizados en bases de datos PubMed, Science Direct, Ovid y Ebsco. Se accedió a estudios sobre adultos obesos publicados entre enero de 2019 hasta marzo de 2024 que evaluaran el efecto de los polifenoles dietarios en biomarcadores de inflamación (FNTα, PCR hs e IL6) y de endotoxemia (LPS).

Resultados: Se incluyeron 11 estudios con 506 participantes. Se evidenció en el 73% de los estudios que los biomarcadores más sensibles a la disminución con el consumo de polifenoles fueron PCR, IL6 y FNTα. Con relación a la endotoxemia la lipoproteína fijadora de lipopolisacáridos aumentó en 29,7% en el grupo de intervención y los lipopolisacáridos no se afectaron. La glicemia disminuyó en promedio 15% y el peso se mantuvo estable lo que indica que los polifenoles puedan ser, además, coadyuvantes en el manejo del peso.

Discusión: el consumo de polifenoles evidenció tolerancia y modulación de la inflamación y la endotoxemia pero se requieren más estudios.

Conclusión: los fitonutrientes dietarios son sustancias prometedoras en el manejo de la inflamación, la endotoxemia, la glicemia y el peso en pacientes con obesidad.

PALABRAS CLAVE

Polifenoles, mediadores inflamatorios, dieta, obesidad, endotoxemia.

SUMMARY

Introduction: Chronic diseases have increased worldwide due to lifestyle and other factors such as smoking, alcohol, obesity, ultra-processed food low in fiber, lacking in fruits and vegetables, etc. Scientific evidence supports the

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use of dietary polyphenols as preventive and therapeutic agents that could help with the burden of these pathologies by modulating the inflammatory response and endotoxemia.

Objective: to evaluate the effects of polyphenol consumption on obesity-related parameters, such as inflammatory and endotoxemia biomarkers, glycemic profiles and weight in people with this condition.

Methodology: We searched for randomized clinical trials in PubMed, Science Direct, Ovid and Ebsco databases. We accessed studies on obese adults published between January 2019 and March 2024 that evaluated the effect of dietary polyphenols on biomarkers of inflammation (TNFα, hs-CRP, IL6 and IL10) and endotoxemia (LPS).

Results: Eleven studies with 506 participants were included. It was evidenced in 73% of the studies that the biomarkers most sensitive to decrease with polyphenol consumption were CRP, IL6 and TNFα. In relation to endotoxemia lipopolysaccharide-binding lipoprotein increased by 30% in the intervention group and lipopolysaccharides were not affected. Glycemia decreased an average of 15% and weight remained stable, which indicates that polyphenols can also be an adjuvant in weight management.

Discussion: polyphenol consumption showed tolerance and modulation of inflammation and endotoxemia, but further studies are required.

Conclusion: dietary phytonutrients are promising substances in the management of inflammation, endotoxemia, glycemia and weight in patients with obesity.

KEY WORDS

Polyphenols, inflammatory mediators, diet, obesity, endotoxemia.

INTRODUCCIÓN

La adiposidad abdominal se correlaciona significativamente con niveles elevados de oxidación e inflamación crónica mediada por radicales libres. La inflamación prolongada y el estrés oxidativo[1], junto con un aumento de peso facilitan la patogénesis de enfermedades relacionadas con el estilo de vida, como diabetes tipo 2, enfermedades cardiovasculares[1] y neurodegenerativas, enfermedad renal crónica, cáncer, enfermedad hepática no alcohólica y trastornos autoinmunes[2,3] así como con disfunción endotelial, dislipidemia e hipertensión arterial. Muy a menudo, estas alteraciones empiezan a ser evidentes durante la fase de sobrepeso (Índice de Masa Corporal <30)[4].

La acumulación excesiva de triglicéridos conduce a la hipertrofia de los adipocitos comprometiendo su disponibilidad de oxígeno y la función celular que los lleva a su muerte. Es entonces cuando se inicia la activación del sistema inmunitario, la producción de citocinas inflamatorias[17] y estrés oxidativo, desencadenantes del desarrollo de inflamación crónica de bajo grado.

El estrés oxidativo está mediado por la sobreproducción de especies reactivas de oxígeno(ROS), y se asocia a disfunción endotelial así como a daño de lípidos, proteínas y ADN[5], adicionalmente, induce daño celular y promueve la activación de cascadas de señalización, generando moléculas proinflamatorias implicadas en el desarrollo de complicaciones relacionadas con la obesidad, incluidas las enfermedades cardiovasculares (ECV) y la diabetes mellitus tipo 2(DM 2)[6,7]. De otro lado, se considera que el aumento de la fuga de lipopolisacáridos bacterianos (LPS, endotoxina) a la circulación, o endotoxemia, es una posible fuente de la reacción inflamatoria crónica en la DM 2[8] agravada por el síndrome del intestino permeable, la disbiosis de la microbiota intestinal y la hiperglucemia[10-14].

La dieta occidental habitual, rica en grasas saturadas y azúcares simples, está asociada con cambios metabólicos como la disfunción de la vía de la insulina que conduce a hiperinsulinemia que, a su vez, estimula la producción del factor de necrosis tumoral alfa (TNFα) en el tejido adiposo, aumentando la lipólisis y al mismo tiempo los ácidos grasos libres (AGL) y el glicerol[14]. También se ha demostrado que este tipo de alimentación se asocia con el desarrollo de alteraciones en el estado redox, alteración de la microbiota intestinal y alta respuesta inflamatoria[15,16]. La dieta baja en fibra se ha relacionado con un desequilibrio en la composición y diversidad de la microbiota intestinal denominada disbiosis[15,16]. Este proceso afecta la producción de ácidos grasos de cadena corta y la integridad de la mucosa intestinal[15,16]. La microbiota intestinal también podría influir en el envío de señales endocrinas al hipotálamo (tanto hormonas orexigénicas como anorexigénicas) induciendo a mayor ingesta de alimentos y almacenamiento de triglicéridos en los adipocitos[17].

Se ha establecido que la microbiota desempeña un papel importante en la aparición de enfermedades metabólicas, en parte debido a la liberación de LPS, que inducen la inflamación crónica de bajo grado[18].

Las modificaciones dietéticas pueden modular positivamente la composición de la microbiota intestinal, lo que lleva a una mejor función de la barrera intestinal y una menor traslocación de endotoxinas del intestino a la circulación[20]. Dichas modificaciones incluyen la ingestión de la fibra soluble la cual favorece que las endotoxinas se adhieran a ella para ser eliminadas y además facilita la producción de ácidos grasos de cadena corta (AGCC) reduciendo la permeabilidad intestinal. También se ha demostrado que fitonutrientes como los polifenoles con propiedades antioxidantes desempeñan un papel crucial en el alivio de la inflamación y la reducción del riesgo de mortalidad[19,22]. Los polifenoles de la dieta tienen efectos inhibidores sobre la activación del factor nuclear potenciador de la cadena ligera kappa de las células

B activadas (NF κB) en los macrófagos, lo que resulta en una disminución de las citocinas proinflamatorias como la interleucina 6(IL6), interleucina 1 beta(IL1β) y factor de necrosis tumoral (TNFα)[23] a pesar de los beneficios que generan los cambios en el estilo de vida los estudios evidencian escasa adherencia a largo plazo[21].

Teniendo en cuenta lo anteriormente mencionado se hace necesaria una evaluación objetiva del efecto de los polifenoles en pacientes con obesidad. Por lo tanto, llevamos a cabo una revisión sistemática de ensayos controlados aleatorizados (ECA) teniendo como objetivo evaluar los efectos del consumo de polifenoles sobre parámetros relacionados con la obesidad, como los marcadores inflamatorios y de endotoxemia, los perfiles glucémicos y medidas antropométricas (peso) en personas con esta condición.

MATERIALES Y MÉTODOS

Estrategia de búsqueda

Se realizó una búsqueda bibliográfica en cuatro bases de datos: PubMed, Science Direct, Ovid y Ebsco. Se utilizaron términos Mesh, empleando la siguiente ecuación de búsqueda "Polyphenols" AND "Inflammation", "Obesity"AND "Endotoxemia", "Polyphenols" AND "Obesity", "Obesity" AND "Inflammation",

Selección de estudios

Los estudios incluidos en esta revisión sistemática fueron ensayos clínicos aleatorizados (ECA) que evaluaron los efectos de diferentes matrices alimentarias y sus polifenoles en la modulación de biomarcadores proinflamatorios y de endotoxemia en personas con obesidad. Los artículos de texto completo se obtuvieron cuando los resúmenes eran potencialmente relevantes y se revisaron de forma independiente por dos de los autores. Los puntos de vista conflictivos se resolvieron mediante discusión entre los cuatro investigadores. Los estudios duplicados, revisiones, otros tipos de artículos (cartas, comentarios, editoriales, reportes de casos, estudios de cohortes y estudios transversales) o texto completo inaccesible, se eliminaron.

Criterios de inclusión

Se incluyeron ensayos clínicos controlados aleatorizados en personas con obesidad (IMC ≥ 30 kg/m2) mayores de 18 años publicados entre enero de 2019 y marzo de 2024 y debían evaluar el efecto de los polifenoles dietarios en biomarcadores de inflamación (FNTα, PCR hs, IL6 e IL10) y de endotoxemia (LPS).

Criterios de exclusión

Se excluyeron los estudios duplicados o realizados con menores de edad, adolescentes o embarazadas. Los estudios en animales o in vitro también fueron excluidos.

Evaluación del riesgo de sesgo

La evaluación de la calidad de los artículos fue realizada de manera independiente por los cuatro autores, teniendo en cuenta los criterios de inclusión y exclusión de los estudios. Para evaluar el sesgo se utilizó el análisis de riesgo habilitado por Cochrane[36]. Esta herramienta evalúa el riesgo de sesgo en los siguientes dominios: sesgo de selección, sesgo de desempeño, sesgo de detección, sesgo de deserción. Los criterios de riesgo de sesgo se consideraron "riesgo bajo", "riesgo alto" o "riesgo incierto". En general, los estudios evaluados presentan, en su mayoría, un bajo riesgo de sesgo en varias categorías, aunque hay áreas donde el riesgo es incierto, lo que indica que hay aspectos de los estudios donde no se puede asegurar completamente la ausencia de sesgo. Sin embargo, se compararon los resultados de la evaluación del riesgo de sesgo para cada dominio de cada estudio y los desacuerdos se resolvieron mediante discusión entre los autores. Figura 1 y 2.

Extracción de datos

La extracción de datos fue realizada por dos de los investigadores de este estudio mediante la utilización de un formato en Excel que incluía información general del estudio (autor, año, país, diseño del estudio), características de los participantes (edad, criterios de inclusión/exclusión), detalles de la intervención (tipo de polifenoles, presentación, dosis, y duración). Un tercer investigador participó para resolver diferencias entre los dos primeros.

Se consideraron desenlaces primarios los cambios séricos en los niveles de factor de necrosis tumoral alfa (FNTα), interleucina 6 (IL6), proteína C reactiva de alta sensibilidad (PCR hs) y lipopolisacáridos (LPS) y secundarios los niveles séricos de glicemia e insulina y cambios en el peso corporal.

Análisis de datos

Se calcularon y analizaron los cambios porcentuales en los niveles séricos de biomarcadores proinflamatorios (PCR hs, FNTα, IL6) y de endotoxemia (LPS) así como bioquímicos (glicemia e insulina) y antropométricos (peso) en los grupos intervenidos y de control.

RESULTADOS

Búsqueda de la literatura

Se identificaron 194 estudios y se seleccionaron 11 para un total de 506 participantes (Figura 3).

Características y estudios seleccionados

Como se muestra en la Tabla 1 la duración de las intervenciones osciló entre 4 y 24 semanas. El tamaño de la muestra varió entre 25 y 78 sujetos para un total de 506 participantes. Los estudios relacionaban personas con sobrepeso/

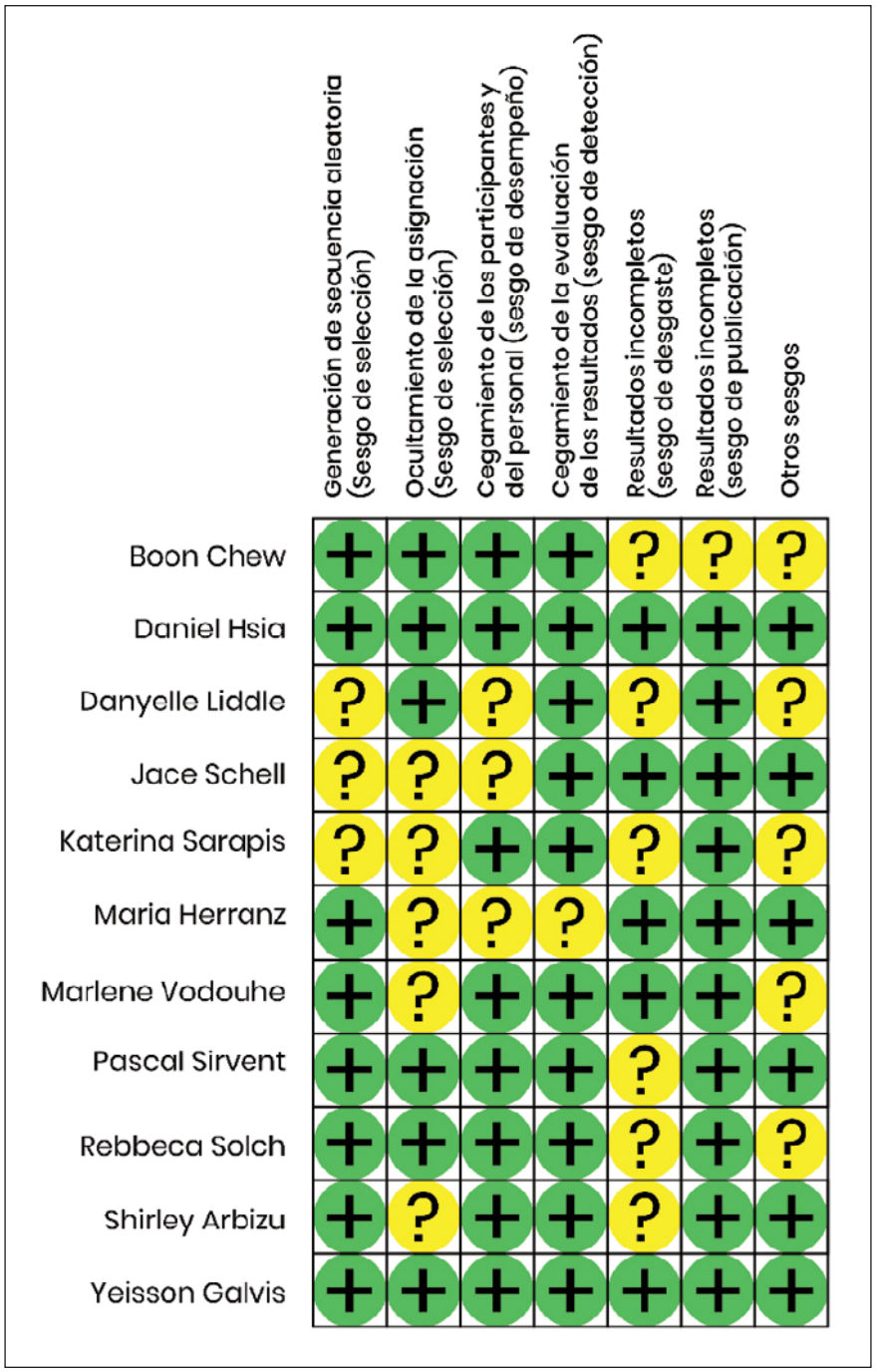

Figura 1. Resumen del riesgo de sesgo: juicios de los autores de la revisión sobre cada elemento de riesgo de sesgo para cada estudio incluido

obesidad y otras patologías asociadas como la resistencia a la insulina, dislipidemia, diabetes mellitus tipo 2 y otras enfermedades metabólicas.

Tipos de polifenoles y matrices

Las matrices más utilizadas fueron extractos encapsulados 27%, extractos en contenidos líquidos 64% y fruta entera 9%.

En cuanto a los polifenoles los más estudiados fueron antocianinas (64%), ácido clorogénico y quercetina (55%), kaemferol (36%), miricetina, ácido cafeico y ácido elágico (18%), proantocianidinas, luteolina, hidroxitirosol y oleuropeina (18%) y ácido hibístico, verbascósido, apigenina, lignanos, rutina, cinarina, tirosol, piperina, resveratrol, oleocantal, ligstroside, ácido ursólico (9%).

RESULTADOS

Entre los resultados principales de los 11 ensayos clínicos aleatorizados analizados, se encontró que el 73% de los biomarcadores como la PCR, la IL6 y el TNFα disminuyeron de manera significativa en 21%, 23% y 4% respectivamente después de la administración de polifenoles.

El 9% de los ensayos que evaluaron la proteína de unión a LPS(LBP) tuvo un aumento significativo del 29,7% en el grupo de intervención. Aunque no hubo significancia estadística, se pudo observar que en el 9% de los estudios evaluados aumentó el 8% los lipopolisacáridos en el grupo control comparado con el de intervención.

En el 36% de los estudios, se encontró que con la suplementación con diferentes polifenoles el peso corporal disminuyó en el grupo intervención y control 2,6% y 2,5% respectivamente del peso basal con significancia estadística.

Otro de los parámetros bioquímicos que se afectó fue la glicemia evidenciado en el 54% de los estudios revisados de los cuales el 18% no tuvo cambios significativos y el 36% presentó una disminución de un promedio de 15% en la concentración comparado con el grupo placebo en el cual aumentó.

Las características de los estudios incluidos y resultados adicionales se observan en la tabla 1.

DISCUSIÓN

En esta revisión el objetivo fue analizar el efecto de polifenoles dietarios en la modulación de diferentes biomarcadores de inflamación (PCR, FNTα e IL6) y endotoxemia (LPS) principalmente, aunque se analizaron otros biomarcadores proin-

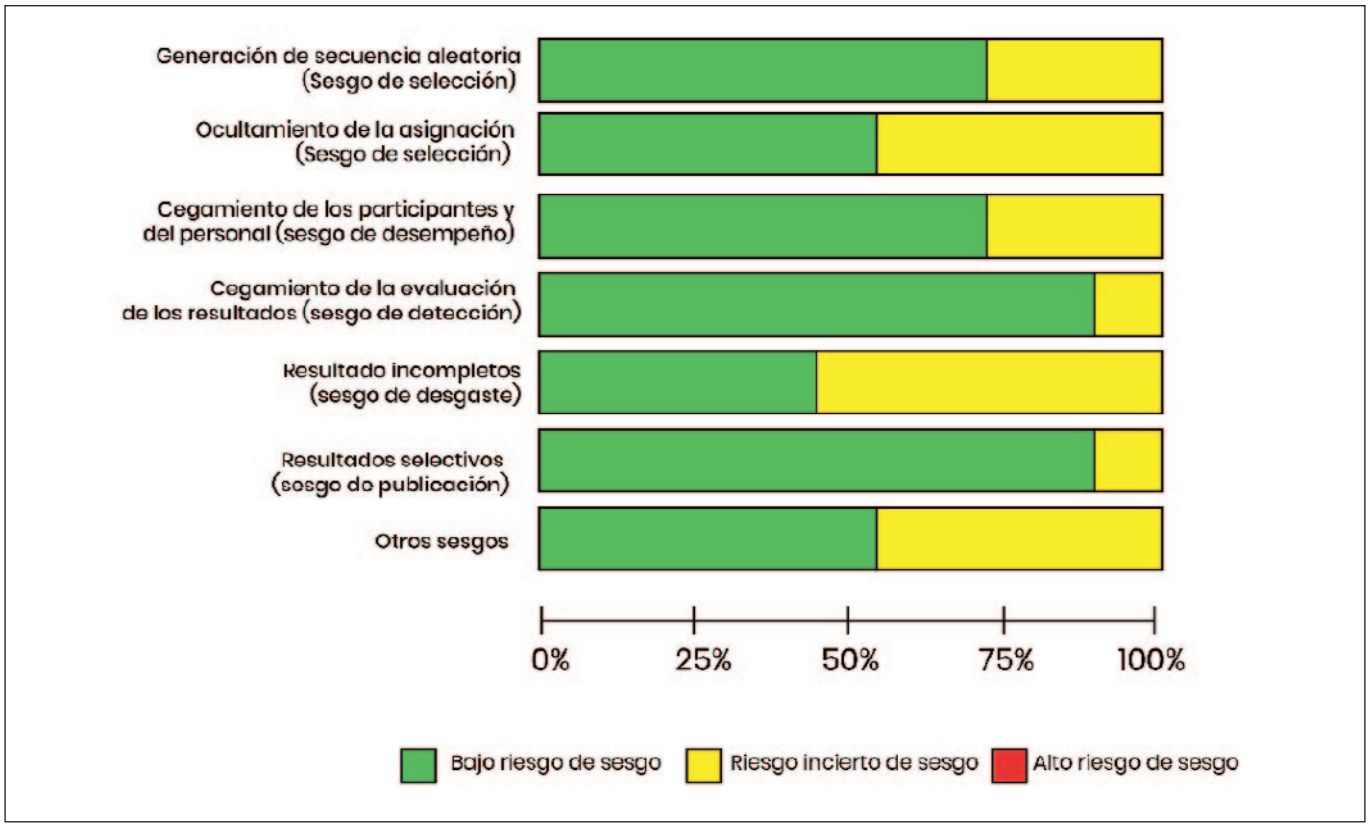

Figura 2. juicios de los autores de la revisión sobre cada elemento de riesgo de sesgo presentado como porcentajes de todos los estudios incluidos

flamatorios (IFN-γ, IL17), antiinflamatorios (IL10), de endotoxemia (LBP), antropométricos (peso) y bioquímicos (glicemia e insulina) en personas con obesidad. Todos los estudios estuvieron enfocados a la administración de matrices alimentarias con contenido de polifenoles en diferentes concentraciones.

Se observó que en el 73% de los estudios los biomarcadores más sensibles a la disminución después de la administración de polifenoles fueron PCR, IL6 y FNTα. Resultados similares se hallaron en el estudio de Astudillo et al. 2019 suministrando una dieta durante 8 semanas con propiedades antiinflamatorias la cual contenía alimentos como fibra, vitaminas, polifenoles y ácidos grasos poliinsaturados, provenientes de frutas, verduras, legumbres, pescado, chocolate amargo, cereales integrales y maní encontrando disminución importante en la PCR e IL6[19]. Por el contrario, Vors et al (2018) no encontraron diferencias significativas en la modulación de biomarcadores inflamatorios IL6 y PCR tras la intervención con curcumina y resveratrol[24].

Otro estudio estableció que el IFN-γ tuvo una disminución estadísticamente significativa después de la intervención con un extracto de arándano en bebida baja en calorías durante 8 semanas[25] Albouchi et al. 2018 obtuvieron resultados similares con la administración de extracto de hojas de *Melaleuca styphelioides* (árbol del té de hojas espinosas)[26].

La administración de cereza dulce oscura durante un mes, evidenció disminución del receptor antagonista de la interleucina 1(IL-1Ra) en el grupo control dado que en el grupo de intervención la disminución no fue estadísticamente significativa[6]. Su disminución implica una menor capacidad para regular la respuesta inflamatoria. Por el contrario, Jung et al. administraron 25 g de soya fermentada resultando en un aumento del 12 % en el receptor agonista de la interleucina-1 (IL-1Ra)[27], hubo disminución significativa de la PCR y de la IL-1β con la administración de la cereza dulce oscura[6] mientras que Liddle et al. 2021 no obtuvieron resultados similares con la administración de manzana durante 6 semanas[16]. Chew et al. 2019 encontraron que la bebida de extracto de arándano disminuyó la IL6[25] mientras que en otro estudio Solch et al. 2022 con la administración de la misma matriz sus desenlaces no fueron significativos sobre este biomarcador[28].

Es importante resaltar que los polifenoles tienen valores nutricionales y terapéuticos para los seres humanos. Sus grupos funcionales e innumerables subclases les permiten participar en diferentes rutas bioquímicas facilitando actividades biológicas[29], pero aún estos beneficios siguen siendo debati-

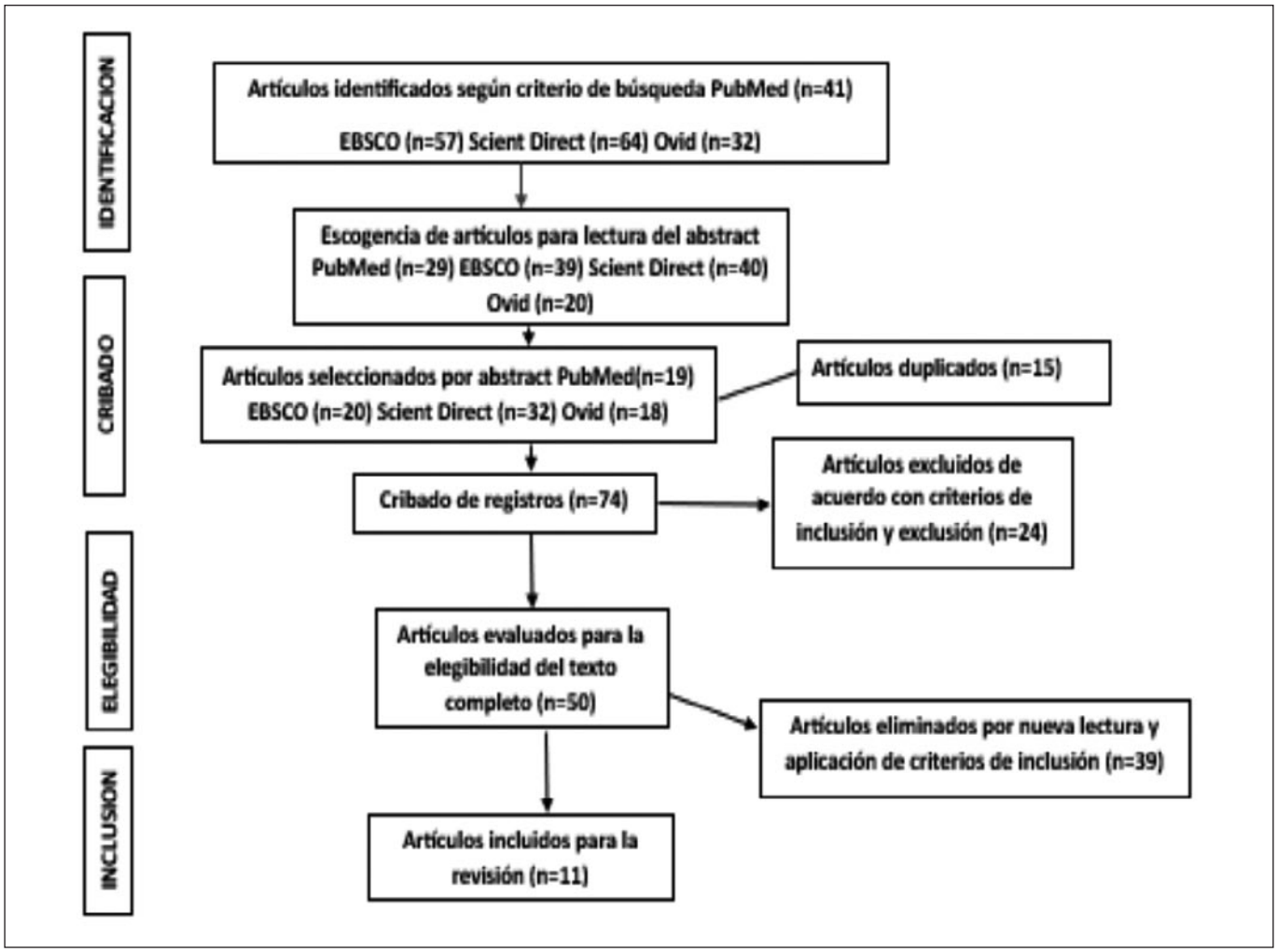

Figura 3. Estrategia de cribado, diagrama de Prisma para identificar estudios que cumplían criterios de inclusión

dos. Los científicos siguen investigando las ventajas de los polifenoles, en ese sentido Chew et al. 2019 evidenciaron efecto antiinflamatorio con la disminución de la PCR tras la administración de una bebida de arándanos rica en polifenoles después de 8 semanas[25].

En el metabolismo de los polifenoles entra en juego el microbioma el cual debe estar en balance para un adecuado funcionamiento transformándolos en metabolitos que tengan una mejor biodisponibilidad y así facilitar las funciones biológicas. Los cambios en la microbiota se han relacionado con la prevalencia de la obesidad.

Se ha demostrado que la microbiota desempeña un papel importante en la aparición de enfermedades metabólicas debido en parte a la liberación de lipopolisacárido (LPS) que produce inflamación crónica de bajo grado. Además la endotoxemia conlleva a la aparición de resistencia a la insulina[14]. En este sentido en esta revisión se pudo observar que hubo aumento de la proteína fijadora de lipopolisacáridos (LBP) en el grupo de intervención debido a la inflamación crónica de los pacientes obesos diabéticos, así mismo Jobe et al. 2022 determinaron que las mujeres delgadas tenían un nivel de LBP más bajo en comparación con las mujeres con obesidad y las mujeres con obesidad-diabetes[30].

A pesar de la evidencia, Solch et al. 2022 no encontraron asociación entre el consumo de polifenoles más ácido acetilsalicílico y la disminución de biomarcadores inflamatorios pero impactó de manera positiva la endotoxemia al no hallarse diferencias estadísticamente significativas de LPS en sangre entre los grupos[28]. Es probable que la administración de polifenoles hubiera tenido un efecto protector de la mucosa intestinal evitando su permeabilidad la cual sería inducida por el ácido acetil salicílico. Se evidenció que la suplementación con diferentes polifenoles mantuvo el peso estable donde tanto en el grupo de intervención como en el grupo control hubo disminución promedio de 2,60% y 2,45% del peso basal probablemente evitando que los sujetos hubieran aumentado de peso, lo que puede indicar que sea un coadyuvante en el manejo de la obe-

Tabla 1. Efectos de los polifenoles sobre diferentes biomarcadores proinflamatorios, endotoxémicos, bioquímicos y antropométricos

Autor	Población	Intervención	Duración	Polifenoles	Marcadores	Basal- post intervención	Efecto neto y Valor p	Conclusión
Herranz et al. 2019 Reino Unido	46 sujetos Media 56 años Obesidad	Lipia citriodora Hibisco sabdariffa Cápsulas de 250 mg dos veces al día	8 semanas	Antocianina Ácido de hibisco Ácido clorogénico Quercetina Luteolina	Peso (Kg)	Sobrepeso Intervención Control Obesidad Intervención Control	↓3,7 Kg (5,4%) (p=0,0001) ↓1,9 Kg (2,8%) (p=0,05) ↓4,6 Kg (5,2%) (p= 0,05) ↓ 2,2 Kg (2,5%) (p= 0,05)	El peso disminuyó en los cuatro grupos, sin embargo, la pérdida de peso en los sujetos intervenidos fue más significativa
Sirvent et al. 2022 Francia	51 sujetos Media 57 años DM-Tipo II Sobrepeso/ obesidad	Cápsulas de 623,85 mg/día 8 cápsulas/día Total=4,99g/día	6 meses	Quercetina Kaempferol Ácido clorogénico Rutina Miricetina Ácido cafeico Proantocianidina Oleuropeína Hidroxitirosol Tirosol Piperina Resveratrol	Peso (Kg) Glucemia en ayunas (mg/dl) Glucemia poscarga (mg/dl)	Intervención Placebo Intervención Placebo Intervención Placebo	↓0,1 kg (0,1 %) (p=0,02) ↑1,9 Kg (1,7%) (p=0,02) ↓4,1 mg/dl (3,3%) (p=0,026) ↑9,1 mg/dl (7,2%) (p=0,026) ↓2,2 mg/dl (1,2%) (p=0,05) ↑31,7 mg/dl (16,3 %) (p=0,05)	La intervención logró disminuir el peso y la glucemia (en ayunas y postcarga)
Chew et al. 2019 EE. UU.	78 sujetos Media 43 años Sobrepeso/ obesidad	Arándano Extracto en bebida 450 ml/día	8 semanas	Quercetina Miricetina Kaempferol Antocianina	IL-6 pg /ml (5h) IFN-γ pg /ml (3h) Glucemia mg/dl IL-6 pg /ml (5h) IFN-γ pg /ml(3h) Glucemia mg/dl	Intervención Placebo	↓1,9(27,1%) (p=0,001) ↓0,3(30%) (p=0,055) ↓20,0(75%) (p=0,05) ↓1,6(23,9%) (p=0,001) ↓0,1(11,1%) (p= 0,055) ↓10,0(16,7%) (p=0,05)	Los biomarcadores de inflamación y la glucemia disminuyeron más en el grupo de intervención que en el grupo placebo, donde también se observó que el IFN-γ disminuyó, pero menos que en el grupo intervenido
Vodouhè et al. 2022 Canadá	56 sujetos Media 53 años Sobrepeso/ obesidad	Ascofilo nudoso Fucus vesiculosus (alga parda) Cápsulas de 500 mg dos veces al día	12 semanas	Florotanino Fucoidan Ácido cafeico Ácido clorogénico	Peso (kg) LBP 10^3 ng/ml Peso (kg) LBP 10^3ng/ml	Intervención Placebo	↓2,0(2,2%) (p=0,001) ↑1,9(29,7%) (p0,002) ↓ 2,0(2,2%) (p=0,03) ↑ 0,9(13,2%) (p=0,17)	El peso disminuyó en ambos grupos y la LBP aumentó en ambos grupos, pero fue más significativa en el grupo intervenido
Arbizu et al. 2023 EE. UU.	40 sujetos ≥ 18 años Obesidad	Cereza oscura dulce Extracto en bebidas, 200 ml dos veces al día TPC 7,64 ± 67 GAE/ml	4 semanas	Antocianina Quercetina Kaempferol Ácido clorogénico Ácido elágico	Peso (Kg) IL-1RA pg/ml IL-10 pg/ml IFN-γ pg/ml PCR mg/l Peso (Kg) IL-1RA pg/ml IL-10 pg/mlI FN-γ pg/ml PCR mg/l	Intervención Placebo	↑0,4(0,4%) (p=0,003) ↓1,7(16,7%) (p=0,001) ↓0,8(0,5%) (p=0,0005) ↓0,5(27,8) (p=0,01) ↓0,7(30,4) (p=0,02) ↑0,8(0,8%) (p=0,0002) ↓4,9(41,1%) (p=0,002) ↑6,1(67%) (p=0,0002) ↑1,8(60%) (p=0,001) ↑1,3(86,7%) (p=0,02)	El peso aumentó en ambos grupos, siendo el grupo placebo el que más aumentó. Los biomarcadores de inflamación disminuyeron en el grupo intervenido mientras que en el grupo placebo aumentaron. Paradójicamente, el IL-1RA disminuyó en ambos grupos

IL6: Interleucina 6; IFN-γ: Interferón gamma; LBP: Proteína de unión a lipopolisacárido; IL1RA: Antagonista del receptor de interleucina 1; PCR: Proteína C reactiva; TNF-α: Factor de necrosis tumoral alfa; TAC: Capacidad antioxidante total; LPS: Lipopolisacáridos.

Tabla 1 continuación. Efectos de los polifenoles sobre diferentes biomarcadores proinflamatorios, endotoxémicos, bioquímicos y antropométricos

Autor	Población	Intervención	Duración	Polifenoles	Marcadores	Basal- post intervención	Efecto neto y Valor p	Conclusión
Hsia et al 2022 EE. UU.	35 sujetos Media 47 años Resistencia a la insulina	Arándano Extracto en bebida 450 ml/día 50 g de arándanos frescos Antocianidina 6,5 mg Proantocianidina 143,6 mg Fenoles totales 458 mg	8 semanas	Antocianidina Proantocianidina Quercetina Miricetina Kaempferol	Peso (kg) Glucemia mg/dl Peso (kg) Glucemia mg/dl	Intervención Placebo	Media 103,8 (p=0,48) Media 97,0 (p=0,63) Media 101,0 Media 99,0 (p=No reporta)	No se observaron variaciones estadísticamente significativas en cuanto al peso y la glucemia en ambos grupos
Sarapis et al. 2022 Alemania	43 sujetos Media 38 años Sobrepeso/ obesidad	Aceite de oliva virgen extra rico en polifenoles 20mg/kg Aceite de oliva bajo en polifenoles 86 mg/kg 60 ml	8 semanas	Hidroxitirosol Oleocantal Oleuropeína Ligstroside	Peso (kg) PCR mg/L Peso (kg) PCR mg/L	Aceite de oliva extra virgen Aceite de oliva bajo en polifenoles	No hay informes Media 68,5 Media 2,6 (p=0,05) Media 72,7 (p=0,249) Media 1,9 (p=0,663)	No hubo variaciones en cuanto al peso en ambos grupos. Descenso significativo de PCR en el grupo intervenido con aceite de oliva extravirgen
Schell et al. 2019 Suiza	25 sujetos Media 54±4,2 años Obesidad/ DM tipo II	250 g de frambuesas licuadas Fenoles totales 343 mg GAE Antocianina 225 mg Eq Cianuro de 3-glucósido Ácido elágico 20 mg GAE Elagitanino 115 mg GAE	10 semanas	Antocianina Ácido cafeico Ácido elágico Quercetina	Glucemia mg/dl IL-6 pg/ml TNF-α pg /ml Glucemia mg/dl IL-6 pg/ml TNF-α pg /ml	Intervención Control	↓17,7% (p=0,05) ↓9,8% (p=0,05) ↓50,3% (p=0,05) ↑30% (p=0,1) ↑99,9% (p=0,1) ↑99,9% (p=0,1)	Los niveles de IL-6, TNF-α y glucemia en suero disminuyeron en el grupo de intervención en comparación con el grupo de control en el cual aumentaron
Galvis et al. 2020 EE. UU.	52 sujetos Media 54 años Síndrome Metabólico	Agraz Antocianina 200±10mg eq/100g Fenol 609±39mg eq/100g Fruta fresca	12 semanas	Antocianina Cianuración Fenoles Ácido ferúlico Ácido cafeico Catequina	HOMA-IR PCR mg/L Insulina mUI /L	Intervención Placebo Intervención Placebo Intervención Placebo	↓8,7% Mujeres ↓1,5% Hombres (p=no reporta) (p=no reporta) ↓18,4% Mujeres ↓12,1% Hombres (p=0,50) (p=no reporta) ↓11,0% Mujeres ↓8% Hombres (p=0,043) (p=no reporta)	En el grupo intervenido se observó una disminución de la insulina, del índice HOMA-IR y PCR, más notoria en el sexo femenino
Liddle et al. 2021 EE. UU.	44 sujetos Media 48 años Sobrepeso/ obesidad	Manzana 200g/día	6 semanas	Flavonoide Ácido ursólico Ácido clorogénico	PCR µg/ml IL6 pg/ml IL17 pg/ml IFN -γ pg/mL LBP µg/ml TAC mml/L PCR µg/ml IL6 pg/ml IL17 pg/ml IFN -γ pg/mL LBP µg/ml TAC mml/L	Intervención Control	↓17,0% (p=0,005) ↓12,4% (p=0,001) ↓11,0% (p=0,001) ↓11,9% (p=0,005) ↓20,7% (p=0,001) ↑18,5% (p=0,001) ↑9,7% (no reporta) ↑16,7% (p=0,001) ↓2,3% (p=0,003) ↑3,8% (p=0,003) ↑7,1% (p=0,001) ↑5,2% (p=0,002)	Los biomarcadores de inflamación disminuyeron en el grupo de intervención y aumentaron en el grupo control excepto IL17 que disminuyó ligeramente. La capacidad antioxidante total aumentó significativamente en el grupo intervenido
Solch et al. 2022 EE. UU.	36 sujetos Media 35,4 años Obesidad	Bebida de arándanos de 480 ml Fenoles totales: 407 mg Antocianina total: 11 mg Proantocianina 535 mg	12 semanas	Antocianina Ácido elágico Ácido clorogénico	PCR mg/l IL6 pg/ml TNF- α pg/ml LPS ml PCR mg/l IL6 pg/ml TNF-α pg/ml LPS ml	Intervención Control	↓1,4% (p=0,92) ↓5,8% (p=0,76) (p=0,44) (p=0,11) ↑19,7% (p=no reporta) ↓17,8% (p=no reporta) ↓8,3% (p=no reporta) ↑50% (p=no reporta)	Los biomarcadores de inflamación y endotoxemia no se modificaron de forma significativa ni en el grupo intervenido ni en el grupo control

IL6: Interleucina 6; IFN-γ: Interferón gamma; LBP: Proteína de unión a lipopolisacárido; IL1RA: Antagonista del receptor de interleucina 1; PCR: Proteína C reactiva; TNF-α: Factor de necrosis tumoral alfa; TAC: Capacidad antioxidante total; LPS: Lipopolisacáridos.

sidad y sobrepeso. Muñoz et al. 2023 tras la administración de una dieta basada en fruta, aguacate, cereales integrales y trucha durante 8 semanas observaron que el peso disminuyó 1,69% siendo estadísticamente significativo. Con relación a la glicemia se observó una reducción promedio de un 15% con la administración de polifenoles, en ese sentido Chew et al. 2019 halló tras la administración de bebida de extracto de arándanos durante 8 semanas respuestas favorables en cuanto a la glucorregulación con una disminución de glicemia de 20%[25], por el contrario Vodouhè et al. 2022 administraron durante 12 semanas 500 mg de extracto de algas pardas ricas en polifenoles sin tener modificaciones en la cifras de glicemia[31]. En cuanto a la insulina se demostró que fue susceptible a la baja con la intervención de polifenoles en promedio de 21% de su concentración, por el contrario Liddle et al. 2021 intervinieron 46 sujetos durante 6 semanas administrando 200 g de manzana al día sin tener cambios estadísticamente significativos en las concentraciones de insulina[16].

Las diferentes matrices ricas en polifenoles aumentaron la capacidad antioxidante total, de igual forma Galvis et al, 2020 con la administración de néctar de agraz a hombres y mujeres durante 12 semanas encontró un aumento importante en la capacidad antioxidante total en el grupo de las mujeres[32].

Hubo diversidad de polifenoles, los arándanos tuvieron impacto en la disminución de algunos biomarcadores inflamatorios como IL6 y el IFN-γ[25], la cereza dulce oscura disminuyó la PCR, la IL6 y el receptor antagonista de la interleucina 1(IL-1RA)[6] mientras que la administración de manzana favoreció la disminución de la PCR, la IL6, IL17 y los lipopolisacáridos(LPS)[16].

El consumo de los polifenoles especialmente en matrices alimentarias genera pocas reacciones adversas[33] y tiene varios beneficios, son agentes antioxidantes esenciales, estos atenúan los efectos de las actividades de los prooxidantes o radicales libres al extinguir su actividad oxidativa[35].

Se ha informado ampliamente que este grupo de compuestos posee potencias antialérgicas, antihipertensivas, antiinflamatorias, anticancerígenas, antivirales y antimicrobianas[34]. Elegir el consumo de polifenoles dietarios como agentes preventivos y terapéuticos en las diferentes enfermedades metabólicas y cardiovasculares conlleva a un mejor estado de salud y adherencia mientras que el manejo farmacológico de la obesidad y el sobrepeso con algunos medicamentos como por ejemplo los agonistas del receptor del péptido tipo 1 similar al glucagón (GLP-1) pueden generar algunas reacciones desagradables especialmente gastrointestinales lo que conlleva en muchos casos al abandono de la terapia.

Limitaciones y fortalezas del estudio

Una limitación de nuestro estudio es la heterogeneidad entre los ensayos clínicos analizados. Hubo diversidad entre los marcadores de disfunción inflamatoria, bioquímicos, antropométricos y de endotoxemia estudiados, la duración de la intervención y la edad de los participantes. Debido a esta heterogeneidad, no fue posible realizar un metaanálisis de los datos proporcionados por estos estudios.

De otro lado, la búsqueda exhaustiva y el rigor de la investigación ofrecen resultados confiables en este estudio.

Conclusiones

La administración de los polifenoles evidenció su efectividad en la mejora de la inflamación y la endotoxemia, incidió además en la modulación de la glicemia e insulina, lo que indica que son prometedores en el manejo de la obesidad.

En el futuro, será necesario realizar más ensayos clínicos aleatorizados en esta área para identificar mejor la efectividad y también revelar el mecanismo subyacente del efecto de la intervención con polifenoles en adultos con esta condición.

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The relationship between water intake and the progression of urine albumin-creatinine ratio in patients with chronic kidney disease: A cohort-prospective study

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ABSTRACT

Introduction: The urine albumin-creatinine ratio (uACR) is a key biomarker for assessing kidney function in patients with chronic kidney disease (CKD), with elevated levels indicating kidney damage. Water and protein metabolism significantly impact kidney function. Proper hydration influences vasopressin feedback and osmolality regulation, while excessive protein intake exacerbates kidney stress through hyperfiltration and increased urea production. This study investigates the relationship between daily water and protein intake and uACR levels in CKD patients.

Methods: A cohort study was conducted on 10 non-dialysis CKD patients at Dr. Wahidin Sudirohusodo Hospital, Makassar, Indonesia. Demographic and clinical data were collected, and average daily water and protein intake were assessed. The Spearman correlation test analyzed the relationship between water and protein intake and changes in uACR, albumin, and creatinine levels.

Results: A strong negative correlation was found between daily water intake and uACR (ρ=-0.891, p=0.001), indicating that higher water consumption reduces uACR. Conversely, protein intake showed a strong positive correlation with uACR (ρ=0.770, p=0.009) and urine albumin levels (ρ=0.806, p=0.005), suggesting that higher protein consumption increases both uACR and albumin excretion. No significant correlation was found between water or protein intake and urine creatinine levels.

Conclusion: This study highlights the importance of hydration and dietary protein regulation in managing CKD progression. Increased water intake may reduce uACR, while excessive protein intake can exacerbate kidney damage, emphasizing the need for dietary management in CKD patients.

KEYWORDS

Chronic kidney disease, urinary markers, fluid regulation, glomerular filtration, kidney function.

ABBEREVIATION

BMI: Body Mass Index.

CKD: Chronic Kidney Disease.

DM: Diabetes Mellitus.

eGFR: Estimated Glomerular Filtration Rate.

uACR: Urine Albumin-Creatinine Ratio.

INTRODUCTION

Chronic kidney disease (CKD) is a progressive condition that affects millions worldwide, leading to deteriorating renal function over time[1]. Understanding the factors that influence the progression of CKD is crucial for developing effective management strategies. Two major factors that play a significant role in kidney function are water and protein intake[2]. Previous studies have explored the impact of hydration and dietary protein on kidney health, but the specific relationship between these factors and the urine albumin-creatinine ratio (uACR), a critical biomarker of kidney function, remains an area of ongoing investigation[3].

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In patients with CKD, the urine albumin-creatinine ratio is a reliable indicator of kidney damage, with elevated levels reflecting compromised renal filtration capabilities[4]. Water intake, through its effect on vasopressin feedback and osmolality regulation, is thought to influence this marker, potentially slowing disease progression[5]. Similarly, protein consumption can exacerbate kidney function decline through hyperfiltration and increased intraglomerular pressure, as excess protein metabolism byproducts, such as urea, strain the kidney's filtering capacity[6]. This study aims to investigate these correlations further, shedding light on the impact of daily water and protein intake on the uACR in CKD patients, and providing insights into dietary management for disease control.

METHODS

Subject's and data collections

A cohort study was conducted on 10 non-dialysis CKD patients in Dr. Wahidin Sudirohusodo Hospital, Makassar, South Sulawesi, Indonesia. This study was approved by the Research Ethics Commission of the Faculty of Medicine, Hasanuddin University (No: 824/UN4.6.4.5.31/PP36/2022). Demographic (age, gender) and clinical (age (years), body mass index BMI (kg/m^2), smoking status, alcoholic status, hypertension, nasopharynx cancer, diabetes mellitus, hyperuricemia dyslipidemia) were collected by collecting medical record data from patients who were examined in Clinical Laboratory of Dr. Wahidin Sudirohusodo Central Hospital. Water (dL/day) and protein intake (g/day) were collected by recall.

Statistical analysis

Baseline data were descriptively summarized and crosstabulated. Each of the demographic and clinical features was analyzed. The correlation between average water and protein intake with changes in uACR (mg/g from urine albumin mg/dL and urine creatinine g/dL) was analyzed using the Spearman correlation test. All statistical analyses were performed using the Statistical Program for Social Sciences (IBM SPSS 24, IL, USA).

RESULTS

A total of 121 patients with chronic kidney disease (CKD) were initially screened for the study. Following the screening process, 110 patients were excluded based on specific criteria: 60 patients were at stage 5 CKD, 30 were at stage 4 CKD and undergoing hemodialysis (HD), 2 were at stage 3b CKD and receiving antidiuretic treatment, and 18 were at stage 2 CKD. After these exclusions, 11 patients from the Nephrology and Hypertension clinic at Dr. Wahidin Sudirohusodo Central Hospital were identified as eligible participants. However, during the study, one patient dropped out, leaving a final enrollment of 10 participants. The average age of the patients was 52.70 (10.26) years, with an average BMI of 23.60 (3.77). The majority of patients were employed (70.0%), male (70.0%), hypertensive (90.0%), and half of them were smokers as mentioned in Table 1.

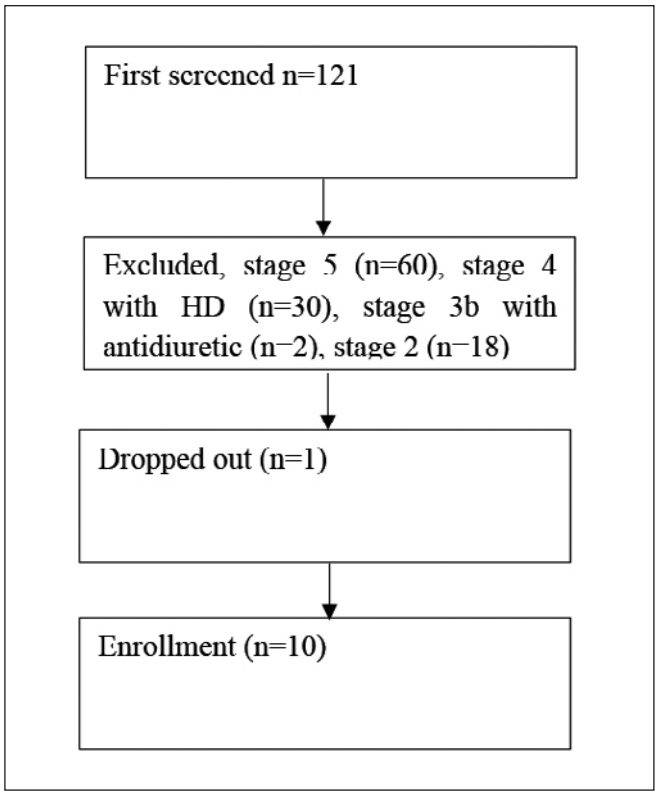

Figure 1. Subject enrollment

Based on the results of the Spearman correlation test, it was found that the average daily water intake was strongly negatively correlated with the urine albumin-creatinine ratio (ρ=-0.891, p-value=0.001), indicating that increased water consumption reduces uACR. The average daily protein intake was strongly positively correlated with the urine albumin-creatinine ratio (ρ=0.770, p-value=0.009), suggesting that reduced protein consumption lowers uACR. Furthermore, the average daily protein intake was very strongly positively correlated with urine albumin levels (ρ=0.806, p-value=0.005), indicating that decreased protein consumption reduces albumin levels. No correlation was found between the average total daily water intake and urine albumin or creatinine levels, nor between the average total daily protein intake and urine creatinine levels. All results can be seen in Table 2.

DISCUSSION

The research findings showed a significant strong negative correlation between average daily water consumption and the urine albumin-creatinine ratio as mentioned in Table 2 and Figure 1. This is consistent with previous studies showing that increased water intake of 2 (1.6-2.4) liters accelerates kidney function decline, leading to a faster decrease in eGFR. However, consumption of less than 1.0 liters per day also

Table 1. Patient's Demographic Data

Variable		Mean (SD)	Median (min-max)	n%
Age (years)		52.70 (10.26)	54.00 (40.00-67.00)	
BMI (kg/m^2)		23.60 (3.77)	23.80 (17.20-30.30)	
Profession	Employee			7 (70.0)
	Unemployed			3 (30.0)
Sex	Male			7 (70.0)
	Female			3 (30.0)
Smoking status	Yes			5 (50.0)
	No			5 (50.0)
Alcoholic	Yes			2 (20.0)
	No			8 (80.0)
Hypertension	Yes			9 (90.0)
	No			1 (10.0)
Nasopharynx cancer	Yes			1 (10.0)
	No			9 (90.0)
Diabetes mellitus	Yes			3 (30.0)
	No			7 (70.0)
Hyperuricemia	Yes			1 (10.0)
	No			9 (90.0)
Dyslipidemia	Yes			1 (10.0)
	No			9 (90.0)

n number, SD standard of deviation, min minimum, max maximum.

resulted in a decline in eGFR compared to those consuming 1.0-1.5 liters per day. The graph of kidney function decline is most evident with minimal water intake at 1.0-1.5 liters[7]. Water intake plays a role in the kidney's ability to concentrate urine in non-dialysis-dependent patients, allowing for tolerance of up to 0.7 liters per day, provided there are no signs of fluid overload[8-10]. Increasing water intake in CKD patients may provide positive effects through vasopressin feedback mechanisms, but it must be carefully monitored with regular assessments[11].

A significant strong positive correlation was found between CKD patients' daily protein intake and urinary albumin levels as mentioned in Table 2 and Figure 5. This indicates that increased protein intake leads to higher albumin excretion in the urine. This condition is related to protein metabolism, where protein is utilized as a substrate for albumin, the largest protein compartment in the body. In CKD patients, the filtration function is impaired due to the loss of charge on the glomerular basement membrane, causing albumin to leak into the urine[12]. Protein intake triggers glomerular hyperfiltration by increasing intraglomerular pressure due to elevated urea, a byproduct of protein metabolism. Therefore, protein restriction must be adjusted according to the patient's condition[13]. Strict protein restriction may lead to reduced glucagon and growth hormone levels, potentially causing malnutrition due to increased proteolysis within the body[14].

A strong positive correlation was also found between CKD patients' daily protein intake and the urine albumin-creatinine ratio as mentioned in Table 2 and Figure 4. This occurs because albumin increases in the numerator, with no significant change in creatinine levels, leading to an increase in the albumin-creatinine ratio.

Table 2. Correlation between variables and changes in the urine albumin-creatinine ratio (uACR) based on the Spearman correlation

Variable		Δ uACR (ratio mg/g)	Δ albumin (mg/dL)	Δ creatinine (g/dL)
Average of water (dL/day) consumption	ρ	-0.891	-0.564	-0.055
	p-value	0.001*	0.090	0.881
Average of protein (gr/day) consumption	ρ	0.770	0.806	0.224
	p-value	0.009*	0.005*	0.533

Spearman correlation test, *significant.

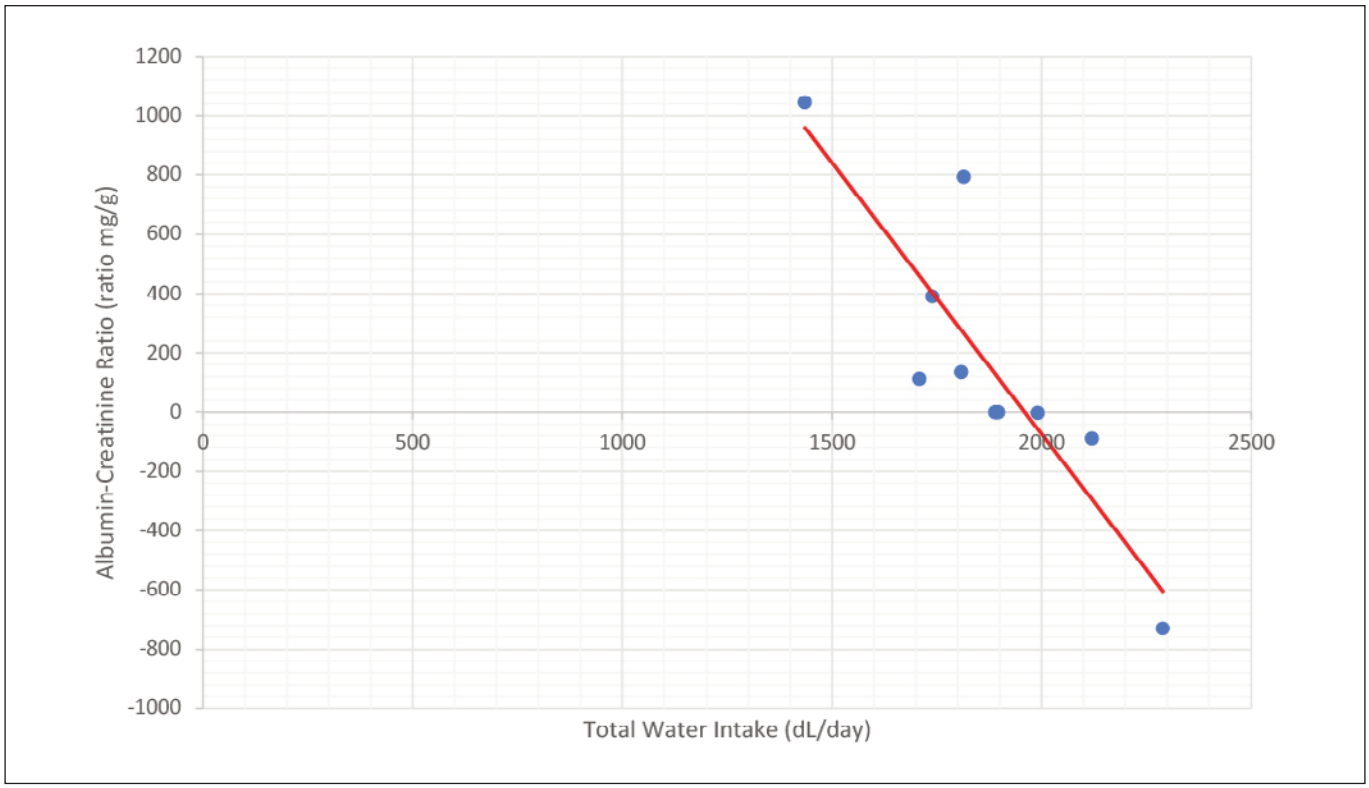

Figure 1. Correlation between average daily water intake and the urine albumin-creatinine ratio (uACR)

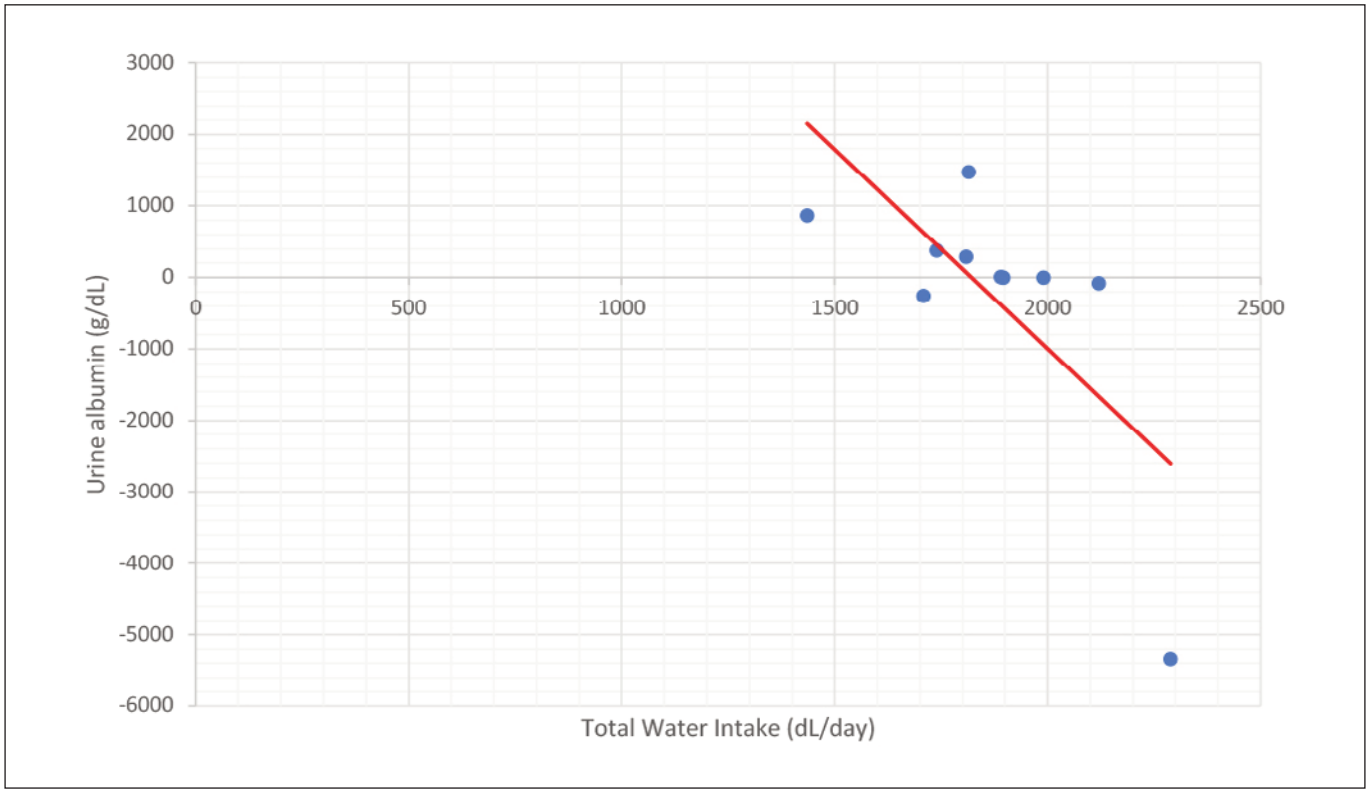

Figure 2. Correlation between average daily water intake and urine albumin levels

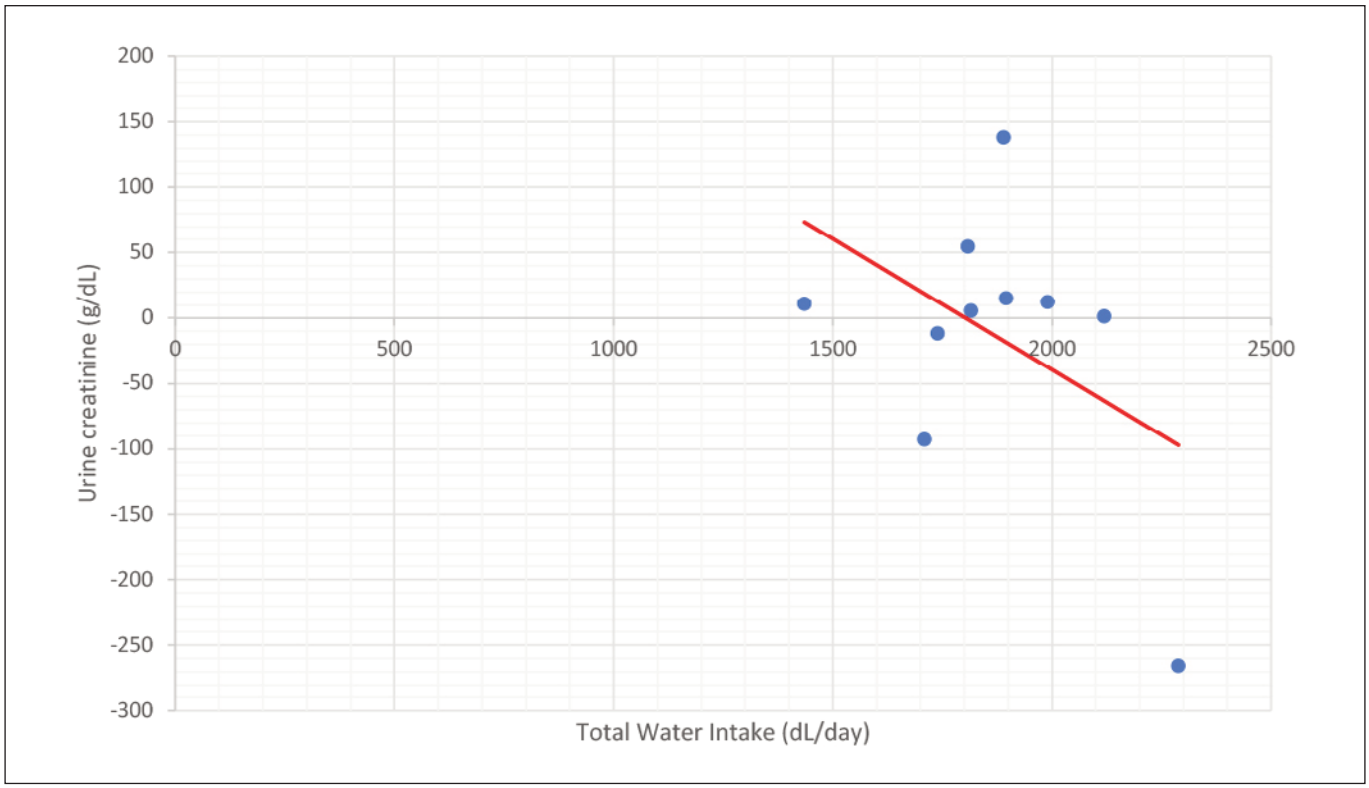

Figure 3. Correlation between average daily water intake and urine creatinine levels

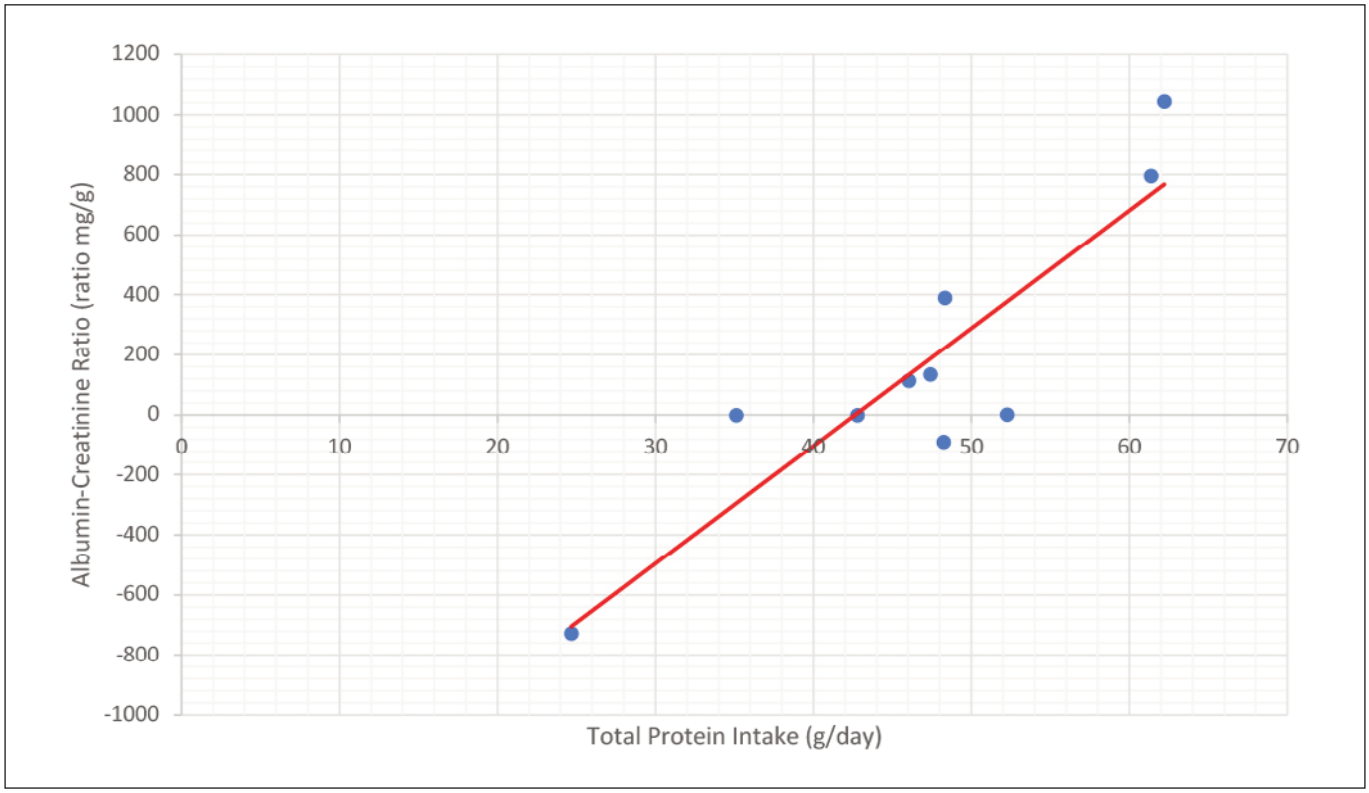

Figure 4. Correlation between average daily protein intake and the urine albumin-creatinine ratio (uACR)

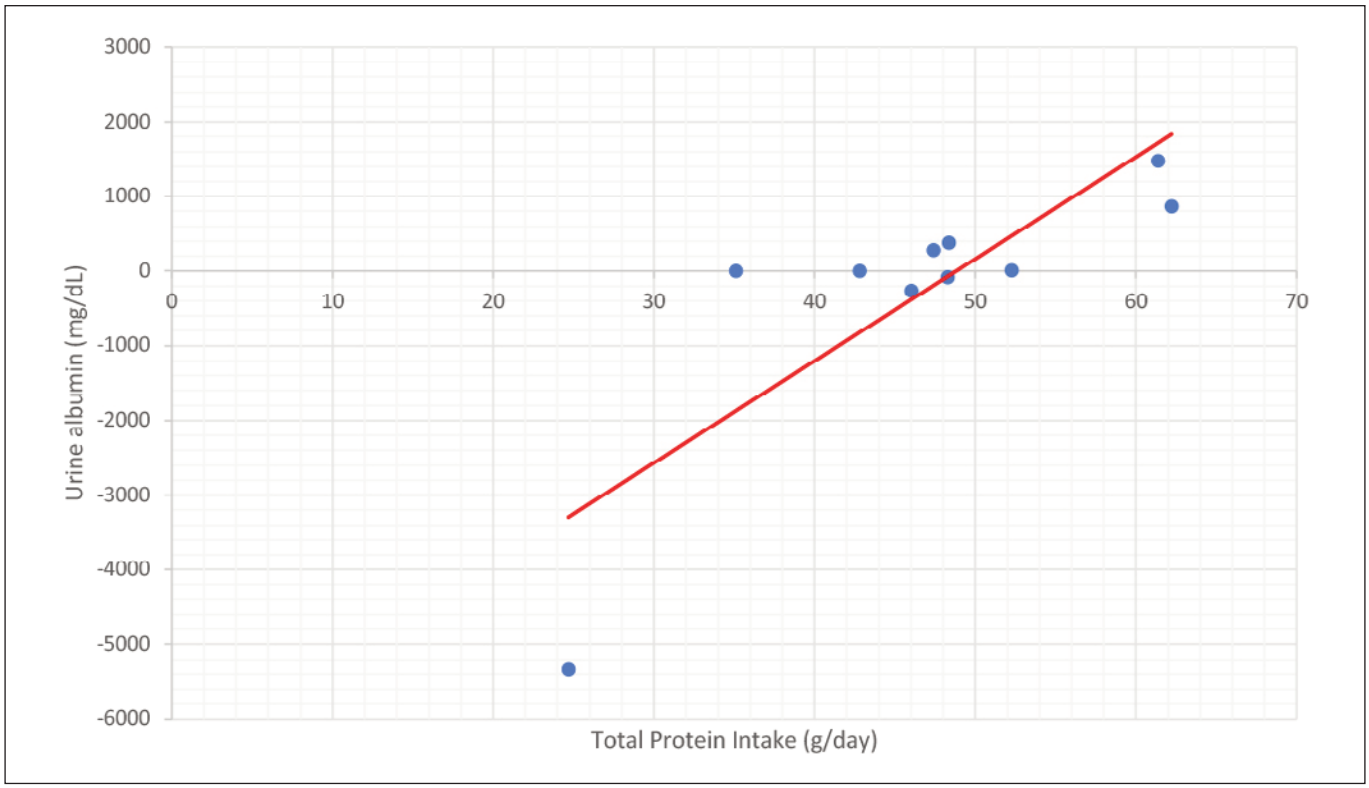

Figure 5. Correlation between average daily protein intake and urine albumin levels

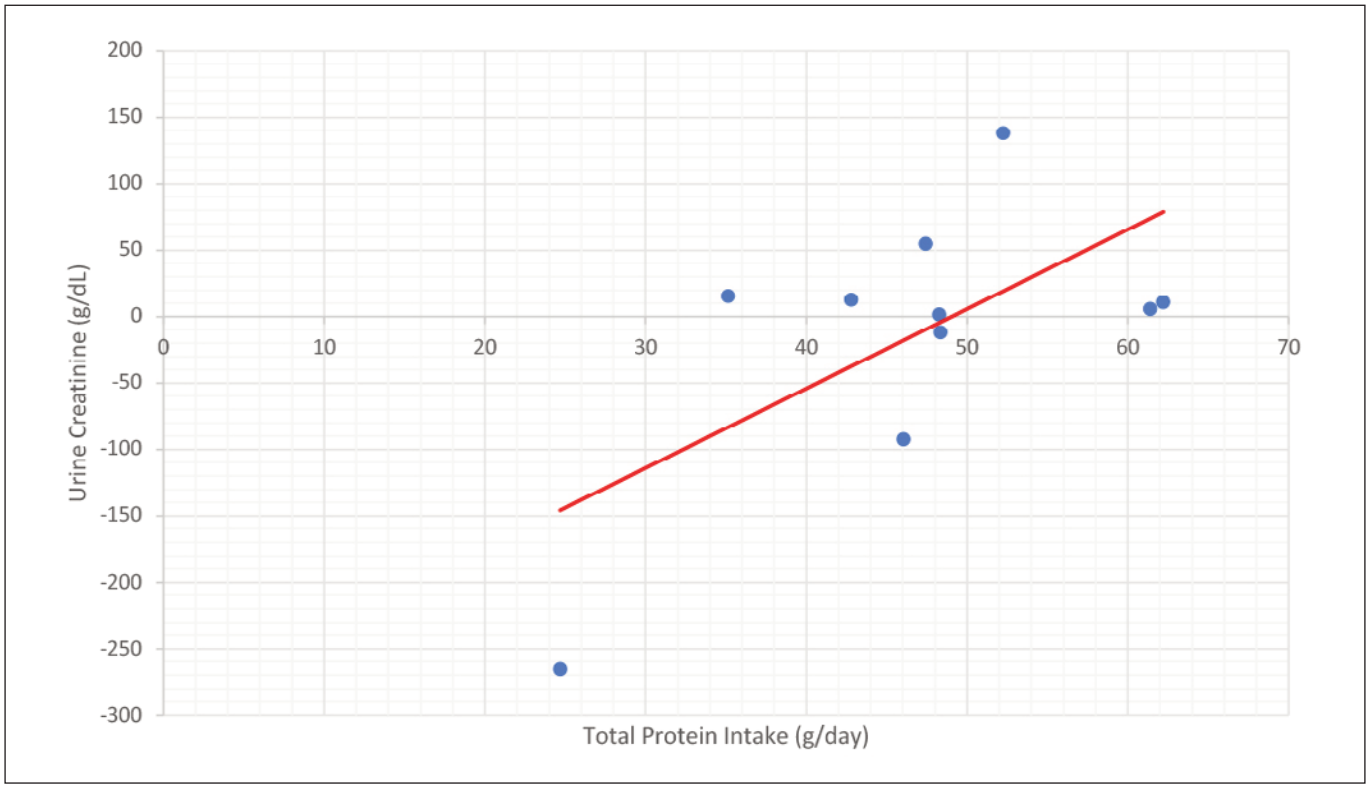

Figure 6. Correlation between average daily protein intake and urine creatinine levels

Increased protein intake increases protein metabolism waste products such as urea excretion. This correlation indicates the progressive decline in kidney function associated with protein consumption[15-17].

No correlation was found between water consumption and urine albumin or creatinine levels, nor was there a correlation between protein consumption and urine creatinine levels. This is because water intake is not directly related to kidney function decline, and excessive restriction can cause the kidney to lose its ability to concentrate urine through the vasopressin feedback mechanism. Another mechanism that contributes to kidney function improvement is the reduction of urea metabolites, which lowers intraglomerular pressure, thus reducing albumin leakage during filtration. All these effects are related to protein intake and not to water consumption. Although previous studies suggested that water intake is associated with albuminuria, the patient population in those studies followed a strict protein diet[18]. Nevertheless, excessive protein consumption is the most closely related factor to kidney function decline[19].

Water and protein intake differ in their mechanisms of regulating kidney filtration. Water consumption is linked to vasopressin feedback mechanisms, osmolality regulation, and improved kidney function at appropriate volumes. Protein intake, on the other hand, is associated with urea metabolism and glomerular hyperfiltration[7,13,18].

Using the urine albumin-creatinine ratio as a monitoring tool for kidney function is crucial for assessing short-term CKD progression, as it is directly linked to the control of protein and water consumption. Therefore, controlling kidney function should be the basis for dietary protein regulation and fluid monitoring[20,21].

The limitations of this study include the relatively small number of patients, and the absence of analysis on critical factors such as diabetes mellitus and hypertension, which may influence the outcomes. Furthermore, the study was conducted over a short period, thus failing to provide data on long-term disease progression in the patients studied.

CONCLUSION

There is a correlation between water intake and the urine albumin-creatinine ratio, indicating that hydration levels may influence this key biomarker in patients with chronic kidney disease. Additionally, protein intake has been shown to correlate with both urine albumin levels and the albumin-creatinine ratio, suggesting that dietary protein may play a role in kidney function and albumin excretion. These relationships highlight the importance of both hydration and dietary management in controlling the progression of kidney disease.

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Efecto del programa de estabilización nutricional "ESNUT" en IMC y composición corporal de menores de ocho años con desayuno escolar

Effect of the ESNUT Nutrition Stabilization Program on BMI and body composition in children under eight who receive school breakfast

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RESUMEN

Introducción. En San Luis Potosí incrementó el peso bajo (2,2% a 5,9%), coexistiendo con sobrepeso (18,1%) y obesidad (17,1%). La malnutrición modifica el crecimiento y composición corporal de los niños y la prevención incluye programas de alimentación escolar.

Objetivo. Evaluar el efecto del programa de estabilización nutricional "ESNUT" en el estado nutricional y composición corporal de niños adscritos al programa de desayunos escolares fríos.

Métodos. Se realizó un estudio de intervención con seguimiento y grupo experimental y grupo control en cuatro escuelas públicas suburbanas (preescolar y primero y segundo grado de primaria), la población se distribuyó en 148 mujeres (50,6%) y 144 hombres (49,3%) con edades comprendidas entre 69 y 75 meses y en el grupo experimental (n=153) y control (n=139) conformados aleatoriamente. La intervención consistió en aplicar el Programa de estabilización nutricional "ESNUT" y evaluar el efecto en talla, peso, índice de masa corporal, peso/edad, talla/edad, peso/talla, masa muscular y masa grasa, medidos con el Bioimpedanciómetro InBody 230 y el Estadímetro Seca 274. En el análisis se aplicó la prueba t-student para muestras independientes y para muestras relacionadas (95% CI; $p \leq 0,05$) con un poder estadístico de 0,80, además de ANOVA de una vía, calculando ETA^2 (post-hoc) y tamaño del efecto, apoyado en SSPS Versión 21.

Resultados. La población tenía estado nutricional normal en ~50% de los casos. La masa muscular se incrementó, observándose de mayor magnitud en los niños, la masa grasa era mayor en las niñas, con un tamaño de efecto pequeño. Se redujo el índice de obesidad el cual migró hacia sobrepeso.

Conclusiones. La intervención ESNUT favoreció el incremento de masa muscular y la reducción del índice de obesidad en los menores. Es recomendable la educación sobre alimentación saludable desde la niñez.

PALABRAS CLAVE

Consumo de alimentos; Nutrición infantil; Estado de salud; Desarrollo infantil; Educación alimentaria y nutricional.

ABSTRACT

Introduction. In San Luis Potosi, underweight increased (2,2% to 5,9%), coexisting with overweight (18,1%) and obesity (17,1%). Malnutrition modifies children's growth and body composition, and prevention includes school feeding programs.

Objective. To evaluate the effect of the nutritional stabilization program "ESNUT" on the nutritional status and body composition of children enrolled in the cold school breakfast program.

Methods. An intervention study with follow-up and an experimental and control group was carried out in four suburban

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public schools (preschool and first and second grade of primary school). The population was distributed into 148 women (50,6%) and 144 men (49,3%) with ages between 69 and 75 months, in the experimental group (n=153) and control (n=139) formed randomly. The intervention consisted of applying the "ESNUT" nutritional stabilization program and evaluating the effect on height, weight, body mass index, weight/age, height/age, muscle mass, and fat mass, measured with the Inbody Bioimpedancemeter 230 and the Seca 274 Statimeter. In the analysis, the t-student test was applied for independent samples and related samples (95% CI; $p \leq 0.05$) with a statistical power of 0,80, in addition, to one-way ANOVA, calculating ETA^2 (post-hoc) and effect size, supported by SSPS Version 21.

Results. The population had a normal nutritional status in ~ 50% of the cases. Muscle mass increased, with a greater magnitude observed in the experimental group, and in the boys, fat mass was greater in girls, although with a small effect size. The obesity rate was reduced, which migrated towards overweight.

Conclusions. The ESNUT intervention favored the increase in muscle mass and the reduction of obesity rate in minors. Education about healthy eating from childhood is recommended.

KEYWORDS

Food consumption; Child nutrition; General health status; Infant development; Food and nutrition education.

ABREVIATURAS

INEGI: Instituto Nacional de Geografía e Informática de México.

PIB: Producto interno bruto.

PMA: Programa Mundial de Alimentos de las Naciones Unidas.

DIF: Sistema Nacional para el Desarrollo Integral de la Familia.

GEF, GCF: Grupo experimental femenino, Grupo control femenino.

GEM, GCM: Grupo experimental masculino, Grupo control masculino.

INTRODUCCIÓN

La población mexicana de 5 a 11 años de edad era de 11,1 millones (8,8%) en 2019, según INEGI[1]. En ese año, la malnutrición ocurría en uno de cada tres menores de 5 años, de acuerdo a UNICEF[2]. En México, las Encuestas de Salud y Nutrición 2006, 2012 y 2018 reportaron la reducción del índice de peso bajo (PB) (10.6% a 4.8%), pero coexistiendo con sobrepeso (SP) (18,1%) y obesidad (OB) (17,1%)[3], aunque para el estado de San Luis Potosí el índice de PB incrementó de 2,2% a 5,9% de acuerdo a reportes de ENSANUT 2012 y 2018[4], mostrando un repunte en el antiguo problema de la desnutrición asociado a la mortalidad de menores de cinco años[5,6]. Este problema de salud pública repercute en costes económicos entre 2% a 5% del PIB mundial anual (~USA 3.5 billones) de acuerdo a la ONU/FAO e Informe de la Nutrición Mundial 2020[7]. En México se evidenció una pérdida neta de PIB de 2,3% anual por desnutrición, 1,5 y 3 veces superior a la del SP y la OB, según el análisis elaborado por la Comisión Económica para América Latina y el Caribe[8]. Se sabe que la malnutrición modifica el crecimiento y composición corporal de los niños[9], una acción clave es el sistema alimentario para la prevención[2] e incluye programas de alimentación escolar administrados por los gobiernos proveyendo mundialmente a ~368 millones de niños al día[10] y en América Latina y el Caribe (LAyC) a ~85 millones de niños en 16 países como trabajo conjunto entre PMA y gobiernos de LAyC[11]. En México, PMA es representado por el Programa de Desayunos Escolares operado por el DIF, dirigido a niños en condiciones de vulnerabilidad de escuelas públicas en zonas indígenas, rurales y urbanas marginadas[12,13]. En 2019 se distribuyeron más de seis millones de desayunos escolares fríos (90%) y desayunos calientes (10%)[14]. En estudio de intervención ESNUT en San Luis Potosí, dirigido a 30 madres e hijos preescolares con desayunos escolares fríos evaluados basalmente y en cinco puntos de corte mensuales post intervención, se observó un efecto positivo en conocimientos y comportamientos maternos en alimentación y una tendencia hacia la estabilización nutricional de los niños en peso, talla, IMC, % de masa grasa (MG) y % de masa muscular (MM)[15]. Otro estudio en San Luis Potosí evaluó el efecto del desayuno escolar frío en niños preescolares y escolares beneficiarios, se observó la asociación del contenido energético con el incremento en la ganancia de peso en niñas por arriba de la referencia para la edad[16]. Este hecho coincide con la narrativa de consumo excesivo de raciones de este tipo de desayuno, constatado en estudio cualitativo teniendo como participantes al profesorado, a cuidadores primarios y a los propios niños[17]. Aunque por otra parte, en varios estudios sobre dimorfismo sexual en niños, el hallazgo coincide en magnitudes superiores de peso en las niñas, lo que pudiera también explicarse bajo la hipótesis de que la mujer canaliza mayor ecorresistencia en ambientes nutricionales adversos y de ahí que la masa grasa se incremente[9,18,19].

Los desayunos escolares deben complementarse con orientación alimentaria a los cuidadores de acuerdo a las reglas de operación, esto último no se constató durante el presente estudio. Es escasa la información de evaluaciones del programa por lo cual es importante aportar evidencia científica que permita identificar su efectividad[6,20]. El objetivo fue evaluar el efecto del programa de estabilización nutricional "ESNUT", en el estado nutricional y composición corporal de los niños adscritos al programa de desayunos escolares fríos.

MÉTODOS

Se realizó un estudio de intervención con seguimiento y grupo experimental y grupo control en cuatro escuelas públicas suburbanas con programa de desayuno escolar. Inicialmente aceptaron participar en el estudio (n=316), al verificar el cumplimiento de criterios de inclusión (no tener morbilidades que modificaran el estado nutricional, asistir a la evaluación basal y consentimiento informado signado por los padres o tutor) algunos no cumplieron completamente, de esta forma la muestra basal definitiva fue n=292 niños. La asignación a los grupos experimental y control se sorteó, conformándose dos paneles de dos planteles (preescolar y primaria con población rural y suburbana), la distribución para el GE (n=153) y para GC (n=139). (Fig. 1).

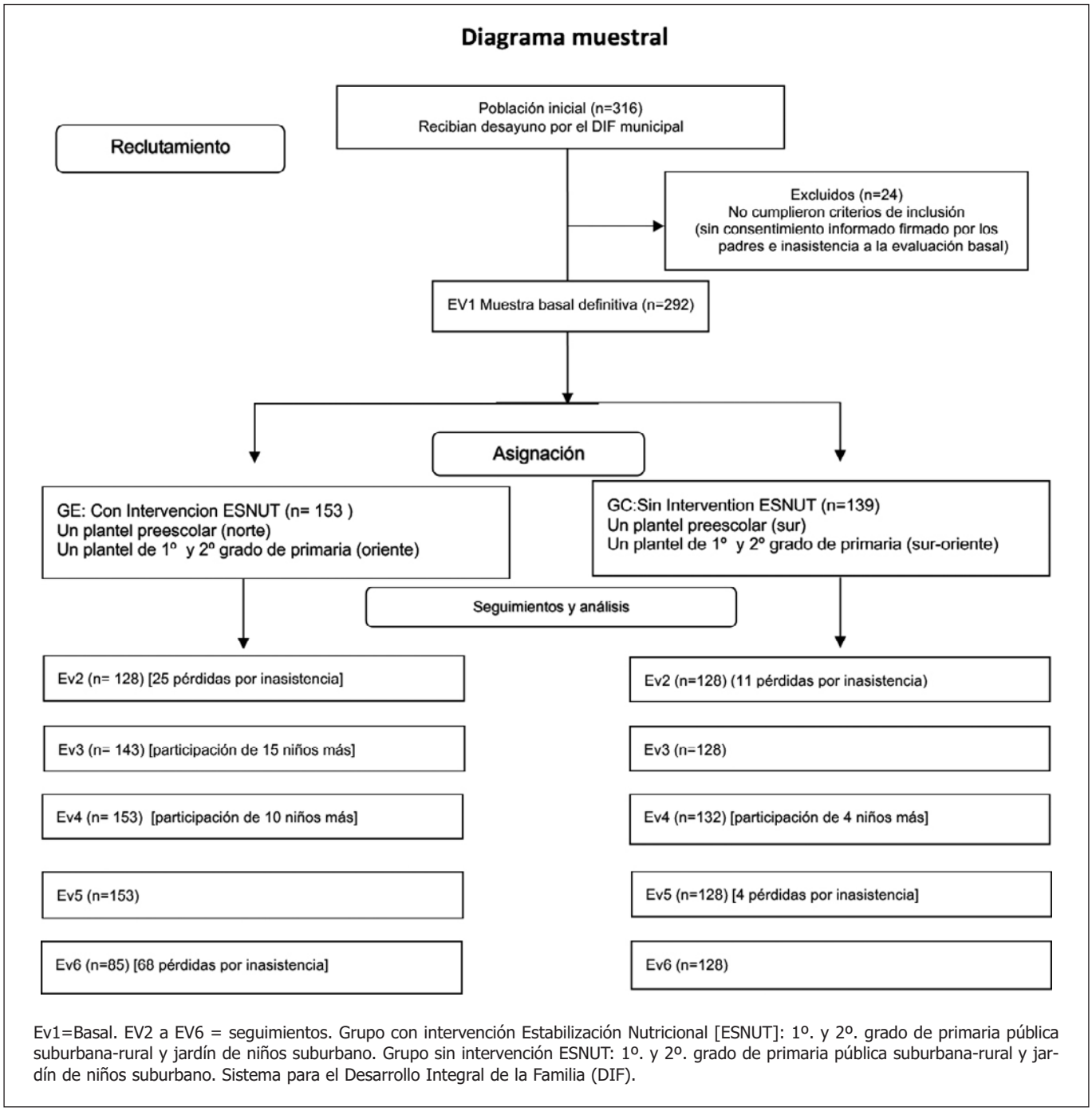

Figura 1. Flujograma del reclutamiento basal y el seguimiento. [Adaptado de Cobos-Carbó A. Ensayos Clínicos Aleatorizados (CONSORT). Med Clin (Barc). 2005;125(Supl 1):21-7]

La intervención consistió en aplicar el Programa de estabilización nutricional "ESNUT" en el GE en modalidad de curso-taller para que los menores pudieran integrar conocimientos y desarrollar habilidades en alimentación correcta y extrapolarlas a la vida cotidiana, apoyados con reforzamiento por sus padres en casa y el profesorado en aula. ESNUT se llevó a cabo en 6 sesiones diseñadas según la teoría del cambio y en fundamentos psicopedagógicos para la edad de los niños. (Tabla 1).

El programa "ESNUT" se fundamenta en el Modelo Transteórico del Cambio, se asumió que los niños se encontraban en la fase de pre-contemplación y mediante la intervención progresivamente se introdujeron en la contemplación al sentir la necesidad de modificar sus hábitos nutricionales. En este punto se dirigió el trabajo hacia la determinación, acción y mantenimiento, apoyado en referentes pedagógicos y del desarrollo cognitivo y la duración de la atención de los niños de 2-3 años (10 min), de 3-4 años (15 min), de 4-5 años (20 min) y de 6-8 años (25 min.) Así como en elementos lúdicos (imaginación y de la libertad de los niños para autoexpresión) e incorporando el drama y humor para comunicación con el otro, todo dentro del concepto ecológico del desarrollo de ser humano (relación con el ambiente que los rodea). Se utilizó la persuasión y la influencia con ética y profesionalismo y el

Tabla 1. Programa ESNUT dirigido a niños de 4 a 7 años adscritos a un programa de desayuno escolar

Información (precontemplación a contemplación)			**Acción**		**Compromiso (mantenimiento)**
1. Bienvenida Conociéndose ¿Los alimentos que consumen son saludables?	2. Características de crecimiento, desarrollo y nutricionales de los niños	3. Alimentos saludables: El plato del bien comer * Jarra del buen beber **	4. Moviéndose a la acción: Elección de comida saludable	5. El balance de la decisión Elección de alimentos y preparación de menú saludable	6. Concordar-Discordar: Pros-Contras de cómo se alimentan versus la forma correcta Acuerdo para alimentación correcta
Material educativo/ Actividades					
Facilitador:presenta el programa. Docente del plantel: apoya a los niños para colocarse un gafete con su nombre. Facilitador: distribuye figuras de alimentos en paletas de cartoncillo y crayones Niños: Colorean y mencionan nombres de los alimentos saludables.	Facilitador: mediante diapositivas presenta tema: crecimiento, desarrollo, desnutrición, obesidad. Niños: Colorean imágenes ESNUT de niño bien nutrido y otro desnutrido, elaboran mural en papel kraft mencionando semejanzas y diferencias observadas.	Los niños miran un videoclip "Cerremos la puerta a la comida chatarra", juegan en subgrupos lotería, memorama y sopa de letras ESNUT, opinando sobre los tópicos y el porqué de la alimentación y bebida sana.	Participación en el sociodrama ESNUT. Los niños se agrupan bajo el criterio de alimentos saludables y no saludables con antifaces de varios tipos de alimentos colocados con listón o liga suave. Mencionan por qué eligieron formar parte de cada subgrupo.	Participan en la construcción del Plato del Bien Comer Utilizando las Réplicas Plásticas de Alimentos *** Iluminan la plantilla de la Jarra del buen beber **	Obra de teatro guiñol ESNUT: importancia del bien comer, el buen beber y saber seleccionar. Opinión libre sobre estos tópicos. Mencionar si de ahora en adelante evitarán alimentos de bajo o nulo valor nutricional ("chatarra") y si comerán alimentos saludables y beberán agua natural.

Apertura/Cierre: El facilitador solicita mencionar alimentos que comen y cuáles son saludables; Hablar voluntariamente mediante el periódico mural lo que aprendieron; Comentar sobre lo aprendido en la sesión de cada día.Tareas: Conversar sobre el tema con la familia; Realizar actividades en familia: jugar memorama y a la lotería de alimentos saludables (recortables) "ESNUT"; Leer en familia el cuento ESNUT "El niño que comió chatarra: Manual del niño para una alimentación correcta."****; Respuesta a preguntas sobre el tema al inicio y final de la sesión.

Estrategias didácticas y tácticas educativas. Evaluación de conocimientos previos y al final de cada sesión; reconocimiento de logros. Escuchar activamente/Preguntar; Planear/Tomar decisiones/Diseñar; Taller de preparación de menús saludables. ESNUT implementada por un equipo de salud (investigadores, nutrióloga, enfermeras) en presencia de docentes. Apoyo del profesorado y padres/cuidadores para reforzamiento mediante actividades complementarias de ESNUT a realizar en casa.Programación de tareas para desarrollar responsabilidad; Uso sistemático de reforzadores durante el estudio y en período vacacional de abril (2 semanas) "Tips para tener una alimentación correcta en vacaciones" (material visual).

* Plato del Bien Comer, ** Jarra del buen beber[21], *** Réplicas plásticas de alimentos[22], **** Cuento[23].

aprendizaje entre pares por imitación de comportamientos saludables, para convencer a los niños y sus padres o cuidadores de mejorar sus comportamientos nutricionales[21].

El efecto de ESNUT se observó a través de las variables nutricionales, las cuales se midieron en seis puntos de corte, basal (EV1) y cinco seguimientos (EV2-EV6) y se comparon entre GE y GC y por género. La talla se midió mediante el estadímetro Seca 206 (rango de 30 a 220 cm y precisión de 0,1 cm), bajo el método establecido por la Sociedad Internacional para el Avance de Cineantropometría (ISAK)[22]. El peso y composición corporal (% MM y % MG) se midieron con el bioimpedanciómetro InBody 230 (rango de 10 a 250 kg, altura de 95 a 220 cm y edad de 3 a 99 años) cumpliendo los requisitos obligatorios para realizar la medición[22]. A partir de los datos de talla y peso de calcularon los índices de Masa Corporal (IMC), peso para la edad (P/E), talla para la edad (T/E) y peso para la talla (P/T) y se determinó el estado nutricional con base en los parámetros de comparación antropométrica (OMS 2006)[24]. Para el reporte de resultados se utilizaron los criterios de la guía CONSORT por sus siglas en inglés (Consolidated Standards of Reporting Trials)[25].

En el análisis estadístico se aplicaron las pruebas t-student para muestras independientes y para muestras relacionadas (95% CI; $p \leq 0,05$) con un poder estadístico de 0,80 y ANOVA de una vía, calculando ETA^2 (post-hoc) y tamaño del efecto, apoyado en el programa estadístico Statistical Package for Social Sciencies (SSPS) Versión 21.

El estudio fue sometido y aprobado por el Comité de Biética de la Facultad de Enfermería y Nutrición de la Universidad Autónoma de San Luis Potosí (Registro CEIFE-2014-091), fundamentándose en los principios éticos para investigación médica en seres humanos y en especial en niños, en la Declaración de Helsinki, Artículo 3º, Fracc. IV, en los artículos 13º y 15º que reza sobre el respeto a la dignidad y protección de los derechos y bienestar de los sujetos de estudio (Ley General de Salud de los Estados Unidos Mexicanos) en materia de investigación en salud[22].

RESULTADOS

Los menores del estudio se distribuyeron en 148 niñas (50,6%) y 144 niños (49,3%) con edades comprendidas entre 69 y 75 meses; la edad en meses para GEF (75,7±11,8), GCF (69±9,9), GEM (74±11,8) y GCM (70±9,6). La talla y peso mostraron cambios en su tendencia respecto al género y etapa de ciclo vital. La talla y peso fueron mayores en GE que en GC, según género y etapa de ciclo vital en todos los puntos de corte ($p \leq 0,01$). El GE incrementó en promedio 2,6 cm y 0,900 Kg, mientras que el GC creció 4,5 cm e incrementó 1,5 Kg en total. Los indicadores antropométricos (P/E, T/E y P/T) evidenciaron índices de normalidad en todas las mediciones y no mostraron diferencia estadística por grupo o por género. El IMC también evidenció normopeso en GE y GC durante las seis evaluaciones, en el GE el IMC incrementó 0,2, mientras que el GC redujo en promedio 0,2 Kg/m^2 mostrando diferencia en la media de IMC en la mayoría de los puntos de corte. El % MM incrementó un 1,1 % en el GE mientras que en GC no incrementó, y el % MG tuvo un incremento de 0,1% en GE mientras que el GC decreció 4,1%. (Tabla 2)

Según la etapa del ciclo vital en la evaluación basal de preescolares las niñas superaban en talla y peso a los niños, los cuales tuvieron ya mayor altura en EV6 lo cual continuó así durante la etapa escolar, condición que se revirtió en EV6 puesto que las niñas los superaron en talla y peso. Por su parte la composición corporal de los preescolares no mostró diferencia por género en la evaluación basal, mientras que en la final (EV6) los niños ya tenían mayor %MM con respecto a las niñas con tamaño de efecto pequeño. Los escolares se diferenciaron significativamente dado que los varones superaron a las niñas en el %MM con un tamaño de efecto pequeño y las niñas tuvieron mayor %MG con respecto a los niños aunque con un tamaño de efecto insignificante. (Tabla 3).

De acuerdo al IMC poco más de la mitad de los menores tenían estado nutricional normal, y el resto presentó malnutrición. Destaca el incremento de la proporción de niños preescolares con estado nutricional "muy por encima" en EV6 y por el contrario en los niños escolares puede obervarse que en la evaluación final (EV6) se redujo la prevalencia del diagnóstico de IMC "muy por encima", incrementándose sobretodo el estado nutricional "por encima", y en menor proporción el estado "normal". (Tabla 4).

DISCUSIÓN

En nuestro estudio la talla y peso de GE incrementó 1,9 cm y de GC 3,0 cm al primer mes, por encima de los hallazgos de un estudio de casos y controles con intervención, en el que se estudió el efecto de la educación nutricional y modificaciones dietéticas en preescolares indios en los cuales al cabo de un mes los casos aumentaron 1,5 cm en talla y los controles 1,0 cm[26].

Comparados por género en las niñas preescolares la talla era superior en EV1 pero los niños ya eran más altos en EV6 similarmente a estudios que refieren tallas mayores para los varones[18,19]. Mientras que en los escolares era totalmente la situación contraria, esto es, en EV1 las niñas eran más pequeñas en talla, pero en EV6 ya superaban a los niños. Respecto al peso los preescolares de nuestro estudio incrementaban el peso a un ritmo de 0,20 Kg y los escolares 0,40 Kg mensual. Los primeros de manera similar y los segundos de mayor magnitud que lo reportado en un estudio longitudinal (sin intervención) sobre consumo de desayuno escolar frío e incremento de peso en el mismo estado de San Luis Potosí, en el cual se observó que los preescolares aumentaron de forma mensual 0,17- 0,20 kg y los escolares de 0,21-0,25 kg[16]. Las niñas escolares sobrepasaron en peso también a los niños en la evaluación final. Podría relacionarse el mayor incremento de

Tabla 2. Comparación de las variables nutricionales de los grupos experimental y control de niños adscritos al programa de desayuno escolar frío del DIF

	EV 1	EV2	EV3	EV4	EV5	EV6	EV1-EV6
GE vs GC	GE n=153 GC n=139	GE n=128 GC n=128	GE n=143 GC n=128	GE n=153 GC n=132	GE n=153 GC n=128	GE n=85 GC n=128	GE vsGC
Talla (cm)	114.9±7.6 107.9±6.3**	116.8±7.4 110.9±8.0**	117.9±7.4 112.0±8.3**	117.9±7.5 111.4±8.6**	117.7±7.8 112.3±8.0**	117.5±7.3 112.4±7.5**	ø ø
Peso (Kg)	22.1±4.5 18.9±3.1**	22.8±4.9 19.9±4.1**	23.0±5.1 20.5±4.2**	23.3±5.1 20.3±4.4**	23.0±5.3 20.5±4.1**	23.0±5.3 20.4±4.3**	ø ø
IMC	16.5±2.1 16.2±1.8**	16.6±2.3 16.0±1.7*	16.3±2.5 16.2±1.8	16.6±2.3 16.0±1.9**	16.5±2.4 16.1±1.9	16.7±2.7 16.0±1.8**	
% MM	35.0±4.4 33.3±3.5*	35.9±3.5 34.1±4.3**	34.5±5.6 34.3±4.1**	36.8±3.3 34.7±3.2**	36.4±4.4 34.0±5.7**	36.1±3.0 33.3±8.1**	ø ø
% MG	24.3±6.8 24.9±6.2	23.2±6.4 24.5±6.5	**22.4±6.8** **24.6±6.4**** **η^2 .049**	22.8±7.0 23.3±6.5	23.1±7.6 23.1±6.7	24.4±6.5 20.8±7.5*	ø ø
P/E	103.9±17.7 102.8±14.9	107.3±19.8 104.3±18.4	**104.8±19.5** **103.5±16.9****†	**107.8±22.2** **103.4±18.2****†	104.9±20.2 101.8±15.6	**106.6±20.7** **101.4±16.7*††**	
T/E	99.6±6.0 97.8±4.9**	98.6±4.3 98.9±4.2	98.9±4.3 98.2±4.2	98.9±4.4 98.4±4.2	99.0±4.1 98.4±4.4	99.1±4.4 98.7±4.2	
P/T	107.8±13.5 105.8±11.5	108.7±15.0 104.4±12.4	106.2±14.3 105.7±11.5	107.6±14.1 104.6±12.4	105.4±15.4 103.3±10.5	**107.3±14.3** **102.5±11.6**†† ø ø**	

Prueba ANOVA. Significancia: * p≤0.05; ** p ≤0.01**η^2** (Eta cuadrado): tamaño del efecto: Pequeño=.01; Mediano=.06; Grande=0.14.Prueba Post Hoc Bonferroni. Significancia: **†** p≤0.05; **† †** p ≤0.01 Prueba T para muestras relacionadas en EV1 vs EV6. Significancia: ø p≤0.05; ø ø p ≤0.01.

Tabla 3. Medias de las variables nutricionales (EV1 vs EV6) comparadas por sexo y etapa del ciclo vital en niños adscritos al programa de desayuno escolar frío del DIF

	EV1		EV6		EV1		EV6	
	Preescolares (n=170)				Escolares (n=122)			
	Niñas	Niños	Niñas	Niños	Niñas	Niños	Niñas	Niños
Talla	107.5±6.0	106.4±5.3	111.9±7.2	114.2±8.4	117.7±6.0	118.4±5.1	120.3±4.6	118.3±5.8
Peso	18.9±3.6	18.5±2.9	20.4±4.7	21.3±5.0	23.4±4.3	23.1±4.7	24.2±4.6	22.3±4.0
%MM	32.8±2.9	32.9±2.9	**33.4±7.6**	**34.8±6.6* η^2 .01**	**35.1±3.5**	**36.1±4.7* η^2 .04**	**25.2±19.1**	**35.1±14.0 *η^2 .01**
%MG	25.0±6.4	25.2±6.0	21.2±7.8	22.3±6.9	**25.3±6.8**	**22.5±7.0* η^2 .04**	**23.0±8.0**	**20.0±8.5* η^2 .007**
IMC	16.3±2.0	16.2±1.7	16.1±2.3	16.2±2.1	16.7±2.2	16.6±2.2	16.1±2.2	16.6±2.1
%PE	103.6±15.3	103.8±17.8	104.0±19.4	105.0±20.6	101.0±17.5	106.6±17.8	104.6±20.0	104.8±10.9
%TE	98.2±97.6	97.6±4.1	98.4±4.4	99.0±4.1	99.1±5.3	100.1±7.8	96.7±4.1	96.9±4.1
%PT	106.2±13.0	107.1±13.3	105.7±14.1	103.1±12.5	109.9±16.5	106.1±12.7	97.7±9.2	97.9±9.2

Prueba ANOVA. Significancia: * p≤0.05; ** p ≤0.01. **η^2** (Eta cuadrado): tamaño del efecto: Pequeño=.01; Mediano=.06; Grande=0.14.

Tabla 4. Diagnósticos nutricionales basados en el IMC comparativos entre evaluación basal y final, según sexo y etapa del ciclo vital de niños adscritos al programa de desayuno escolar frío del DIF

Diagnósticos	Frecuencia (%)			
	EV1		EV6	
	GE	GC	GE	GC
Por debajo	10 (6.5)	8 (5.8)	7 (8.2)	16 (12.5)
Normal	82 (53.6)	77 (55.4)	46 (54.1)	72 (56.3)
Por encima	28 (18.3)	48 (34.5)	19 (22.4)	27 (21.1)
Muy por encima	33 (21.6)	6 (4.3)	13 (15.3)	13 (10.2)
	Preescolares		Escolares	
	EV1	EV6	EV1	EV6
Por debajo	11 (6.5)	19 (11.2)	7 (5.7)	4 (9.1)
Normal	96 (56.5)	92 (54.4)	63 (51.6)	26 (59.1)
Por encima	50 (29.4)	35 (20.7)	26 (21.3)	11 (25.0)
Muy por encima	13 (7.6)	23 (13.6)	26 (21.3)	3 (6.8)

Diagnóstico nutricional basado en el Índice de Masa Corporal. Prueba Chi Cuadrado. Significancia: *p≤0.05; **p ≤0.01; ***p≤0.06 (marginal).

peso y talla en las niñas con el consumo en exceso de energía a partir del desayuno escolar asociado al incremento en la ganancia de peso en niñas por arriba de la referencia para la edad[16]. En ese sentido, el desequilibrio entre la ingesta y gasto de energía genera malnutrición influyendo en alteraciones del crecimiento de los menores[9].

Así como la media de la edad del GE mayor a la de GC podría significar que por tanto los parámetros de talla y peso serían mayores.

Este hecho coincide con la narrativa de consumo excesivo de raciones de este tipo de desayuno, más de dos raciones, constatado en estudio cualitativo teniendo como participantes al profesorado, a cuidadores primarios y a los propios niños[17]. Puede arrojar más claridad desde el entendimiento de un fenómeno natural en el crecimiento de las niñas y niños mencionado en varios estudios sobre dimorfismo sexual, además de explicarse bajo la hipótesis de que la mujer canaliza mayor ecorresistencia en ambientes nutricionales adversos y de ahí que la masa grasa se incremente[9,18,19].

Las variables P/E, T/E y P/T no se diferenciaron entre GE y GC o por género, al igual que en nuestro estudio, se ha reportado en preescolares y escolares índices de T/E y P/T similares en las niñas con respecto a los varones[18,19]. Es interesante que mediante los parámetros basados en índices que los hacen comparables de una manera mas precisa, no se constató diferencia.

El IMC se diferenció solamente entre grupos pero no por género, en un estudio fue informada también la similaridad del IMC en ambos géneros[19,27]. En los diagnósticos de estado nutricional por IMC se observó que en EV1 la prevalencia de BP en GE fue superior a la media nacional, mientras que el SP era semejante a la media nacional, incrementando en EV6, mientras que la OB basal superó la nacional, la cual revirtió en EV6[1]. Puede obervarse que en EV6 el IMC de GE "muy por encima" se redujo y migró hacia el IMC "por encima" sin embargo, no corroborado en la prueba post hoc, pero sí de importancia clínica para la implementación de la intervención ESNUT. Comparando los diagnósticos en escolares se distinguieron diferencias entre la evaluación basal y final, aunque no significativas estadísticamente, situación que se ha discutido en una revisión sistemática sobre intervenciones para modificar riesgo nutricional y de salud, concluyendo que pueden llegar a ser efectivas, no obstante, el IMC es un indicador que difícilmente provee evidencia de sostenibilidad de cambios a través de los seguimientos[28].

La composición corporal de los menores, por su parte ofrece algunos datos alentadores en función de los beneficios de la intervención ESNUT. El %MM del GE presentó magnitudes mayores al GC, toda vez que los menores de ambos grupos consumían el desayuno, en esta condición de igualdad es factible atribuir al factor que los diferencia, la intervención ESNUT, esa superioridad en la magnitud de %MM a favor del GE. Comparando por género el %MM en las niñas y niños preescolares se comportó similarmente en EV1 solamente, a partir de la EV6 de preescolares y en la etapa escolar, los niños mantuvieron un %MM mayor al de las niñas, corroborado por el tamaño del efecto que abarcó desde un efecto pequeño a uno mediano, cuestión de importancia clínica en los cambios de composición corporal atribuibles a la intervención ESNUT. Por su parte el %MG presentaba algunas diferencias mostrando un poco de mayor adiposidad en los niños preescolares, pero que se revirtió en los escolares, al ser superados en adiposidad por las niñas, corroborado por un tamaño del efecto mínimo.

En un estudio sobre dimorfismo sexual se observó que este puede variar de acuerdo a la edad, y muy importante, de acuerdo al estado nutricional normal y sobrepeso, así, los hallazgos muestran que las niñas presentaron mayor adiposidad que los niños y estos mayor masa muscular, siendo un patrón normal. Es importante la observación en el estudio sobre dimorfismo sexual que en los menores con bajo peso no se distinguía y en casos de obesidad se atenuaba[9]. Considerando que coexisten en nuestra población de estudio BP, SP y OB en cerca de la mitad de los casos, es posible se atenuen o desaparezcan las diferencias entre géneros, especialmente por BP u OB[19]. Por lo cual sería útil en futuros estudios incorporar un análisis ajustado por estado nutricional. Con base en que al-

gunos cambios fueron favorables por la intervención, se constata que la educación sobre alimentación saludable es recomendable, como lo ha sido señalado en diversos estudios[22,28].

CONCLUSIONES

Cerca de la mitad de los menores tenían estado nutricional normal y una alta proporción presentó malnutrición en la evaluación basal.

Destaca la elevada proporción inicial de IMC "muy por encima" en escolares la cual se revirtió hacia la evaluación final.

La talla y % MG de las niñas superó al final la talla y % MG de los niños.

Los escolares varones superaron a las niñas en el % MM y las niñas tuvieron mayor %MG con respecto a los niños con un tamaño de efecto pequeño pero clínicamente significativo a favor de la intervención.

El estudio se focalizó en cambios en estilos de alimentación fundamentados en etapas del cambio, que no ha sido reportado en niños, aunque sería necesario fortalecer el programa de estabilización ESNUT, incluyendo otros elementos que favorezcan el sano crecimiento de los menores, como el incluir de manera más consistente a los padres o cuidadores y al profesorado, la actividad física y ampliar el seguimiento más allá del sexto mes post intervención para constatar el paso de una fase a otra de acuerdo las etapas del cambio de comportamiento.

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Estado metabólico como predictor de enfermedad cardiovascular en una cohorte laboral: más allá del índice de masa corporal

Metabolic status as a predictor of cardiovascular disease in a working cohort: beyond body mass index

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RESUMEN

Introducción: Las enfermedades cardiovasculares (ECV) son una causa principal de morbimortalidad global. Recientes investigaciones sugieren que el estado metabólico podría ser un mejor predictor del riesgo cardiovascular que el índice de masa corporal (IMC) por sí solo.

Objetivo: Evaluar los diferentes fenotipos metabólicos y el riesgo de desarrollar ECV en una cohorte de trabajadores.

Metodología: Estudio de cohorte observacional analítico retrospectivo con 4,158 trabajadores seguidos durante un máximo de 8 años. La variable respuesta fue la presencia de ECV, que se definió como la presencia del diagnóstico de accidente cerebro vascular o infarto por autorreporte. La combinación del estado metabólico y el IMC resultó en seis fenotipos: normopeso metabólicamente saludable (NMS), normopeso metabólicamente no saludable (NMNS), sobrepeso metabólicamente saludable (OBMSW), sobrepeso metabólicamente no saludable (OBMNSW), obesidad metabólicamente saludable (OBMS) y obesidad metabólicamente no saludable (OBMNS). Se calculó la incidencia de ECV y se utilizaron modelos de regresión de Cox para estimar los hazard ratios (HR) ajustados.

Resultados: La incidencia global de ECV fue de 5.64 por 1000 personas-año. Comparado con el fenotipo NMS, los fenotipos metabólicamente no saludables mostraron un riesgo significativamente mayor de ECV: NMNS (HRa: 5.19, IC 95%: 1.29-20.84), OBMNSW (HRa: 7.07, IC 95%: 2.40-20.86), y OBMNS (HRa: 7.35, IC 95%: 2.43-22.21).

Discusión: Los hallazgos subrayan la importancia del estado metabólico, independientemente del IMC, en el desarrollo del ECV. Esto tiene implicaciones significativas para la práctica clínica y la salud pública, sugiriendo la necesidad de implementar evaluaciones metabólicas comprehensivas y estrategias de prevención personalizadas en todas las categorías de IMC, especialmente en el ámbito laboral.

PALABRAS CLAVE (DECS)

Salud cardiovascular, Prevención primaria, Factores de Riesgo de Enfermedad Cardiaca, Predicción clínica, Salud Laboral.

ABSTRACT

Introduction: Cardiovascular diseases (CVD) are a leading cause of global morbidity and mortality. Recent research suggests that metabolic status could better predict cardiovascular risk than body mass index (BMI) alone.

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Objective: To evaluate different metabolic phenotypes and the risk of developing CVD in a cohort of workers.

Methodology: A retrospective analytical observational cohort study with 4,158 workers followed for up to 8 years. The outcome variable was the presence of CVD, defined as the self-reported diagnosis of stroke or myocardial infarction. The combination of metabolic status and BMI resulted in six phenotypes: metabolically healthy normal weight (MHNW), metabolically unhealthy normal weight (MUNW), metabolically healthy overweight (MHOW), metabolically unhealthy overweight (MUOW), metabolically healthy obese (MHO), and metabolically unhealthy obese (MUO). CVD incidence was calculated, and Cox regression models were used to estimate adjusted hazard ratios (HR).

Results: The overall incidence of CVD was 5.64 per 1,000 person-years. Compared to the MHNW phenotype, metabolically unhealthy phenotypes showed a significantly higher risk of CVD: MUNW (aHR: 5.19, 95% CI: 1.29-20.84), MUOW (aHR: 7.07, 95% CI: 2.40-20.86), and MUO (aHR: 7.35, 95% CI: 2.43-22.21).

Conclusion: The findings underscore the importance of metabolic status, independent of BMI, in predicting cardiovascular risk. This has significant implications for clinical practice and public health, suggesting the need to implement comprehensive metabolic assessments and personalized prevention strategies across all BMI categories, especially in the workplace.

KEYWORDS (MESH)

Cardiovascular health, Primary prevention, Heart disease risk factors, Clinical prediction, Occupational health

INTRODUCCIÓN

Las enfermedades cardiovasculares (ECV) continúan siendo la principal causa de morbimortalidad a nivel mundial, representando un desafío significativo para los sistemas de salud pública[1]. Factores de riesgo tradicionales como la obesidad, la hipertensión, la dislipidemia y la diabetes mellitus tipo 2 han sido ampliamente estudiados en relación con el desarrollo de ECV[2]. Sin embargo, la heterogeneidad en la presentación clínica y el riesgo asociado a estos factores ha llevado a la identificación de fenotipos metabólicos distintos, que desafían la comprensión convencional de la relación entre la composición corporal y el riesgo cardiovascular[3].

El concepto de fenotipos metabólicos ha ganado relevancia en la última década, distinguiendo entre individuos metabólicamente saludables y no saludables, independientemente de su índice de masa corporal (IMC)[4]. Esta categorización ha permitido identificar subgrupos de población que, a pesar de presentar un peso normal, exhiben alteraciones metabólicas significativas, como el fenotipo de peso normal metabólicamente no saludable, así como individuos con obesidad que mantienen un perfil metabólico favorable, lo que se denomina fenotipo de obesidad metabólicamente saludable[5].

La llamada "paradoja de la obesidad" ha generado un debate considerable en la comunidad científica, sugiriendo que algunos individuos con obesidad podrían tener un menor riesgo cardiovascular que aquellos con peso normal pero perfil metabólico alterado[6]. Este fenómeno subraya la importancia de considerar no solo el IMC, sino también el estado metabólico en la evaluación del riesgo cardiovascular. Sin embargo, la estabilidad temporal de estos fenotipos y su impacto a largo plazo en el desarrollo de ECV siguen siendo objeto de investigación[7].

En el contexto laboral, la evaluación y seguimiento del riesgo cardiovascular adquiere una dimensión adicional, dado el impacto potencial en la productividad, el absentismo y los costos asociados a la atención médica[8]. Los programas de salud ocupacional ofrecen una oportunidad única para el monitoreo longitudinal de los trabajadores, permitiendo la identificación temprana de cambios en el estado metabólico y la implementación de estrategias preventivas personalizadas[9].

Es por ello por lo que el presente estudio tiene como objetivo evaluar la asociación entre los diferentes fenotipos metabólicos y el riesgo de desarrollar enfermedades cardiovasculares en una cohorte de trabajadores. Al examinar la incidencia de eventos cardiovasculares en relación con el estado metabólico y el IMC, este estudio busca contribuir a una comprensión más matizada del riesgo cardiovascular, con implicaciones potenciales para la estratificación del riesgo y la personalización de intervenciones preventivas en el ámbito laboral.

METODOLOGÍA

Tipo y diseño de investigación

Este estudio se diseñó como una cohorte observacional analítica retrospectiva, basada en el análisis secundario de datos ocupacionales recopilados durante el período comprendido entre 2013 y 2022. El diseño y la presentación de los resultados se han realizado siguiendo las directrices STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) para garantizar una comunicación clara y completa de esta investigación[10].

Población, muestra y criterios de elegibilidad

La población de estudio estuvo constituida por trabajadores de múltiples empresas sometidos a evaluaciones ocupacionales anuales. Se empleó un muestreo no probabilístico por conveniencia. Se incluyeron a aquellos trabajadores que contaban con registros completos de las variables de interés para el estudio; además los participantes seleccionados debían contar con al menos dos evaluaciones ocupacionales conse-

cutivas, garantizando así un seguimiento mínimo de un año. Mientras que se excluyó a los que presentaban alguna ECV al inicio del estudio.

Es importante señalar que, una vez que un trabajador era diagnosticado con el evento, era retirado del seguimiento activo. Los datos recopilados posterior a este diagnóstico no se incluyeron en el análisis subsecuente, evitando así posibles sesgos en la evaluación de la incidencia y la asociación buscada.

Variables y medición

La variable respuesta fue la presencia de ECV. Esta se definió como la presencia del diagnóstico de accidente cerebro vascular (ACV) o infarto durante el periodo de seguimiento. El diagnóstico de ACV e infarto se efectuó mediante un proceso de autoinforme, en el cual el trabajador comunicaba si le ocurrió o no el evento.

La variable dependiente fue la incidencia de enfermedad cardiovascular, definida como el diagnóstico de infarto agudo de miocardio o accidente cerebrovascular durante el período de seguimiento. Esta información se obtuvo mediante autoinforme de los participantes durante las evaluaciones periódicas.

La variable principal fue el estado metabólico, categorizado como saludable o no saludable[11,12]. Este define un estado metabólico no saludable como la presencia de dos o más de las siguientes alteraciones: obesidad abdominal según la circunferencia de cintura (CA) (≥88 cm en mujeres, ≥102 cm en hombres), hiperglucemia (glucosa en ayunas ≥100 mg/dL), hipertrigliceridemia (triglicéridos en ayunas >150 mg/dL), hipercolesterolemia (colesterol total en ayunas ≥200 mg/dL), o presión arterial elevada si la sistólica (PAS) ≥130 mmHg o diastólica (PAD) ≥85 mmHg.

Como variable de estratificación se utilizó el IMC, calculado como el peso en kilogramos dividido por el cuadrado de la altura en metros. Siguiendo las directrices de la Organización Mundial de la Salud, se establecieron tres categorías: peso normal (IMC <25 kg/m²), sobrepeso (IMC 25-29,9 kg/m²) y obesidad (IMC ≥30 kg/m²). La combinación del estado metabólico y el IMC resultó en seis fenotipos: normopeso metabólicamente saludable (NMS), normopeso metabólicamente no saludable (NMNS), sobrepeso metabólicamente saludable (OBMSW), sobrepeso metabólicamente no saludable (OBMNSW), obesidad metabólicamente saludable (OBMS) y obesidad metabólicamente no saludable (OBMNS).

Adicionalmente, se consideraron las siguiente covariables, como sexo (masculino y femenino), edad (18 a 59 años, de 60 años a más), las variables fumador, consumo de alcohol y trabajo nocturnos, se clasificaron como variables nominales dicotómicas en respuestas de si y no; por último, la variable tiempo sentado se clasificó en tiempo sentado más de 4 horas y tiempo sentado hasta 4 horas.

Procedimientos

La recolección de datos se realizó en el contexto de evaluaciones ocupacionales rutinarias, que incluían exámenes de ingreso, periódicos y de cese laboral. Cada evaluación comenzaba con el registro de información demográfica y laboral por parte del trabajador en su historia clínica.

Las mediciones de presión arterial se efectuaron utilizando dispositivos oscilométricos calibrados. Se tomaron tres mediciones en el brazo derecho del trabajador en posición sentada, con intervalos de cinco minutos. La presión arterial final se calculó como el promedio de las dos últimas mediciones.

La evaluación antropométrica incluyó mediciones de peso, talla y circunferencia de cintura abdominal. El peso se registró con una báscula electrónica calibrada, mientras que la altura se midió con un estadiómetro, con el trabajador descalzo sobre una superficie plana. La circunferencia de cintura se midió con una cinta métrica flexible en el punto medio entre la última costilla y el borde superior de la cresta ilíaca.

Se obtuvieron muestras de sangre por venopunción tras un ayuno de 8 a 12 horas. Estas muestras se analizaron para determinar los niveles de glucosa, triglicéridos y colesterol total.

Un médico ocupacional realizó una evaluación clínica que incluyó una anamnesis detallada sobre antecedentes patológicos personales y familiares, así como hábitos de vida (tabaquismo, consumo de alcohol, sedentarismo, patrones de sueño y actividad física). Esta evaluación se complementó con un examen físico completo.

Toda la información recopilada se registró en la historia clínica del trabajador y se ingresó en una base de datos electrónica por el personal de la clínica. No se implementó un procedimiento de cegamiento, ya que los datos se recolectaron como parte de la atención ocupacional rutinaria, sin un propósito de investigación específico en el momento de la recolección.

Adicionalmente, es importante señalar que todos los equipos utilizados para las mediciones antropométricas y bioquímicas se calibraron periódicamente según las recomendaciones del fabricante y las normas vigentes. La balanza se verificó con pesas patrón certificadas antes del inicio del estudio y cada 6 meses para asegurar su exactitud. El estadiómetro fue revisado antes de cada sesión de medición para confirmar su verticalidad y el correcto desplazamiento del tope. Así mismo, el esfigmomanómetro automático empleado para la medición de la presión arterial fue calibrado de acuerdo con las directrices de la Asociación Americana del Corazón, utilizando un manómetro patrón certificado al inicio del estudio y tras cada 200 mediciones o cuando existió sospecha de variación. Finalmente, las determinaciones bioquímicas (glucemia, perfil lipídico) se realizaron en un laboratorio clínico certificado que sigue protocolos estandarizados de control interno y externo de calidad. El laboratorio utilizó calibradores trazables a estándares internacionales y controles internos diarios, así como evaluaciones perió-

dicas por programas externos de aseguramiento de la calidad, garantizando la reproducibilidad y exactitud de los resultados analíticos.

Análisis estadísticos

El análisis estadístico se realizó utilizando el software R (versión 4.1.0 o superior). Inicialmente, los datos recopilados en hojas de cálculo de Excel se sometieron a un proceso exhaustivo de limpieza y validación para garantizar la calidad de la información.

Se llevó a cabo un análisis descriptivo de las características basales de la población de estudio. Para las variables categóricas, se presentaron frecuencias absolutas y relativas, mientras que para las variables continuas se calcularon medidas de tendencia central (media) y de dispersión (desviación estándar).

Se calculó la densidad de incidencia de enfermedad cardiovascular por 1000 personas-año de seguimiento para cada uno de los fenotipos metabólicos definidos (NMS, NMNS, OBMSW, OBMNSW, OBMS, OBMNS). Para cada estimación, se proporcionaron los intervalos de confianza al 95% (IC 95%). Se generaron curvas de supervivencia de Kaplan-Meier para visualizar la progresión temporal de los eventos cardiovasculares en cada fenotipo.

Para evaluar la asociación entre los fenotipos metabólicos y el riesgo de enfermedad cardiovascular, se construyeron modelos de regresión de Cox. Se obtuvieron tanto los hazard ratios crudos (HRc) como los ajustados (HRa), acompañados de sus respectivos intervalos de confianza del 95%. El modelo ajustado incluyó variables potencialmente confusoras identificadas a priori, como edad, sexo, tabaquismo y nivel de actividad física.

La selección de variables para el modelo ajustado se basó en un análisis utilizando un Gráfico Acíclico Dirigido, que permitió identificar las verdaderas variables confusoras en la relación entre los fenotipos metabólicos y el riesgo de enfermedad cardiovascular.

Los análisis se llevaron a cabo utilizando los paquetes 'survival', 'ggplot2', y 'tidyverse' en R. Este enfoque analítico nos permitió examinar de manera comprehensiva la relación entre los fenotipos metabólicos y el riesgo de enfermedad cardiovascular, controlando adecuadamente por los factores de confusión identificados.

Aspectos éticos

La presente investigación se condujo bajo la aprobación formal del Comité de Ética en Investigación de la Universidad Nacional Toribio Rodríguez de Mendoza, así como la autorización expresa de la clínica ocupacional, para el uso de su base de datos de trabajadores. Se implementaron medidas estrictas de protección de datos, incluyendo la anonimización completa de la información para eliminar cualquier posibilidad de identificación individual. El acceso a los datos fue rigurosamente controlado, limitándose exclusivamente al equipo de investigación principal, lo que garantizó la máxima confidencialidad de la información utilizada en el estudio.

Considerando la naturaleza retrospectiva y observacional de la investigación, que utilizó datos previamente recolectados como parte de la atención médica ocupacional rutinaria, no se requirió la obtención de consentimiento informado adicional. Todos los análisis y la presentación de resultados se realizaron a nivel agregado, preservando el anonimato de los participantes. En línea con los principios de transparencia científica y reproducibilidad, los datos anonimizados empleados en este estudio se han puesto a disposición de la comunidad científica a través de un repositorio de acceso abierto[13]. Este enfoque no solo asegura el cumplimiento de los estándares éticos internacionales, sino que también contribuye al avance del conocimiento en salud ocupacional de una manera ética y transparente.

RESULTADOS

En este estudio, la muestra total fue de 4 159 participantes. El 5,29%, 19,58% y 14,57% presentaron NMNS, OBMNSW y OBMNS. Mientras que el 31,07%, 48,22% y el 20,71%; tienen normopeso, sobrepeso y obesidad. El 79,44% era de sexo masculino. En cuanto al tipo de ocupación se encontró una mayor cantidad era de oficina (56,35%), seguida del físico-manual (35,04%). En cuanto a la edad, solo el 7,48% tenía edad mayor o igual a 60 años. El resto de los resultados lo pueden ver en la tabla 1.

La figura 1 ilustra las distribuciones de varios parámetros metabólicos en relación con el ECV. En general, se observa que la CA, IMC, colesterol, glucosa, PAS, PAD y triglicéridos presentan medianas más elevadas en el grupo con ECV. La dispersión de los datos es también generalmente mayor en este grupo, particularmente para glucosa, PAS, PAD y triglicéridos. Las diferencias más pronunciadas se aprecian en los triglicéridos y la presión arterial, con distribuciones claramente desplazadas hacia valores más altos en el grupo con ECV. Aunque el IMC muestra una diferencia menos marcada, sigue siendo ligeramente superior en aquellos con ECV.

La Figura 2 muestra las curvas de supervivencia de Kaplan-Meier para la incidencia de ECV según los diferentes estados metabólicos a lo largo de 8 años de seguimiento. Se observa una clara divergencia entre los grupos metabólicamente saludables (NMS, OBMSW, OBMS) y los no saludables (NMNS, OBMNSW, OBMNS). Los grupos metabólicamente no saludables, especialmente OBMNSW y OBMNS, muestran una disminución más rápida y pronunciada en la supervivencia libre de ECV, con caídas notables a partir del tercer año. En contraste, los grupos metabólicamente saludables mantienen una supervivencia más alta y estable a lo largo del tiempo. Notablemente, el grupo NMNS muestra una tendencia de su-

Tabla 1. Características de los participantes al inicio del estudio

Características	n = 4,158
Sexo	
Femenino	855 (20,56%)
Masculino	3,303 (79,44%)
Edad (años)	38.86 (12,23)
Grupos de edad	
18 - 59 años	3 847 (92,52%)
60 años o más	311 (7,48%)
Tipos de ocupación	
Oficina	2,343 (56,35%)
Trabajo físico o manual	1 457 (35,04%)
Servicio al cliente o ventas	20 (0,48%)
Profesionales de salud	73 (1,76%)
Servicios sociales	265 (6,37%)
Tiempo sentado	
Hasta 4 horas	2 183 (52,50%)
Más de 4 horas	1 975 (47,50%)
Trabajo nocturno	
No	3 858 (92,78%)
Sí	300 (7,22%)
Estado de fumador	
No	2 492 (59,93%)
Sí	1 666 (40,07%)
Consumo de alcohol	
No	2 097 (50,43%)
Sí	2 061 (49,57%)
CA	91,42 (10,72)
PAS	111,75 (12,52)
PAD	72,64 (16,47)

Características	n = 4,158
Glucosa en ayunas	94,67 (23,33)
Niveles de colesterol	195,67 (37,61)
Niveles de triglicéridos	144,41 (80,16)
Obesidad abdominal	
No	3 227 (77,61%)
Sí	931 (22,39%)
Presión arterial alta	
No	3 805 (91,51%)
Sí	353 (8,49%)
Hiperglicemia	
No	3,342 (80.38%)
Sí	816 (19.62%)
Hipertrigliceridemia	
No	2 595 (62,41%)
Sí	1 563 (37,59%)
Hipercolesterolemia	
No	2 360 (56,76%)
Sí	1 798 (43,24%)
Estado nutricional	
Normopeso	1 292 (31,07%)
Sobrepeso	2 005 (48,22%)
Obesidad	861 (20,71%)
Estado metabólico	
NMS	1 072 (25,78%)
NMNS	220 (5,29%)
OBMSW	1 191 (28,64%)
OBMNSW	814 (19,58%)
OBMS	255 (6,13%)
OBMNS	606 (14,57%)

n (%), Media (DE).
CA: Circunferencia Abdominal, PAS: Presión Arterial Sistólica, PAD: Presión Arterial Diastólica. NMS: Normopeso Metabólicamente Saludable, NMNS: Normopeso Metabólicamente No Saludable, OBMSW: Sobrepeso Metabólicamente Saludable, OBMNSW: Sobrepeso Metabólicamente No Saludable, OBMS: Obesidad Metabólicamente Saludable, OBMNS: Obesidad Metabólicamente No Saludable.

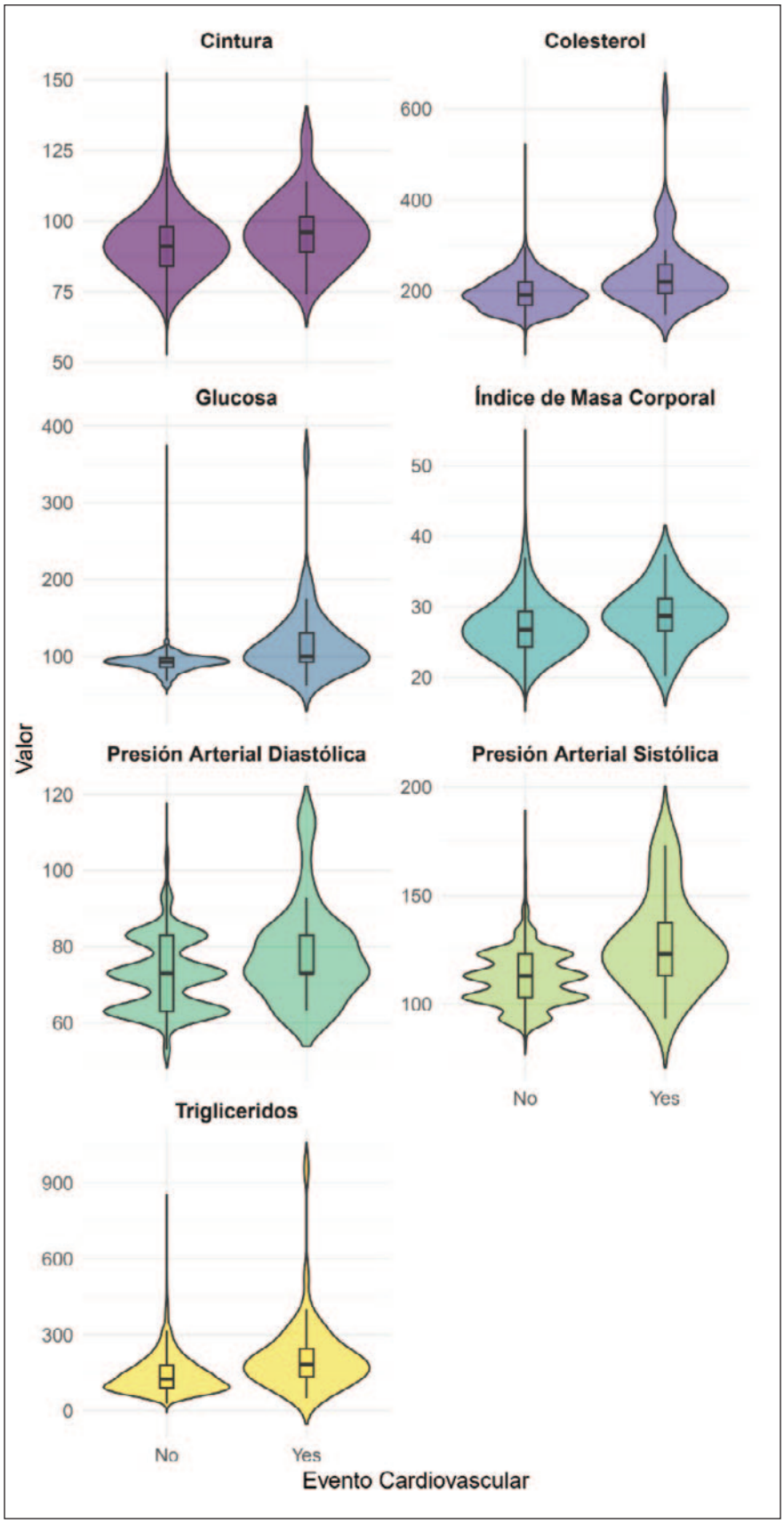


Figura 1. Diagramas de violín comparativos de parámetros metabólicos según el ECV

pervivencia intermedia, sugiriendo un riesgo elevado incluso en ausencia de obesidad. Al final del seguimiento, los grupos no saludables presentan una supervivencia acumulada considerablemente menor en comparación con sus contrapartes saludables, independientemente del IMC.

La tabla 2 muestra la incidencia global de ECV fue de 5.64 por 1000 personas-año (IC 95%: 4.26 - 7.02). Los fenotipos metabólicamente no saludables mostraron incidencias notablemente más altas en comparación con sus contrapartes saludables, siendo la más elevada para el grupo de OBMNS con 9.19 por 1000 personas-año (IC 95%: 4.54 - 13.84). En el análisis ajustado, todos los fenotipos metabólicamente no saludables mostraron riesgos en el grupo OBMNS (HRa: 7.35, IC 95%: 2.43 - 22.21), seguido de cerca por el grupo de OBMNSW (HRa: 7.07, IC 95%: 2.40 - 20.86) y NMNS (HRa: 5.19, IC 95%: 1.29 - 20.84) en comparación con el grupo de referencia (NMS).

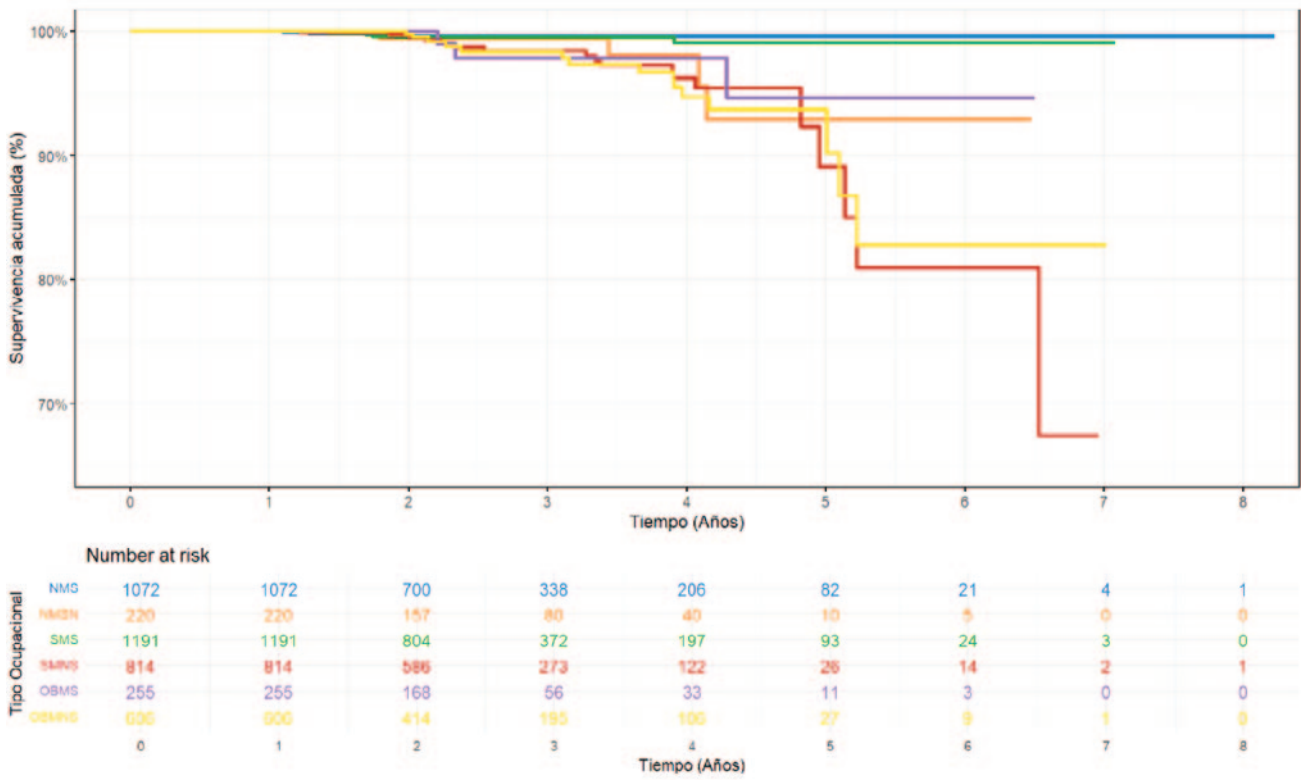
DISCUSIÓN

Hallazgos principales

Este estudio reveló diferencias significativas en el riesgo de ECV entre los distintos fenotipos metabólicos. Los individuos con fenotipos metabólicamente no saludables presentaron un riesgo considerablemente mayor de ECV en comparación con el grupo de referencia de NMS. Notablemente, el grupo de OBMNS mostró el riesgo más elevado, seguido de cerca por el grupo de OBMNSW. Incluso el grupo de NMNS exhibió un riesgo significativamente elevado, subrayando la importancia del estado metabólico independientemente del índice de masa corporal en la predicción del riesgo cardiovascular.

Estados metabólicos como riesgo de ECV

Este estudio reveló una asociación significativa entre los estados metabólicos no saludables y un mayor riesgo de ECV, independientemente del IMC. Los individuos con fenotipos metabólicamente no saludables, incluyendo aquellos con



CA: Circunferencia Abdominal, PAS: Presión Arterial Sistólica, PAD: Presión Arterial Diastólica, NMS: Normopeso Metabólicamente Saludable, NMNS: Normopeso Metabólicamente No Saludable, OBMSW: Sobrepeso Metabólicamente Saludable, OBMNSW: Sobrepeso Metabólicamente No Saludable, OBMS: Obesidad Metabólicamente Saludable, OBMNS: Obesidad Metabólicamente No Saludable.

Figura 2. Curva de supervivencia de incidencia de ECV por cada estado metabólico

Tabla 2. Tasas de incidencia y riesgo de los estados metabólicos para ECV

Características	Incidencia por 1000 personas – año (IC 95%)	Número de casos	Tiempo de seguimiento (años)	HRc (IC 95%)	HRa (IC 95%)*
Incidencia de ECV	5,64 (4,26 – 7,02)	64	11350,46	—	—
Estado metabólico					
NMS	1,38 (0,03 - 2,73)	4	2896,89	Ref,	Ref,
NMNS	6,51 (0,13 - 12,90)	4	614,04	4,39 (1,08 - 17,82)	5,19 (1,29 - 20,84)
OBMSW	1,86 (0,37 - 3,36)	6	3218,09	1,05 (0,29 - 3,73)	1,36 (0,38 - 4,82)
OBMNSW	8,56 (4,71 - 12,41)	19	2219,58	4,44 (1,47 - 13,38)	7,07 (2,40 - 20,86)
OBMS	4,71 (0,01 - 10,04)	3	636,88	3,37 (0,75 - 15,19)	4,17 (0,93 - 18,68)
OBMNS	9,19 (4,54 - 13,84)	15	1631,83	4,66 (1,52 - 14,31)	7,35 (2,43 - 22,21)

* modelo ajustado por edad, sexo, consumo de alcohol, fumador. IC 95%: intervalo de confianza al 95%. HRc: Hazard ratio crudo; HRa: Hazard ratio ajustado. CA: Circunferencia Abdominal, PAS: Presión Arterial Sistólica, PAD: Presión Arterial Diastólica, NMS: Normopeso Metabólicamente Saludable, NMNS: Normopeso Metabólicamente No Saludable, OBMSW: Sobrepeso Metabólicamente Saludable, OBMNSW: Sobrepeso Metabólicamente No Saludable, OBMS: Obesidad Metabólicamente Saludable, OBMNS: Obesidad Metabólicamente No Saludable.

NMNS, OBMNSW y OBMNS, mostraron un riesgo significativamente elevado de ECV en comparación con el grupo de referencia de NMS. Estos hallazgos están en línea con los reportados por Eckel et al.[7] en un estudio prospectivo a gran escala, donde se observó que el estado metabólico no saludable se asociaba con un mayor riesgo de ECV en todas las categorías de IMC.

Particularmente notable fue el hallazgo de que los individuos con NMNS presentaron un riesgo sustancialmente elevado de ECV (HRa: 5.19, IC 95%: 1.29 - 20.84). Este resultado subraya la importancia de considerar el estado metabólico más allá del simple IMC en la evaluación del riesgo cardiovascular. Estudios previos, como el de Caleyachetty et al.[14], han reportado hallazgos similares, sugiriendo que el fenotipo NMNS podría representar un "subtipo oculto" de alto riesgo que a menudo pasa desapercibido en la práctica clínica convencional.

El fenómeno de la OBMS ha sido objeto de considerable debate en la literatura científica. Los resultados del presente estudio mostraron que, aunque los individuos con OBMS tenían un riesgo menor que aquellos con OBMNS, aún presentaban un riesgo elevado de ECV en comparación con el grupo NMS (HRa: 4.17, IC 95%: 0.93 - 18.68). Estos hallazgos son consistentes con un metaanálisis reciente de Eckel et al.[15], que concluyó que el fenotipo OBMS no es benigno y aún conlleva un riesgo cardiovascular incrementado a largo plazo.

Es importante destacar que nuestro estudio, al igual que otros estudios longitudinales como el de Mongraw-Chaffin et al.[16], sugiere que el riesgo asociado con los estados metabólicos no saludables persiste y posiblemente se incrementa con el tiempo. La incidencia acumulada de ECV en los grupos metabólicamente no saludables mostró una divergencia creciente respecto al grupo NMS a lo largo del período de seguimiento, lo que subraya la importancia de intervenciones tempranas y sostenidas para mejorar el perfil metabólico.

Los mecanismos subyacentes a la asociación entre estados metabólicos no saludables y riesgo de ECV son complejos y multifactoriales. La resistencia a la insulina, la inflamación crónica de bajo grado y la disfunción del tejido adiposo se han propuesto como factores clave[17]. Neeland et al.[18] han sugerido que la distribución de la grasa corporal, particularmente la adiposidad visceral y ectópica, podría ser un determinante más importante del riesgo metabólico y cardiovascular que la masa grasa total. Esto podría explicar, en parte, el elevado riesgo observado en individuos NMNS, quienes podrían tener una distribución de grasa desfavorable a pesar de un IMC normal.

Los hallazgos encontrados tienen implicaciones importantes para la práctica clínica y la salud pública. Sugieren que las estrategias de prevención cardiovascular deberían enfocarse no solo en el control del peso, sino también en la optimización del perfil metabólico en todas las categorías de IMC. La implementación de evaluaciones más comprehensivas del riesgo metabólico, que vayan más allá del simple IMC, podría mejorar la identificación de individuos en alto riesgo de ECV, incluyendo aquellos con peso normal pero perfil metabólico desfavorable[2].

Es así como es interesante que un hallazgo fundamental de nuestro estudio es que el IMC por sí solo parece ser insuficiente para predecir con precisión el riesgo cardiovascular. Los resultados subrayan que es el componente metabólico el que juega un papel decisivo en el desarrollo de ECV, independientemente de la categoría de peso. Esta observación se alinea con las conclusiones de Lavie et al.[4], quienes argumentan que la "calidad" metabólica del tejido adiposo es más relevante que su cantidad para determinar el riesgo cardiovascular. Nuestros datos muestran que individuos con NMNS tienen un riesgo significativamente mayor de ECV comparado con aquellos de NMS, mientras que algunos individuos con OBMS presentan un riesgo menor que sus contrapartes no saludables. Esto sugiere que los marcadores metabólicos, como la resistencia a la insulina, la dislipidemia y la inflamación crónica, podrían ser los verdaderos impulsores del riesgo cardiovascular[19]. Stefan et al.[20] han propuesto que la distribución de la grasa corporal y la funcionalidad del tejido adiposo son determinantes cruciales del estado metabólico y, por ende, del riesgo cardiovascular, más allá del simple IMC. Por lo tanto, nuestros hallazgos refuerzan la necesidad de un enfoque más matizado en la evaluación del riesgo cardiovascular, que incorpore marcadores metabólicos junto con medidas antropométricas tradicionales para una estratificación más precisa del riesgo y una intervención más efectiva en la prevención de ECV.

Importancia del estudio para la salud pública

Los hallazgos de nuestro estudio tienen implicaciones significativas para la salud pública, especialmente en la prevención y manejo de ECV. Nuestros resultados subrayan la necesidad de reconsiderar los enfoques actuales de estratificación del riesgo cardiovascular. La observación de que individuos NMNS presentan un riesgo elevado de ECV sugiere que las estrategias de screening basadas únicamente en el IMC podrían estar pasando por alto a un grupo significativo de población en riesgo. Es decir, es crucial aumentar la conciencia sobre la importancia del estado metabólico más allá del peso corporal.

En cuanto a los programas de prevención de ECV, nuestro estudio resalta la importancia de un enfoque más personalizado. Los resultados sugieren que las intervenciones no deberían centrarse exclusivamente en la pérdida de peso, sino también en la mejora del perfil metabólico en todas las categorías de IMC. Además, la relevancia en el ámbito laboral es particularmente notable. Nuestros hallazgos apoyan la implementación de programas de salud laboral que vayan más allá de las evaluaciones tradicionales de IMC, incorporando cribados metabólicos regulares. Justamente, los lugares sugieren que los lugares de trabajo ofrecen una oportunidad única

para implementar intervenciones de salud a gran escala, como otros estudios lo han señalado[21–23].

Desde una perspectiva de políticas de salud pública, nuestro estudio subraya la necesidad de un cambio de paradigma en la prevención cardiovascular a nivel poblacional. Las políticas actuales podrían beneficiarse de estrategias dirigidas a mejorar la salud metabólica en todas las categorías de peso, alineándose con las recomendaciones de la Organización Mundial de la Salud para un enfoque integrado en la prevención de enfermedades no transmisibles.

Fortalezas y limitaciones del estudio

Este estudio presenta varias fortalezas notables, incluyendo un tamaño de muestra considerable (n=4,158) y un seguimiento longitudinal de hasta 8 años, lo que permite una evaluación robusta de la incidencia de ECV en diferentes fenotipos metabólicos. La inclusión de una población trabajadora diversa aumenta la generalización de los resultados a entornos laborales similares. Además, la clasificación detallada de los fenotipos metabólicos basada en múltiples parámetros proporciona una evaluación más completa que los estudios que se basan únicamente en el IMC. Sin embargo, el estudio también tiene limitaciones que deben considerarse. En primer lugar, la naturaleza observacional del diseño limita la capacidad de establecer relaciones causales directas. Segundo, aunque se ajustaron varios factores de confusión, no se puede descartar la influencia de variables no medidas. La definición de salud metabólica utilizada, aunque basada en criterios establecidos, puede diferir de otros estudios, lo que podría afectar la comparabilidad de los resultados. Además, el autorreporte de ECV podría introducir un sesgo de información, aunque se hizo un esfuerzo por verificar estos eventos mediante registros médicos cuando fue posible.

Una potencial limitación de este estudio es la composición demográfica de la muestra, con una predominancia masculina (79.44%) que podría afectar la generalización de los resultados a otros grupos poblacionales. Sin embargo, es importante contextualizar esta distribución dentro del marco laboral formal del país. Estudios previos han reportado que, en el sector laboral formal nacional, solo aproximadamente el 20% son mujeres[24]. Por lo tanto, nuestra muestra refleja con bastante precisión la realidad del mercado laboral formal del país.

Conclusiones y recomendaciones

En conclusión, el estudio demuestra que el estado metabólico es un factor crucial en la predicción del riesgo de ECV, independientemente del IMC. Los fenotipos metabólicamente no saludables, incluyendo NMNS, OBMNSW y OBMNS, presentan un riesgo significativamente elevado de ECV en comparación con NMS. Estos hallazgos subrayan la necesidad de un cambio de paradigma en la evaluación y manejo del riesgo cardiovascular, más allá del enfoque tradicional basado en el IMC.

Frente a ello, se recomienda la implementación de cribados metabólicos comprehensivos en la práctica clínica y los programas de salud ocupacional, con especial atención a los individuos NMNS que podrían pasar desapercibidos en las evaluaciones estándar. Si bien las intervenciones de salud pública se deben enfocar la reducción de peso, también este debe ser dirigido en mejorar el perfil metabólico, independiente del IMC. En el ámbito laboral, sugerimos la implementación de programas que promuevan la salud metabólica a través de intervenciones en el estilo de vida, adaptadas al perfil de riesgo individual. Para futuras investigaciones, se recomiendan estudios longitudinales más extensos que examinen la estabilidad de los fenotipos metabólicos a lo largo del tiempo y su impacto en la incidencia de ECV, así como ensayos de intervención que evalúen la eficacia de estrategias dirigidas a mejorar el estado metabólico en la reducción del riesgo cardiovascular.

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Efecto de la suplementación nutricional oral hiperproteica en el estado nutricional y parámetros bioquímicos de pacientes con insuficiencia cardíaca congestiva

Effect of high protein oral nutritional supplementation on the nutritional status and biochemical parameters of patients with congestive heart failure

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RESUMEN

Introducción: Los pacientes con insuficiencia cardiaca congestiva (ICC) presentan riesgo nutricional asociado a una inadecuada ingesta de proteínas.

Objetivos: Evaluar el efecto de la suplementación nutricional oral hiperproteica, sobre el estado nutricional y parámetros bioquímicos de los pacientes con ICC.

Materiales y Métodos: Investigación de enfoque cuantitativo, de diseño experimental de nivel cuasi- experimental. La muestra estuvo conformada por 194 pacientes adultos con diagnóstico de ICC, divididos en 2 grupos (Grupo con desnutrición =54; Grupo sin desnutrición =140); hospitalizados entre el 01 de abril al 31 de mayo del 2023; en el área de cardiología del Hospital Guillermo Almenara Irigoyen (HNGAI), Lima, Perú. La información de los parámetros bioquímicos fue obtenida a través del registro electrónico de las historias clínicas que fueron llenadas por profesionales de la salud. La evaluación del estado nutricional se realizó por medio de la toma de datos antropométricos al inicio y final de la intervención nutricional (Se administró terapia nutricional con un aporte calórico total de 1800 kcal a ambos grupos, proteína 1,2-1,5 g/kg/día, utilizando dieta prescripta y un suplemento nutricional oral hiperproteico). Para evaluar el efecto se utilizó la prueba T-Student y la prueba d-Cohen, para comparar las medias. Un valor de p<0,05 se consideró estadísticamente significativo.

Resultados: Posterior a las 2 semanas de intervención el grupo con desnutrición experimentó un aumento significativo de 0,97 kg en el peso y un incremento de la circunferencia braquial (CB) de 0,71cm. El grupo sin desnutrición, mostró un aumento significativo en la CB de 0,32cm. En los hallazgos bioquímicos, ambos grupos evidenciaron mejoras en el caso de la albúmina y hemoglobina, observándose aumentos significativos de albumina (3,04 a 3,6 g/dl) y hemoglobina (12,05 a 13,03 g/dl) en el grupo con desnutrición. Asimismo, evidenció una disminución significativa (p<0,036) de los valores de colesterol y de glucosa (-3,52md/dl y -4,21mg/dl, respectivamente). De manera similar, en el grupo sin desnutrición; la variación fue de -7,40mg/dl y -7,78md/dl (p=0,000).

Conclusión: la terapia nutricional mejoró el estado nutricional y los niveles de albúmina en pacientes desnutridos con ICC, asimismo la presencia de antecedentes patológicos influye significativamente.

PALABRAS CLAVE

Nutrición enteral, función cardiaca, desnutrición, calidad de vida, terapia nutricional, módulo hiperproteico hospitalario.

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ABSTRACT

Introduction: Patients with congestive heart failure (CHF) present nutritional risk associated with inadequate protein intake.

Objectives: To evaluate the effect of hyperprotein oral nutritional supplementation on the nutritional status and biochemical parameters of patients with CHF.

Materials and Methods: Research with a quantitative approach, with a quasi-experimental experimental design. The sample consisted of 194 adult patients with a diagnosis of CHF, divided into 2 groups (group with malnutrition =54; group without malnutrition =140); hospitalized between April 1 and May 31, 2023; in the cardiology area of the Hospital Guillermo Almenara Irigoyen (HNGAI), Lima, Peru. The information on biochemical parameters was obtained through the electronic recording of clinical histories that were filled out by health professionals. The evaluation of nutritional status was performed by taking anthropometric data at the beginning and end of the nutritional intervention (Nutritional therapy was administered with a total caloric intake of 1800 kcal to both groups, protein 1.2-1.5 g/kg/day, using prescribed diet and an oral hyperproteic nutritional supplement). To evaluate the effect, the Student's t-test and the d-Cohen test were used to compare means. A value of $p<0.05$ was considered statistically significant.

Results: After 2 weeks of intervention, the malnourished group experienced a significant increase of 0.97 kg in weight and an increase of 0.71cm in arm circumference (BC). The group without malnutrition showed a significant increase in BC of 0.32cm. In the biochemical findings, both groups showed improvements in albumin and hemoglobin, with significant increases in albumin (3.04 to 3.6 g/dL) and hemoglobin (12.05 to 13.03 g/dL) in the group with malnutrition. It also showed a significant decrease ($p<0.036$) in cholesterol and glucose values (-3.52md/dl and -4.21mg/dl, respectively). Similarly, in the group without malnutrition, the variation was -7.40mg/dl and -7.78md/dl ($p=0.000$).

In **conclusion**, nutritional therapy improved nutritional status and albumin levels in malnourished patients with CHF, and the presence of pathological history had a significant influence.

KEY WORDS

Enteral nutrition; cardiac function; malnutrition; quality of life; nutritional therapy; hospital high protein module.

LISTA DE ABREVIATURAS

ICC: Insuficiencia Cardiaca Congestiva.

IMC: Índice de Masa Corporal.

CB: Circunferencia Braquial.

EsSi: Servicio de Salud Inteligente.

NE: Nutrición Enteral.

OMS: Organización Mundial de la Salud.

RET: Requerimiento Energético Total.

INTRODUCCIÓN

Los pacientes hospitalizados con insuficiencia cardíaca (ICC) experimentan un deterioro en su estado nutricional, que se debe a varios factores. Uno de ellos es el aumento en el metabolismo debido al esfuerzo respiratorio adicional que conlleva la enfermedad. Además, los trastornos hepáticos y gastrointestinales también contribuyen a este deterioro, ya que la presión venosa elevada en la región abdominal puede causar síntomas como anorexia, náuseas, y dificultades en la absorción de nutrientes en el intestino, entre otros[1,2,3]. Estudios reportan que al menos un tercio de estos pacientes desarrollan desnutrición leve o moderado[4,5]. En casos graves, pueden desarrollar caquexia cardiaca y/o sarcopenia, cuyo pronóstico es desalentador debido a tasas de mortalidad significativamente más altas en comparación con pacientes con ICC no caquéctica[6,7,8].

En este contexto, el índice de masa corporal (IMC) destaca como prueba de uso principal, complementada por mediciones del pliegue tricipital (PCT) para evaluar la grasa corporal y la circunferencia braquial (CB) para determinar la reserva proteica. Adicionalmente, la valoración bioquímica también es de gran utilidad, ya que pueden revelar la presencia de indicadores como bajos niveles de hemoglobina, albúmina sérica, prealbúmina, colesterol total, entre otros[9,10].

En la actualidad no existen recomendaciones específicas para la ingesta de proteínas y energía. Siendo la ingesta de 31,8 a 35 kcal/kg/día la más segura y eficaz para aumentar la masa magra en pacientes con ICC. Evitando exceder la ingesta de energía puesto que, genera un aumento de las concentraciones plasmática de catecolaminas e insulina, causando estrés fisiológico[11].

La recomendación de ingesta de proteínas debe seguir las recomendaciones para personas sanas y en pacientes con caquexia cardiaca puede llegar hasta 2,0 g/kg/día[12]. Requerimiento difícil de cubrir únicamente con la dieta oral, haciendo necesaria la prescripción de suplementos nutricionales orales (SNO), priorizando el aporte de proteínas[13]. Estos suplementos parecen tener un impacto positivo en la reducción de la inflamación, la mejora de la calidad de vida y la prolongación de la supervivencia en pacientes con ICC[4,14,15].

Se ha demostrado que los SNO hiperproteicos e hipercalóricos mejoran el peso corporal, la composición corporal, los parámetros de laboratorio, la calidad de vida[16], la capacidad de ejercicio, además de mejorar la función inmunológica al reducir los niveles de factores inflamatorios y mejorar los indicadores nutricionales[17,18].

Estas investigaciones proporcionan un sólido punto de partida para el estudio, aunque es notable que hayan sido llevadas a cabo en países de Europa o Asia. Por otro lado, existe una notable falta de evidencia sobre la influencia de las comorbilidades y los niveles de albúmina, sobre los efectos de la suplementación en la ICC. Dada esta falta de evidencia científica, la realización de esta investigación es crucial.

MATERIALES Y MÉTODOS

Investigación de enfoque cuantitativo, de diseño experimental de nivel cuasi- experimental. El estudio se realizó con 194 pacientes hospitalizados con diagnóstico médico de ICC, durante el periodo comprendido entre el 01 de abril al 31 de mayo del 2023; en el área de cardiología del Hospital Guillermo Almenara Irigoyen (HNGAI), Lima - Perú; cuyos criterios de inclusión fueron, pacientes mayores de 18 años con diagnóstico de ICC, hemodinámicamente estables con un aceptable control de los síntomas en la medida en que fueran susceptibles de ser dados de alta. Además, de tener historia clínica completa (diagnóstico médico, exámenes bioquímicos e información nutricional); no obstante se excluyó a pacientes con historia clínica incompleta, cuya permanencia fue menor a 2 semanas; pacientes sin posibilidad de ser pesados y tallados, gestantes, puérperas, como también aquellos que se encontraban con soporte nutricional antes de la evaluación nutricional antropométrica y bioquímica, pacientes con signos de procesos inflamatorios agudos, cáncer o insuficiencia renal crónica.

Los pacientes que cumplieron los criterios de inclusión fueron divididos en 2 grupos, a través de un método no probabilístico, por conveniencia, para consumir Inmunocare Hp ® (suplemento nutricional con alto contenido de proteínas (20gr/prot/toma), calostro bovino, fibra prebiótica (polidextrosa), inmunoglobulinas, osmolaridad adecuada (278 mosm/L, menor riesgo de diarrea osmótica), vitaminas y minerales); por vía oral durante 2 semanas. A todos los pacientes se les realizó la evaluación nutricional antropométrica y bioquímica, al inicio y final del tiempo de intervención.

La información fue recolectada a través del registro de las historias clínicas físicas y electrónicas del sistema EsSi (Servicio de Salud Inteligente) y kardex de nutrición del servicio de cardiología, las cuales fueron llenadas por profesionales de la salud. Se recolectó datos como diagnostico principal, valores bioquímicos (albumina, hemoglobina, urea, creatinina, sodio, glucosa, colesterol), valores antropométricos (peso, talla, etc), vía de alimentación, comorbilidades y otros datos clínicos.

El primer grupo estuvo compuesto por 54 pacientes con desnutrición y el segundo grupo por 140 pacientes sin desnutrición, determinado a través del IMC y/o valores de albúmina. Se realizaron 2 controles a cada grupo. T0: Al ingreso a hospitalización, 24 horas antes del inicio de suplementación (albúmina sérica, hemoglobina, urea, sodio, creatinina, colesterol, glucosa, peso, circunferencia braquial). T2: El monitoreo se realizó en la segunda semana de haber iniciado la suplementación e incluyó las mismas mediciones para comparar los resultados después de la intervención.

La intervención nutricional administrada fue una dieta de 1800 kcal con una composición de macronutrientes del 54% de hidratos de carbono (243 gramos), 30% de grasas (60gramos) y 16% de ingesta diaria de proteínas que se fijó en 1,2 g/kg de peso corporal para los pacientes sin desnutrición (IMC: normal, sobrepeso u obesidad; y albúmina >3,5g/dl), también se administró la terapia nutricional 16% RET (290 kcal) por vía enteral dividido en dos tomas iguales por día (40g/prot), administradas entre las comidas principales para evitar la supresión del apetito; y en pacientes con desnutrición (IMC: delgadez y/o albúmina <3,5g/dl), se administró el 21% de proteínas para corrección de la hipoalbuminemia con aporte proteico de 1,5 g/kg de peso corporal (94,5 g), 50% de hidratos de carbono (225 gramos) y 29% de grasas (58 gramos), asimismo, se administró el 24% RET (436 kcal) del suplemento nutricional oral hiperproteico dividido en tres tomas iguales por día (60g/prot) o acorde a la necesidad y/o demanda nutricional del paciente.

La investigación, consentimiento informado y los instrumentos de recolección de datos fueron revisados y aprobados por el comité de ética institucional del Hospital Guillermo Almenara Irigoyen (HNGAI), Lima, Perú. Cumpliendo con las pautas éticas en investigación, incluyendo el balance beneficio/riesgo, confidencialidad de los datos y otros.

Análisis estadístico

Se registró la base de datos en el programa Microsoft Excel, que abarcó datos demográficos, características clínicas y el diagnóstico médico. En cuanto al diagnóstico nutricional, se documentaron el peso, la circunferencia braquial y los valores bioquímicos tanto antes de la intervención (T0) como después de la intervención (T2). Las variables cuantitativas se describieron utilizando medias y desviaciones estándar (DE). Para comparar las variables entre grupos, se aplicó la prueba T de Student. Los tamaños de efecto (TE) se evaluaron mediante la prueba d de Cohen, en la que se consideró un TE muy bajo para puntuaciones menores a 0,2; un TE leve para puntuaciones entre 0,2 y 0,5; TE moderados para valores entre 0,5 y 0,8; TE altos para valores entre 0.8 y 1, y TE muy altos para puntuaciones >1.

RESULTADOS

En total se estudiaron 194 pacientes (Grupo con desnutrición =54; Grupo sin desnutrición =140). Después de 2 semanas (tabla 1), el Grupo con desnutrición aumentó su peso en 0,97 kg (p=0,000) y su CB en 0,71 cm (p=0,000) con tamaños de efecto muy bajo y leve, respectivamente. Además, se observaron mejoras significativas en los niveles de colesterol, glucosa,

Tabla 1. Resultados descriptivos antes y después de la intervención en ambos grupos

Medición	GRUPO CON DESNUTRICIÓN		Diferencia	Valor P	d Cohen
	Base	2 semanas			
Peso (kg)	60,77 (10,59)	61,74 (10,22)	0,97	0,000	0,093
Cb (cm)	25,09 (3,48)	25,81 (3,38)	0,71	0,000	0,207
Albúmina (g/dL)	3,04 (0,43)	3,60 (0,30)	0,56	0,000	1,517
Creatinina (mg/dL)	1,14 (0,94)	0,97 (0,53)	-0,17	0,013	0,223
Urea (mg/dL)	48,74 (26,53)	47,65 (26,45)	-1.10	0,682	0,041
Sodio (mmol/L)	140,35 (4,76)	139,93 (3,36)	-0,43	0,361	0,103
Colesterol (mg/dL)	134,52 (32,60)	131 (29,03)	-3,52	0,001	0,114
Hemoglobina (g/dL)	12,05 (1,16)	13,03 (0,84)	0,98	0,000	0,965
Glucosa (mg/dL)	109,69 (26,92)	105,48 (19,44)	-4,21	0,036	0,179
Medición	**GRUPO SIN DESNUTRICIÓN**		**Diferencia**	**Valor P**	**d Cohen**
	Base	**2 semanas**			
Peso (kg)	71,79 (13,40)	71,78 (13,10)	-0,01	0,937	0,000
Cb (cm)	27,10 (3,12)	27,42 (2,90)	0,32	0,000	0,109
Albúmina (g/dL)	4,04 (0,35)	4,25 (0,40)	0,21	0,000	0,574
Creatinina (mg/dL)	1,06 (1,38)	1,00 (0,97)	-0,06	0,160	0,049
Urea (mg/dL)	34,74 (12,31)	35,27 (10,28)	0,53	0,288	0,046
Sodio (mmol/L)	139,54 (9,22)	139,84 (3,30)	0,30	0,692	0,044
Colesterol (mg/dL)	161,44 (40,18)	154,04 (33,19)	-7,40	0,000	0,187
Hemoglobina (g/dL)	13,22 (1,11)	13,51 (0,85)	0,29	0,000	0,294
Glucosa (mg/dL)	111,22 (34,94)	103,44 (19,99)	-7,78	0,000	0,273

albúmina y hemoglobina. En el Grupo sin desnutrición, el peso disminuyó en 0,01 kg (p>0,9) y su CB aumentó significativamente en 0,32 cm con un tamaño de efecto muy bajo. Este grupo también presentó mejoras en los niveles de colesterol, glucosa, albúmina y hemoglobina, aunque en menor medida. No se observaron cambios significativos en urea y sodio en ambos grupos (p>0,05). Los niveles de creatinina presentaron cambios significativos únicamente en el grupo con desnutrición.

Al analizar si la presencia de comorbilidades influía sobre el efecto de la suplementación, se encontró que en el grupo con desnutrición (figura 1), los pacientes sin antecedentes mostraron un aumento de peso significativo (1,18 kg, p=0,000), mientras que aquellos con diabetes tuvieron una ganancia menor (0,46 kg, p<0,05), con TE muy bajos. En el grupo sin desnutrición (figura 2), no se encontró asociación significativa con el peso en ningún escenario (p>0,05). Respecto a la CB, en el grupo con desnutrición, hubo una relación significativa con la mayoría de antecedentes, excepto diabetes (p=0,067), con un mayor aumento en pacientes sin comorbilidades (0,97 cm, TE leve) y menor en hipertensos (0,61 cm, TE muy bajo). Para el grupo sin desnutrición, la CB presentó relación significativa en la mayoría de casos, excepto diabetes (p=0,201), con un mayor aumento en pacientes sin antecedentes (0,38 cm, TE muy bajo) y menor en aquellos con 2 o más antecedentes (0,25 cm, TE muy bajo). Con relación a los parámetros bioquímicos, en el grupo con desnutrición, los niveles de albúmina aumentaron

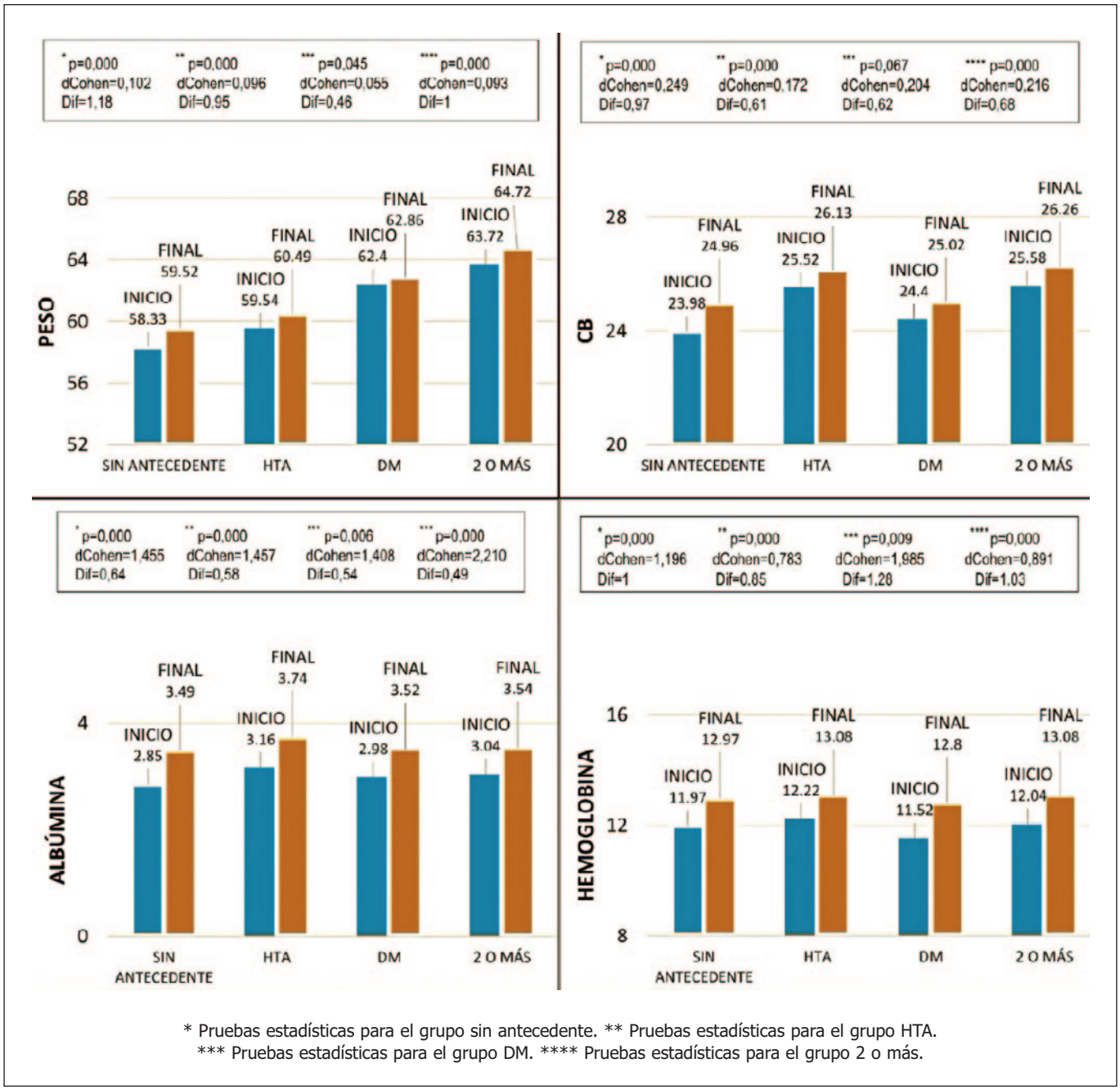

Figura 1. Cambios descriptivos antes y después de la intervención en el grupo con desnutrición

significativamente en todos los casos, siendo mayor el aumento en pacientes sin antecedentes (0,64g/dL, TE muy alto) y el menor en aquellos con 2 o más antecedentes (0,49g/dL, dCohen=2,210).

En cuanto a la hemoglobina, se observaron aumentos significativos en todos los casos del grupo con desnutrición, siendo el mayor en pacientes con diabetes (1,28g/dL, TE muy alto) y el menor en los hipertensos (0,85g/dL, dCohen=0,783). En el grupo sin desnutrición, los niveles de albúmina aumentaron en la mayoría de casos, destacando el aumento en pacientes con 2 o más antecedentes (0,24g/dL, TE moderado), mientras que la hemoglobina tuvo mayor aumento en los pacientes sin antecedentes (+0,35g/dL, TE leve).

Al analizar el efecto de la suplementación en el grupo sin desnutrición, según el IMC (figura 3). Se encontró una relación significativa en relación al peso de los pacientes con normopeso y obesidad ($p<0,05$), donde los de peso normal mostraron un aumento de 0,27 kg y los obesos, una disminución de 0,64 kg, con TE muy baja. La CB, presentó variación estadísticamente significativa en normopesos y sobrepesos

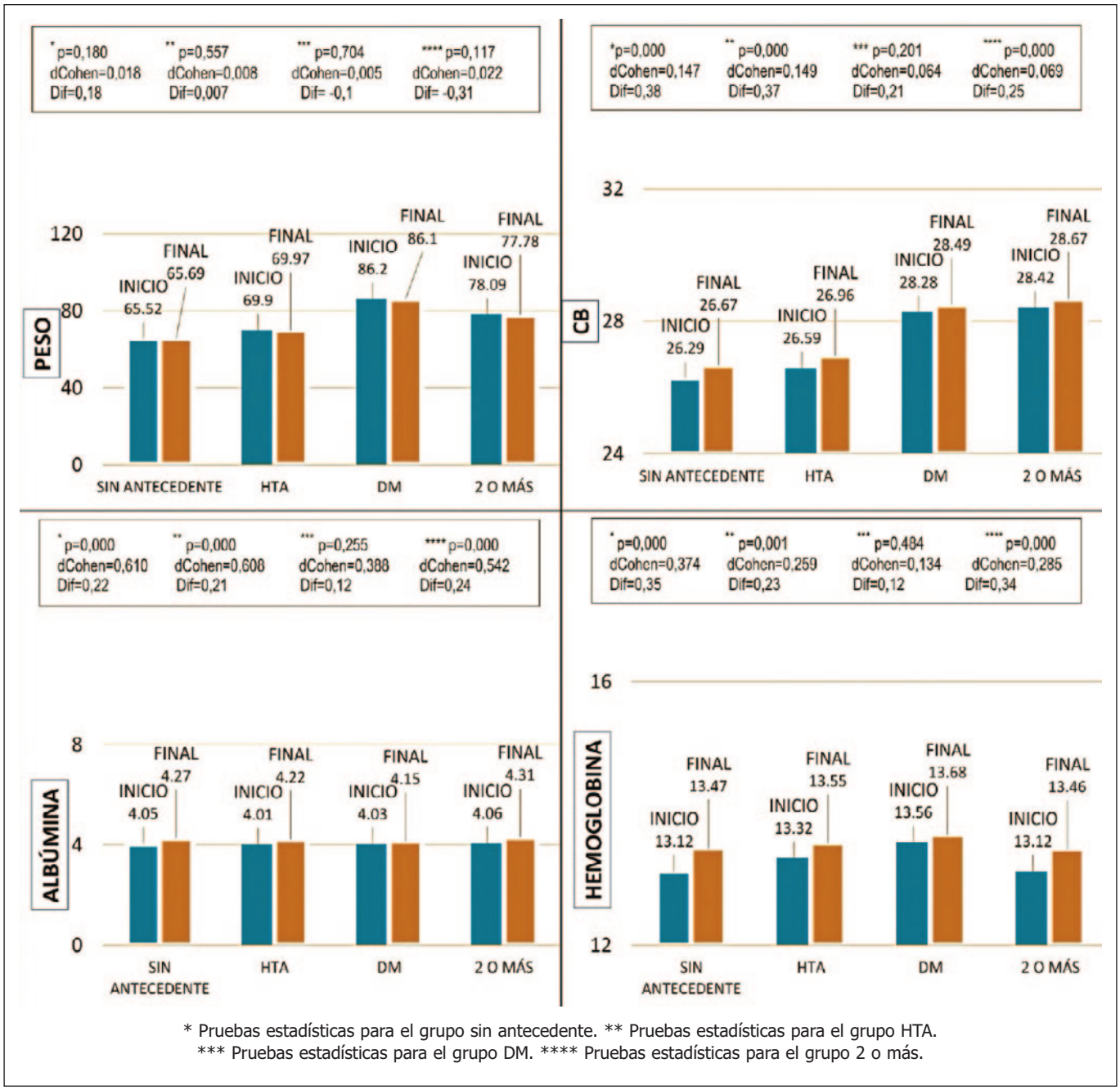

Figura 2. Cambios descriptivos antes y después de la intervención en el grupo sin desnutrición

(p<0,05), con un aumento de 0,49 cm y 0,21 cm, con TE leve y muy bajo, respectivamente. Los niveles de albúmina presentaron relación significativa con la suplementación según los IMC (p=0,000). Siendo mayor el aumento (0,23g/dl) en pacientes normopesos, con un TE moderado. En cuanto a la hemoglobina, el mayor aumento (0,34g/dl se registró en pacientes normopesos (p=0,000, TE leve).

En el análisis sobre efecto de la suplementación en el grupo con desnutrición, en función de los niveles de albúmina sérica (figura 4), el peso presentó un mayor aumento (p<0,05) en pacientes con hipoalbúminemia severa (1,63 kg, TE moderado). En la CB, la suplementación tuvo un efecto significativo en todos los niveles de albúmina (p<0,05), con el mayor aumento en pacientes con hipoalbuminemia severa (1,33 cm, TE leve). Los niveles de albúmina presentaron mayor aumento en aquellos con hipoalbuminemia severa (1g/dL,) y menor en pacientes con niveles normales (0,35g/dL), con un TE muy alto en todos los casos. En la hemoglobina, se encontró un aumento mayor en la hipoalbuminemia severa

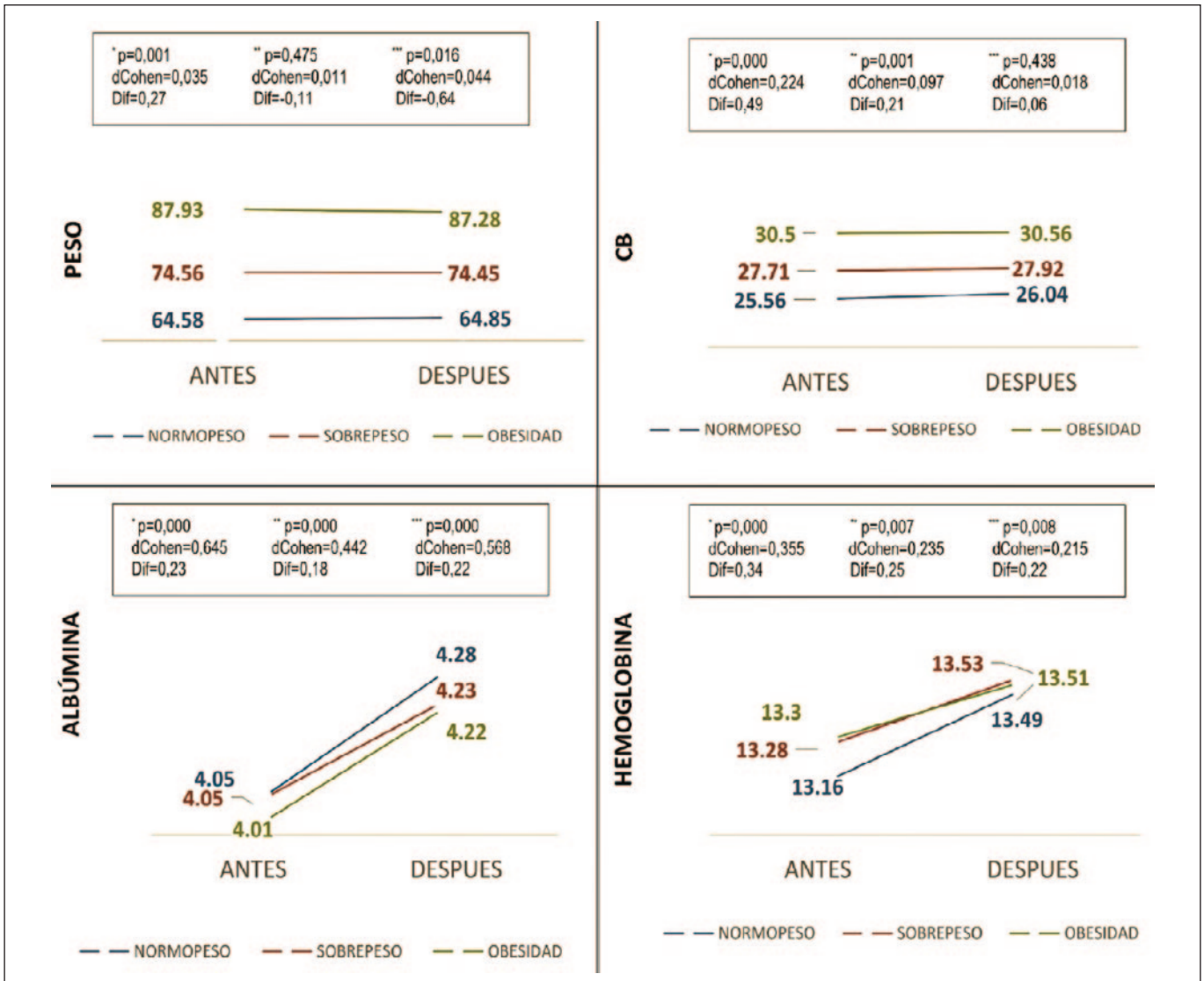

Figura 3. Cambios descriptivos antes y después de la intervención en ambos grupos según índice de masa corporal

(1,23g/dL, TE muy alto), y menor en pacientes con niveles normales (0,7g/dL, TE leve).

DISCUSIÓN

La desnutrición en pacientes con ICC no solo agrava los síntomas de la enfermedad, sino que también empeora el pronóstico a largo plazo. Actualmente la terapia no farmacológica como el soporte nutricional es considerada una pieza fundamental en la prevención y tratamiento de la desnutrición o caquexia en estos pacientes[11].

En ese sentido, estudios previos han demostrado efectividad en el uso de un suplemento nutricional en diversos ámbitos, por ejemplo, partiendo de los resultados de nuestro estudio, podemos observar un aumento de peso de 0.97 kg, tras el consumo del suplemento oral nutricional hiperproteico (SON-H) en el grupo con desnutrición, en 2 semanas, coincidiendo con lo reportado por Aquilani[19], quien encontró que el 80 % de pacientes con ICC del grupo suplementado con aminoácidos esenciales evidenció un aumento de peso corporal de más de 1 kg, con la diferencia de que el grupo suplementado se trataba de pacientes con IMC normal; sin embargo, el aumento se midió a los 2 meses, lo cual difiere de nuestra investigación. Así mismo, Rozentryt[16] realizó una investigación aleatorizada con 29 pacientes con desnutrición, estos pacientes luego de recibir un suple-

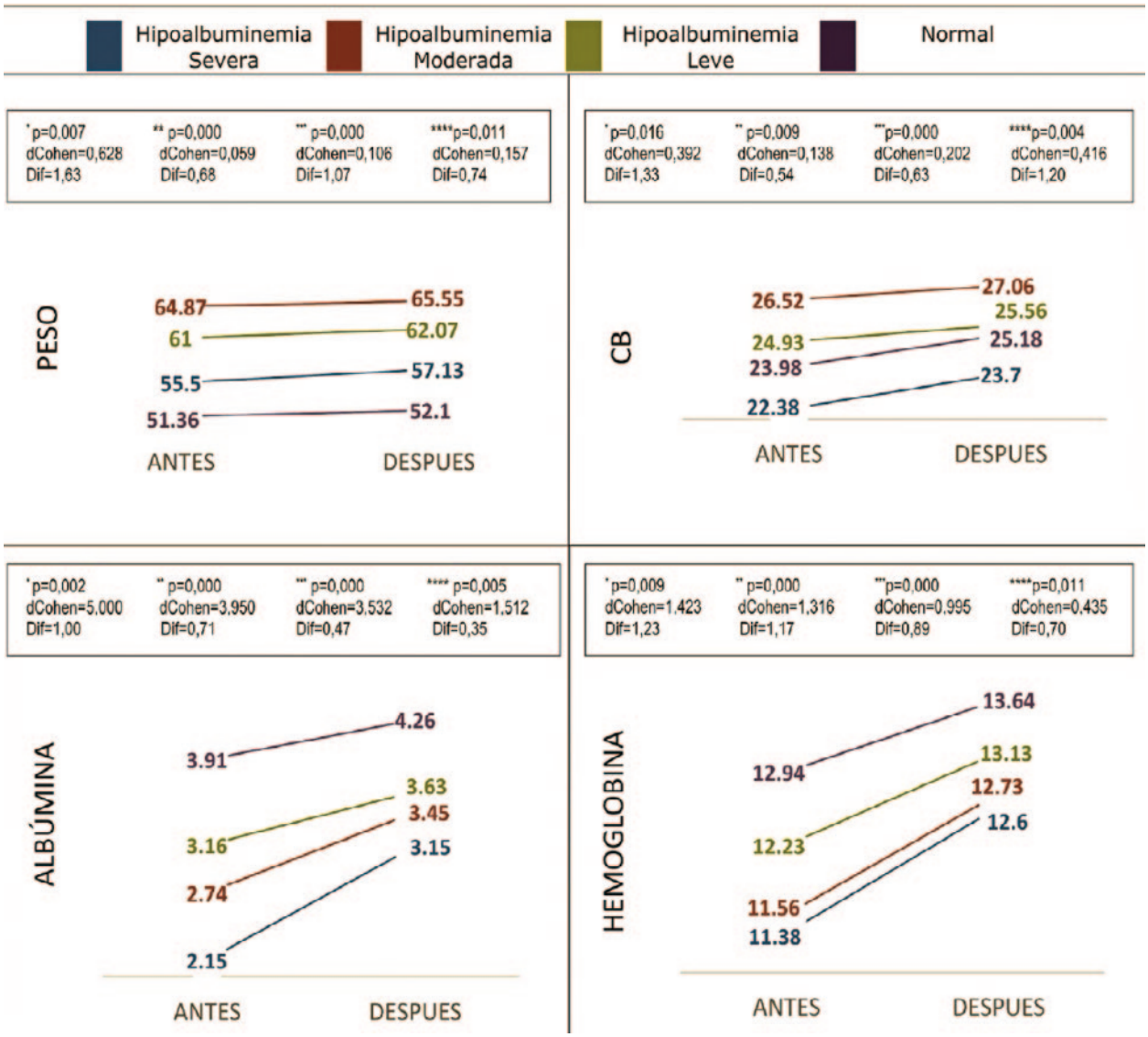

Figura 4. Cambios descriptivos antes y después de la intervención en ambos grupos según los niveles de albúmina

mento hiperproteico e hipercalórico, entre los resultados más relevantes se encontró un promedio de aumento de peso de 2,0 ± 1,7 kg en 18 de ellos a las 6 semanas de intervención, y se mantuvo en una evaluación posterior a las 18 semanas.

Si bien, el aumento de peso del último estudio en referencia es mayor y dada la similitud con nuestra investigación, se podría sugerir que esto se debe a la corta intervención de 2 semanas propuesta, y que podría verse un mayor efecto si se administrara durante más tiempo. Así mismo, cabe resaltar la importancia del aumento de peso en pacientes con ICC, ya que estudios han reportado que el tener un IMC mayor; además de una mayor masa grasa, se asocia con un menor riesgo de mortalidad[16,20].

Sin embargo, un estudio reciente de Dos Santos[21] informó que los pacientes que recibieron proteína de suero de leche tuvieron reducciones significativas en el porcentaje de grasa corporal y grasa corporal total, lo cual podría ser más beneficioso en pacientes con sobrepeso y obesidad. Sería importante especificar el compartimento corporal que evidenció el aumento con este suplemento en futuras investigaciones, como lo han reportado otros estudios.

En la evaluación de medidas corporales, otro resultado relevante de nuestro estudio, es el aumento de la CB en ambos grupos, ya que, la masa muscular estimada mediante este método, se asocia de manera inversa con la mortalidad global de pacientes con ICC[22]. Sin embargo, se obtuvo un nivel de efecto mayor en el grupo con desnutrición (+ 0.71 cm), similar al reportado por Zhou[18]. Otros estudios reportan aumento de CB en pacientes suplementados, pero sin ser estadísticamente significativos[23].

En nuestros hallazgos bioquímicos, resalta el aumento de la albúmina en 0.56 g/dl, en ambos grupos tras las 2 semanas de intervención. Este resultado es comparable a lo reportado por Zhou[18] que, a través de la administración de 500ml de una formula enteral hipercalórica e hiperproteica, la albumina sérica aumentó en 0.52 g/dl en un mes y 0.55 g/dl en 3 meses de suplementación. De igual manera, en un estudio preliminar de Uchino[24] se reportó el aumento de albumina en 0,44 g/dl, durante 28 días con la suplementación de aminoácidos esenciales (L-valina, L-leucina y L-isoleucina) en pacientes con albuminemia.

Todos los estudios con aumento significativo de albúmina, sugieren distintas formas de suplemento, a base solo de aminoácidos esenciales o suplementos hiperproteicos e hipercalóricos, sin embargo, el mayor aumento, solo en 2 semanas se evidenció en nuestro estudio, pudiendo sugerirse que este cambio se da por el tipo de suplemento utilizado. En nuestro caso, un suplemento hiperproteico a base de proteína de suero de leche que contiene todos los aminoácidos esenciales y algunos condicionalmente esenciales en cantidades moderadas, fundamental en la mejora del paciente con desnutrición, puesto que la proteína de alto valor biológico, estimula eficazmente la síntesis de fracciones de proteínas miofibrilares y sarcoplásmicas en el músculo aún en condiciones de reposo, como la experimentada por los pacientes hospitalizados[25].

La hemoglobina que también evidenció un aumento significativo en ambos grupos, se considera relevante, ya que sugiere una mejora del estado funcional en pacientes con ICC; sin embargo, puede haber un mayor número de complicaciones cardiovasculares en los pacientes con anemia[26].

Así también, a través de los años, se ha observado un aumento de la prevalencia de enfermedades crónicas asociadas en pacientes con ICC, influyendo en la complicación de la enfermedad. A partir de ahí nace la relevancia de identificarlos por ser subgrupos más vulnerables y con peor pronóstico[27]. Por ese motivo, buscamos determinar si la presencia de antecedentes médicos más comunes encontrados (Hipertensión, Diabetes Mellitus y otros) influyeron sobre el efecto de la suplementación; encontrando que el peso corporal aumentó significativamente en los diferentes antecedentes médicos del grupo con desnutrición, al igual que la albumina, cuyo aumento también se hizo presente en el grupo sin desnutrición con excepción en la diabetes; sin embargo, en relación a otras investigaciones solo se ha mencionado la cantidad de pacientes con determinados antecedentes, siendo el mayor porcentaje: de pacientes hipertensos, con dislipidemia, hipercolesterolemia, y en menor cantidad diabéticos[18,21]. Asimismo, el presente estudio muestra que los parámetros bioquímicos como la glucosa y colesterol, disminuyeron significativamente tras el consumo del suplemento, y que los valores de sodio, urea y creatina no mostraron cambios significativos después de las dos semanas de intervención en ambos grupos. De este modo el presente estudio, proporciona una nueva perspectiva en la que los pacientes con una comorbilidad específica y añadida a la ICC, interfiere en el efecto de la suplementación, tanto en el aumento del peso, CB, albumina y hemoglobina.

Por último, en pacientes con desnutrición e hipoalbuminemia severa se evidenció un aumento significativo en la ganancia de peso (+ 1.63 kg) y CB (+1.33 cm), así como también se demostró que los indicadores bioquímicos (albumina sérica y hemoglobina) aumentaron significativamente en los pacientes con hipoalbuminemia severa, hipoalbuminemia moderada y albumina normal, mejorando el estado nutricional y estancia hospitalaria. Estos resultados son de gran importancia, ya que la hipoalbuminemia es una condición frecuente en pacientes con insuficiencia cardíaca congestiva (ICC) y su presencia se ha relacionado con un aumento significativo en la mortalidad intrahospitalaria[28]. Asimismo, en pacientes pediátricos con deficiencia de hierro, el consumo del complemento alimentario Nutrihem, normalizó los niveles de hemoglobina, en el 75% de niños menores de dos años con diagnóstico de anemia leve o moderada, durante tres meses de intervención[29].

Este es el primer estudio en nuestro medio que analiza la repercusión y el impacto clínico que genera una intervención nutricional oportuna en los pacientes con ICC, para prevenir las complicaciones propias de la enfermedad y mejorar el estado nutricional.

Dentro de las limitaciones que tuvo nuestra investigación, fue la falta de un grupo control, lo cual hubiera ayudado a poder descartar cualquier respuesta o factor no controlado como el efecto Hawthorne, el efecto placebo, la regresión a la media y el no control de la evolución natural de la enfermedad. La segunda limitación identificada es en relación al tiempo de intervención (2 semanas), por lo cual, no podremos generalizar los resultados con tiempos de intervención más prolongados.

CONCLUSIÓN

La terapia nutricional mejoró el estado nutricional y los niveles de albúmina en pacientes desnutridos con ICC, asimismo la presencia de antecedentes patológicos influye significativamente. La inclusión de un suplemento nutricional oral hiperproteico tiene un impacto positivo en la mejora del estado nutricional de los pacientes que padecen insufi-

ciencia cardiaca congestiva, ya sea que presenten desnutrición o no.

En el caso de los pacientes con desnutrición, esta mejora se traduce en un aumento significativo en el peso corporal, la circunferencia braquial, los niveles de albúmina y hemoglobina, además de una reducción en ciertos parámetros hematológicos y bioquímicos como la creatina, el colesterol y la glucosa. La presencia de antecedentes médicos, el nivel de albúmina sérica y el IMC desempeñaron un papel crucial sobre los efectos y los resultados obtenidos a través de la suplementación nutricional oral hiperproteica.

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Nephroprotective effect of *Opuntia ficus indica* purple variety fruit juice in rats induced to renal damage by gentamicin

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ABSTRACT

Introduction: Chronic Kidney Disease (CKD) has become a silent epidemic affecting about 10% of the world's population, the discovery of new protective functional foods is important to hinder the development of this disease.

Objective: Evaluate the nephroprotective effect of fruit juice of *Opuntia ficus indica* purple variety in rats induced by renal damage by gentamicin.

Methods: 32 male Holtzman rats were involved in the experiment; we used the fruit juice of *Opuntia ficus indica* purple variety to test its nephroprotective properties. The rats were randomized into four groups (n = 8). Which were treated orally for 27 days with the following: Group I and II-1 ml / kg of physiological serum; Group III-20 ml / kg of *Opuntia ficus indica* juice (OJ); Group IV-40 ml / kg of *OJ*. From day 21, Group II to IV received intramuscular gentamicin at a dose of 50 mg/kg for 7 days.

Results: The administration of 40 ml/kg of *Opuntia ficus indica* evidenced a statistically significant decrease of serum creatinine, urea, uric acid and urine proteins, histologically, we observed a conserved structure at the level of the glomerulus, capsule of Bowman and a slight desquamation of the level of the proximal and distal tubules.

Conclusion: The juice of *Opuntia ficus indica* purple variety at a dose of 40 ml / kg exerted a nephroprotective effect in the renal tissue with the improvement of the biochemical parameters and the histological study.

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KEYWORDS

Medicinal plant; *Opuntia ficus indica*; Gentamycin; Prickly Pear; Nephroprotection.

ABBREVIATIONS

CKD: Chronic kidney disease.

AKI: Acute kidney injury.

OJ: Opuntia juice.

OSS: Oral saline solution.

ISS: Intramuscular saline injection.

AA: Ascorbic acid.

NAG: N-Acetyl-/β-glucosaminidase.

NF-κβ: Nuclear factor kappa beta.

TNF-α: Tumoral necrosis factor alpha.

INTRODUCTION

Chronic kidney disease (CKD) has become a silent epidemic affecting more than 10% of the global population. This prevalence, similar to that of other chronic diseases, presents a significant challenge for public health due to the high treatment costs in the terminal stages of the disease, the increased frequency of complications, and the higher risk of cardiovascular diseases[1].

CKD and its principal risk factors, such as diabetes and hypertension[2], have shown a sustained increase in prevalence and incidence, becoming critical public health issues both locally and globally[3]. Many of these risk factors have a nutritional origin, closely related to excessive consumption of sugars, fats, cholesterol, alcohol, sodium, and a limited

intake of fruits and vegetables, compounded by sedentary lifestyles[4].

Other diseases, such as acute kidney injury (AKI), significantly increase the hazard of developing CKD (5–7). One of the contributing factors to AKI is antibiotics, which are estimated to cause 60% of AKI cases in hospitalized patients[8].

Diet plays a fundamental role in the treatment of CKD, not only as a protective measure in its various stages but also to avoid the dangers of overweight, which can further complicate the progression of the disease. The kidneys, with their multiple functions in maintaining body homeostasis, assume a vital role in this context, regulating the excretion of metabolic waste products, fluid balance, electrolyte composition, and blood pressure[9].

The discovery of functional foods with nephroprotective properties holds great importance as a preventive measure in public health. Previous studies have found evidence that *Opuntia ficus* indica extract exerts nephroprotective properties; however, its effect at lower doses in more common forms of consumption, such as juices, in the prevention of antibiotic-induced kidney damage has not been studied. The aim of this study is to determine the nephroprotective effect of *Opuntia ficus indica* juice in rats with gentamicin-induced kidney damage.

METHODS

The study has a pure experimental design, with a control group and post-test. The acquisition of the purple variety of *Opuntia ficus indica* fruit was carried out at the Wholesale Fruit Market located in the San Luis district, sourced from the Ayacucho region. The fruits were selected intact, fresh, without bruises or browning, then packed in cloth bags and boxes for transport to the laboratory. The Opuntia juice (OJ) was obtained daily, after disinfecting and peeling to extract the edible part of the fruit (mesocarp) and using an extractor Oster® to obtain the fruit juice. The juice was placed in an amber bottle for protection from light.

The sample size calculation was based on a previous study[10]. We used the necessary sample size to observe a 12.1% decrease in creatinine levels between the experimental group and the control group after treatment, considering a 15% increase for possible skewness and a 20% attrition rate. Using the KISS approach, we estimated a sample size of eight rats per group.

Evaluation of the nephroprotective effect: Male Holtzman *Rattus norvegicus* rats, three months old, weighing between 200-220 g, were used. They were acquired from the National Agrarian University - La Molina (Lima, Peru) and acclimated for one week at an average temperature of 22 ºC, with alternating 12-hour light and dark cycles, balanced diet, and water ad libitum.

The Welwood technique with modifications was applied to induce nephrotoxicity[11]. The animals were randomly divided into four groups (n=8), receiving the following treatments via orogastric administration for 27 days:

- Group I: physiological saline (0.9% NaCl) 10 mL/kg
- Group II: physiological saline (0.9% NaCl) 10 mL/kg
- Group III: Opuntia juice 20 mL/kg
- Group IV: Opuntia juice 40 mL/kg

From day 21 to day 27, groups II-IV received 50 mg/kg of gentamicin - Gentacar® (G) via intramuscular injection, while group I received 50 mg/kg of 0.9% NaCl via the same route. At the end of the experimental treatment (day 27), the rats fasted for 24 hours with water ad libitum and were placed in individual metabolic cages for urine collection over 24 hours. They were then anesthetized with diethyl ether vapor for blood extraction by cardiac puncture and subsequently given a lethal dose of pentobarbital. Cervical dislocation was then performed to proceed with bilateral nephrectomy, where both kidneys were removed from the abdominal cavity, washed with 0.9% NaCl, and preserved in 10% buffered formaldehyde solution for histological study.

The urine volume was measured using a graduated cylinder, then centrifuged at 2000 rpm for 5 minutes. The determination of protein was done using the Lowry method, a colorimetric technique based on the reaction of urinary proteins with Na2CO3, NaOH, CuSO4, tartrate, and the Folin-Ciocalteu reagent, measuring the color intensity at 580 nm[12].

Serum uric acid levels were determined using the Searcy method with Tietz modifications, employing reagents such as 4-Aminoantipyrine, 3-5-dichloro-2-hydroxybenzenesulfonic acid (DCHBS), uricase, and peroxidase. The final reaction was read at 505 nm[13,14].

Serum urea was determined by the Faucet and Scott method, where urea is enzymatically decomposed in an alkaline environment, forming a green complex measured at 600 nm[15].

Serum creatinine quantification was evaluated through a reaction with alkaline picrate, forming a chromogen measured at 510 nm[16]. All the reagents used for uric acid, urea and creatinine quantification were obtained from Wiener Lab.

The histopathological analysis of kidney tissue was conducted at the Institute of Pathology of the National University of San Marcos located at the National Archbishop Loayza Hospital. The analysis of the histological sections was performed by Dr. José Ernesto Raez Gonzales, a pathologist at the Institute. Indicators considered for evaluation included aspects of histological structure, luminal spaces, glomeruli, Bowman's capsule, and renal tubules.

Statistical analysis: For indicators that met the assumptions of normality of residuals and homoscedasticity, we used

mean ± standard deviation. For log-normal residuals with homoscedasticity, we used the geometric mean with 95% confidence intervals. Statistical analysis was conducted using R 4.2.2. To determine the distribution of the residuals, we applied the Q-Q plot and Shapiro-Wilk normality test. The ANOVA test was used to compare the means of the groups, and the Dunnett test was employed as a post hoc test to evaluate intergroup differences. A value of $p<0.05$ was considered to indicate a statistically significant difference.

Ethical approval: This study was approved by the Ethics and Research Committee of the Professional School of Nutrition at the National University of San Marcos (RD N°0034-D-FM-2015). Ethical standards and procedures were followed in accordance with Peruvian Law N° 30407, the Animal Protection and Welfare Law[17].

Table 2. Protein excretion in urine samples according to treatment group

Treatment groups	Protein §	24 h protein excretion *
	(mg/mL)	(mg/dL)
Group I OSS + ISS	8.25 (6.33–10.77) [a]	103.95 ± 54.35[a]
Group II SS + G	13.38 (11.54–15.51)	291.13 ± 66.08
Group III OJ 20 mL/kg + G	9.28 (8.08–10.66) [a]	169.38 ± 34.22[a]
Group IV OJ 40 mL/kg + G	9.34 (8.51–10.26) [a]	95.93 ± 20.13[a]

OSS: Oral saline solution (NaCl 0.9%), ISS: Intramuscular saline solution, OJ: Opuntia juice, G: Gentamicin.
§ Geometric mean (95% Confidence intervals).
* Mean ± standard deviation.
(a) $p<0.01$ compared to group II – ANOVA, Post hoc Dunnet test.

RESULTS

The administration of 50 mg/kg of gentamicin in Group II resulted in a notable increase in creatinine, uric acid, and urea levels compared to Group I (Table 1). The OJ at 20 mL/kg (Group III) did not show a significant impact on creatinine and urea levels compared to Group II (Table 1). However, uric acid (Table 1), protein levels and 24-hour protein excretion were significantly reduced ($p<0.01$) (Table 2). In contrast, when OJ was administered at 40 mL/kg (Group IV), there was a significant decrease in creatinine, uric acid, urea, protein levels, and 24-hour protein excretion compared to Group II ($p<0.01$) (Table 1 and 2).

Histopathology findings showed preserved nephron structure in OJ+G groups **(Figure 1C-D)** compared with gentamicin-only group **(Figure 1B)**, showing glomeruli, Bowman's space and capsule in preserved state similar to control group **(Figure 1A)**.

DISCUSSION

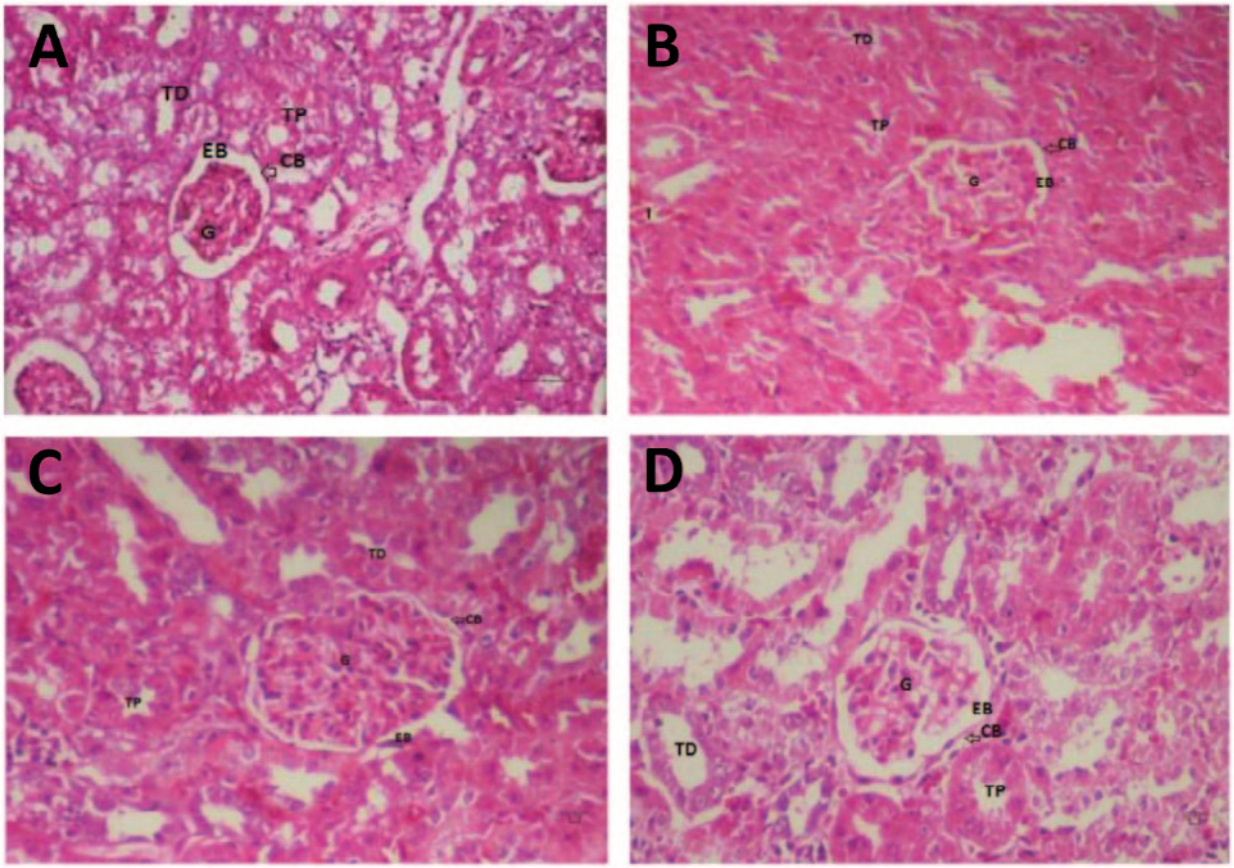
Our results indicate that a natural formulation of *Opuntia* fruit (juice) exhibits nephroprotective properties by preserving the cytoarchitecture of the nephron and reducing markers of kidney damage, including creatinine, uric acid, urea, and protein excretion.

The results can be explained considering the effects of the phytochemicals found in *Opuntia*, this include quercetin, isorhamnetin, kaempferol and luteolin, vitamins such as ascorbic acid (AA) and tocopherols are also found in high quantities in OJ. Quercetin has shown to be an inhibitor of both 15-lipoxygenase-1[18] and cyclooxygenase activity[19], which are mediators in renal ischemia mechanism of injury[20,21].

Table 1. Biochemical analysis of blood samples according to treatment group

Treatment groups	Creatinine *	Uric acid *	Urea §
	(mg/dL)	(mg/dL)	(mg/dL)
Group I OSS + ISS	11.9 ± 0.9 [a]	0.77 ± 0.10 [a]	32.6 (29.6–36.0) [a]
Group II SS + G	13.7 ± 0.9	1.11 ± 0.15	56.3 (51.0–62.2)
Group III OJ 20 mL/kg + G	12.9 ± 1.0	0.83 ± 0.15 [a]	53.4 (45.1–63.2)
Group IV OJ 40 mL/kg + G	10.8 ± 0.9 [a]	0.37 ± 0.13 [a]	33.3 (29.1–38.2) [a]

OSS: Oral saline solution (NaCl 0.9%), ISS: Intramuscular saline solution, OJ: Opuntia juice, G: Gentamicin.
§ Geometric mean (95% Confidence intervals).
* Mean ± standard deviation.
(a) $p<0.01$ compared to group II – ANOVA, Post hoc Dunnet.



(A) Group I shows glomeruli (G) in normal conditions, Bowman's capsule (CB) preserved, distal tubules (TD) and proximal tubules (TP) without desquamation. **(B)** Group II shows congested glomeruli (G), damaged Bowman's capsule (CB), reduced Bowman's space (EB), proximal tubules (TP) and distal tubules (TD) with pronounced desquamation, luminal space obstruction and infiltration (I). **(C)** Group III shows glomerular congestion (G), reduction of Bowman's space (EB); proximal tubules (TP) and distal tubules (TD) with mild desquamation. **(D)** Group IV: Glomeruli (G) in normal state, normal Bowman's space (EB) without thickening of its capsule (CB) and proximal tubules (TP) and distal tubules (TD) with slight desquamation. **H-E. 20X.**

Figure 1. Photomicrographs of kidney tissue

Mechanistic evidence has shown that AA is an effective inhibitor of N-Acetyl-/β-glucosaminidase (NAG)[22], enzyme associated with tubular damage[23]. Both quercetin and AA have shown to be noticeable scavengers of reactive oxygen species (ROS)[24,25], thereby reducing oxidative stress, one of the most important components in AKI mechanisms[26]. Luteolin has also exerted protective properties in AKI by inhibition of caspase-3, downregulation of NF-κβ and TNF-α[27].

Previous findings focused on the plant extract, not the fruit, have also reported the nephroprotective effect of *Opuntia ficus indica*[10,28], Saad *et al* (2017) used a lyophilized extract at doses of 100 mg/kg on rats for 60 days before lithium-induced kidney toxicity. The authors reported only minor damages in kidney structures; serum urea and creatinine were significantly minor compared to control group[10].

Similar results were evidenced in Hfaiedh *et al* (2018) where 100 mg/kg of *Opuntia* for 40 days before sodium dichromate-induced kidney toxicity prevented tissue necrosis and biochemical alteration. Our findings are aligned with those results, showing that lower doses of *Opuntia* (40 mL/kg) can also exert protective properties in less time (27 days)[28].

The strengths of our study include the use of a common dietary formulation to assess nephroprotection, we also included histopathological findings to assess the robustness of our findings. The limitation of our study include not measuring kidney tissue antioxidant activity, having both enzymatic and non-enzymatic antioxidant profiles would have provided a more comprehensive view of nephroprotection.

CONCLUSION

The juice of *Opuntia ficus indica* purple variety at a dose of 40 ml / kg exerted a nephroprotective effect in the renal tissue with the improvement of the biochemical parameters and the histological study.

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Neuroprotective effect of *Chenopodium pallidicaule* flour (cañihuaco) suspension against ethanol toxicity in mice

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ABSTRACT

Introduction: Food plays an important role in preventing various neurodegenerative diseases. *Chenopodium pallidicaule* flour (cañihuaco) is characterized by its phytonutrients content, among them polyphenols which have the potential to exert neuroprotective properties.

Objective: To evaluate the effect of the administration of cañihuaco suspension against ethanol toxicity in mice.

Materials and methods: Experimental design. 35 male mice were used, receiving the following treatments, for five days: groups I-II water 10mL/kg, groups III-V received cañihuaco at doses of 200mg/kg, 400mg/kg and 800mg/kg respectively. On the fifth day, 99% ethanol was administered subcutaneously, 5g/kg, except for group I. After four hours mice were sacrificed by decapitation. The brain and cerebellum were extracted, weighed, and stored for histological analysis. Biochemical indicators were determined in the right hemisphere.

Results: Group III and IV showed higher tissue protein levels ($p<0.05$). Groups III-V showed higher levels of protein sulfhydryl groups, with a significant increase observed in group V. There was no difference in GSH levels in any treatment group with respect to group II. At the histological level, group V showed preservation of nervous tissue.

Conclusion: The administration of *Chenopodium pallidicaule* (cañihuaco) flour suspension at doses of 200, 400, and 800 mg/kg exhibits a dose-response trend reduction of histological damage in the brain and cerebellum. Additionally, it enhances the levels of protein SH groups.

KEY WORDS

Medicinal plant; neurodegeneration; glutathione; Chenopodium; mice.

INTRODUCTION

Aging is considered a risk factor for various neurodegenerative because it promotes neuronal dysfunction. This places a greater burden on the health care system and a greater financial impact on the country, consequently, therapies aimed at delaying or preventing the onset of neurodegenerative diseases should be taken into consideration[1].

It has been seen that there is a close relationship between people's diet and cognitive impairment, in fact, it is known that a diet rich in antioxidants with a high consumption of fruits, vegetables and whole grains could reduce the prevalence of neurodegenerative diseases. It is for this reason that dietary patterns such as the Mediterranean diet have been shown to delay the progression of these diseases[2].

Neuronal cell death in neurodegenerative diseases is related to protein misfolding and aggregation, mitochondrial dysfunction, generation of reactive oxygen species and neuroinflammation. This is why research for the treatment of these pathologies has been pointing to the regulation of these pathways using a therapeutic approach[3].

In this sense, Peruvian Andean grains such as cañihua contains interesting bioactive metabolites, developed in extreme climates, enabling efficient antioxidant defense systems to survive in these environments, consequently they could be

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used to delay or prevent neurodegenerative diseases in the population at higher risk[4].

The aim of the study was to evaluate the neuroprotective effect of the administration of *Chenopodium pallidicaule* (cañihuaco) flour suspension against ethanol toxicity in mice.

MATERIALS AND METHODS

Study design: The study is pure experimental with a post-test and control group, designed with an explanatory scope. (Hernández Sampieri 2018)[5].

Sample size calculation: The sample size was calculated to get a 24.7% difference in GSH levels comparing control and intervention groups, according to previous literature addressing similar functional foods using the KISS method[6], an increase in 15% in sample was considered because previous research used non-parametric inferential tests and present skewed data[7].

Acquisition of the flour and preparation of the suspension: The flour of *Chenopodium pallidicaule* (cañihuaco) was acquired in a local supermarket in Lima - Peru, this product presented the sanitary registration number E4656217N DAPOAD - DIGESA, lot 06 ABR HA. The flour was dissolved in boiling water (100ºC) at a concentration of 8% and then allowed to stand for 30 minutes.

Evaluation of neuroprotection: male *Mus musculus* mice of the BALB/c strain with weights between 30.7 ± 1.9 g of three months of age were used in the study, these mice were obtained from the National Institute of Health (INS). The animals were acclimatized in the biotherium of the Faculty of Medicine of San Fernando, fed a balanced diet provided by the National Agrarian University of La Molina (UNALM) and had ad libitum water consumption for seven days, respecting the photoperiods.

The experimental animals were randomly distributed into five groups (n=7) which received the treatment via orogastric for five days after fasting.

- Group I: (Negative Control), Water 10 mL/kg
- Group II: (Positive Control), Water 10 mL/kg
- Group III (Experimental 1): Dose 200 mg/kg, *Chenopodium pallidicaule* (cañihuaco) flour suspension.
- Group IV (Experimental 2): Dose 400 mg/kg, *Chenopodium pallidicaule* (cañihuaco) flour suspension.
- Group V (Experimental 3): Dose 800 mg/kg, *Chenopodium pallidicaule* (cañihuaco) flour suspension.

On the final day (5th day), immediately after the last treatment, ethanol at a concentration of 5 g/kg was administered subcutaneously Tahir Ali (6) to groups II-VI, and after four hours the animals were sacrificed by decapitation, and then the brain was removed, washed with NaCl 0.9% and weighed on an analytical balance. The left hemisphere was preserved in 10% buffered formalin (phosphate buffer 0.075 mol/L pH 7.4) for the corresponding histological analysis, and the right hemisphere was used for biochemical tests.

Histological description

For the histological study, the tissues were fixed in kerosene by a medical technology professional and then stained with hematoxylin-eosin. The slides were read by a pathologist of the Institute of Legal Medicine and Forensic Science. The analysis took into account the state of the cerebral and cerebellar cortex, level of edema in glial cells, pyramidal cells and in the perivascular zone, distribution of Purkinje cells per field with or without edema, as well as the presence and degree of eosinophilia in nervous tissue[7].

Determination of Biochemical Indicators

Preparation of the homogenate: The previously weighed right hemisphere was homogenized with phosphate buffer 0.01 mol/L pH 7.4 in a ratio of 1:10, then centrifuged at 3000 rpm for 5 minutes to obtain the supernatant of the homogenate, which was used for biochemical evaluation.

Determination of GSH: The method of Lindsay and Sedlak (1968) with Béjar (2016) modifications was performed[8], a deproteinized sample was prepared with 950 µL of supernatant and 50 µL of 100% TCA, then centrifuged at 13 000 rpm for 5 minutes. From the supernatant obtained, 300 µL were mixed with 1.5 mL of phosphate buffer pH 6.8 0.5 mol/L. Ascorbic acid and glyoxylic acid were used in a 2:1 ratio for the detection of total GSH, these samples were placed in a water bath at 67°C for 5 minutes, then allowed to cool and 0.3 mL of DTNB (5,5'-Dithiobis 2-nitrobenzoic acid) in 0.5 mol/L phosphate buffer was added at a concentration of 1.5 mg/mL. Readings were taken at 412 nm[9].

Determination of protein levels and protein sulfhydryl groups: The amount of protein was quantified following Lowry's technique (1951)[9]. The method of Lindsay and Sedlak (1968) was used to measure the total sulfhydryl groups (SH)[10] with modifications from Suarez (2014)[11], for this purpose 0.1 mL of the homogenate supernatant was diluted and combined with 900 µL of buffer pH 7.4 mol/L and placed in a water bath at 37°C for 5 minutes, subsequently DNTB was added continuing with the steps outlined in the GSH protocol, these samples were read at 412 nm. To get the protein sulfhydryl groups the total SH groups were subtracted with the non-protein sulfhydryl groups (GSH).

Statistical Analysis

To evaluate the distribution of the results, the evaluation was based on histograms, the Skewness test, kurtosis and the

Shapiro-Wilk normality test (n<50), followed by an ANOVA test to determine if there was a difference between the means of the groups, Levene's test for homogeneity of variances and Dunnet's post hoc test for those variables that showed symmetry. For asymmetric variables, the Kruskal-Wallis test and Mann Whitney U test with Holm's correction for multiple comparisons were used. A p value < 0.05 was considered. The data were entered in Microsoft Excel 2019 and then exported to the R Studio program.

Ethical Considerations

This protocol was approved by the Ethics and Research Committee of the Nutrition Department of the Universidad Nacional Mayor de San Marcos (RD N°000392-2024-D-FM/UNMSM). The reduction and refinement of the 3Rs of Rusell and Burch (1959) were taken into account[12]. To minimize the number of animals used in control groups, our research was conducted concurrently with another project of our research group using the same ethanol-induced damage methodology[13]. In addition, the Peruvian animal protection and safety law 30407 of 2016 was also considered[14].

RESULTS

Protein levels in brain tissue in the groups III and IV (received cañihuaco) were higher compared to group II (p<0.01) **(Table 1)**. The protein sulfhydryl levels in the groups receiving various doses of cañihuaco exhibited a gradual increase; in group V, this increase was significant compared to group II (p=0.01) **(Table 1)**.

With respect to GSH levels, all the groups treated with cañihuaco (III-V) showed a tendency to increase GSH and the GSH/GSSG ratio; however, no significant differences were observed compared to group II **(Table 2)**.

Table 1. Levels of proteins and protein sulfhydryl groups in brain tissue according to treatment group

Treatment groups	Protein* (mg/g tissue) Mean ± SD	Protein SH** (µmol/mg protein) Median (IQR)
Group I: Water + NaCl	60.4 ± 4.30	2.69 (2.11-3.40)
Group II: Water + ethanol	55.7 ± 5.68	3.00 (2.70-3.21)
Group III: Cañihuaco 200 mg/kg + ethanol	72.0 ± 6.56 (a)	2.60 (2.51-2.78)
Group IV: Cañihuaco 400 mg/kg + ethanol	67.1 ± 4.32 (b)	2.98 (2.54-3.35)
Group V: Cañihuaco 800 mg/kg + ethanol	60.9 ± 4.56	4.25 (3.90-4.48) (b)

* Skewness=0.36, Levene (p>0.05), ANOVA (p<0.01), Post hoc Dunnet.
** Skewness=0.51, Levene (p>0.05) Kruskal-Wallis (p=0.01), U de Mann-Whitney with Holm-Bonferroni correction.
(a) p < 0.01 compared to group II.
(b) p =0.01 compared to group II.

Table 2. GSH, total GSH and GSH/GSSG levels according to treatment group

Treatment groups	GSH (nmol/mg prot)** Median (IQR)	GSH total (nmol/ mg prot)* Mean ± SD	GSH/GSSG** Median (IQR)
Group I: Water + NaCl	83.6 (76.2-109)	278 ± 64.5	0.64 (0.47- 0.79) (b)
Group II: Water + ethanol	68.9 (60.5-80.0)	303 ± 33.5	0.31 (0.25-0.33)
Group III: Cañihuaco 200 mg/kg + ethanol	33.9 (30.1-35.4) (a)	197 ± 21.3 (a)	0.20 (0.19-0.20)
Group IV: Cañihuaco 400 mg/kg + ethanol	41.0 (35.8-53.6)	224 ± 32.4	0.23 (0.20-0.27)
Group V: Cañihuaco 800 mg/kg + ethanol	61.0 (59.9-78.7)	260 ± 16.6	0.31 (0.30-0.41)

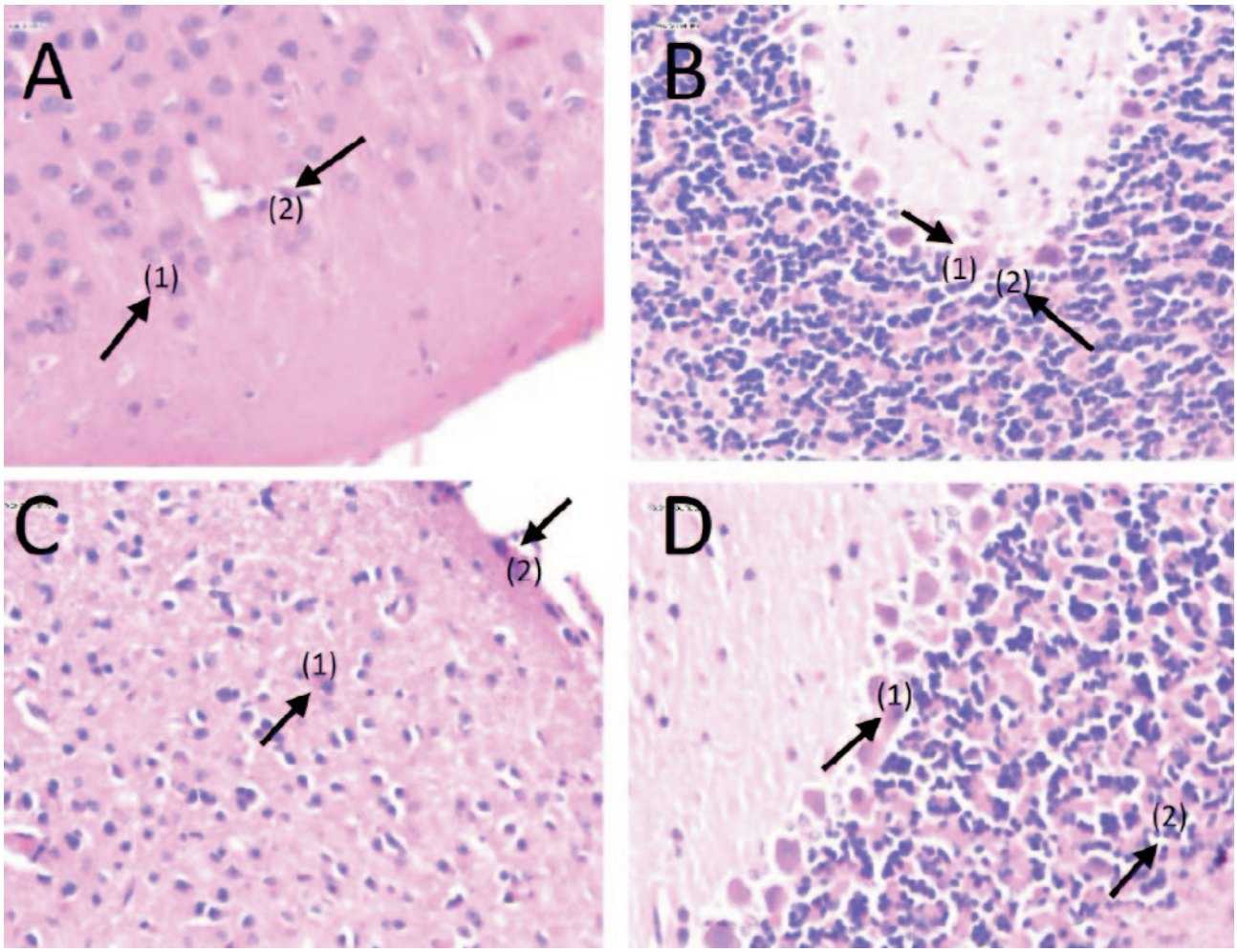
* Skewness=0.24, Levene (p>0.05), ANOVA (p<0.01), Post hoc Dunnet.
** Skewness=1.4 – Kruskal Wallis (p<0.05), Mann-Whitney U test with Holm-Bonferroni correction.
(a) p < 0.01 compared to group II.
(b) p < 0.05 compared to group II.

In the histological section, in group I (received water + NaCl) there was no alteration neither in the brain nor in cerebellum tissue. In group II (received ethanol) there was mononuclear inflammation in the perivascular zone, an increase of glial cells, edema in neuronal cells, eosinophilia, nuclear pyknosis and disruption of the cytoplasm around the nucleus. In the cerebellum, cytoplasmic retraction was observed in the molecular layer and eosinophilia in the Purkinje layer.

In the brain tissue of group III, congestive vessels, hypercellularity, cytoplasmic eosinophilia and few glia were observed. Regarding the cerebellum, slightly congestive blood vessels, scarce lymphocytes, and eosinophilia in some Purkinje cells, with double and triple row distribution were observed. Finally, there was marked hypercellularity in the granular layer.

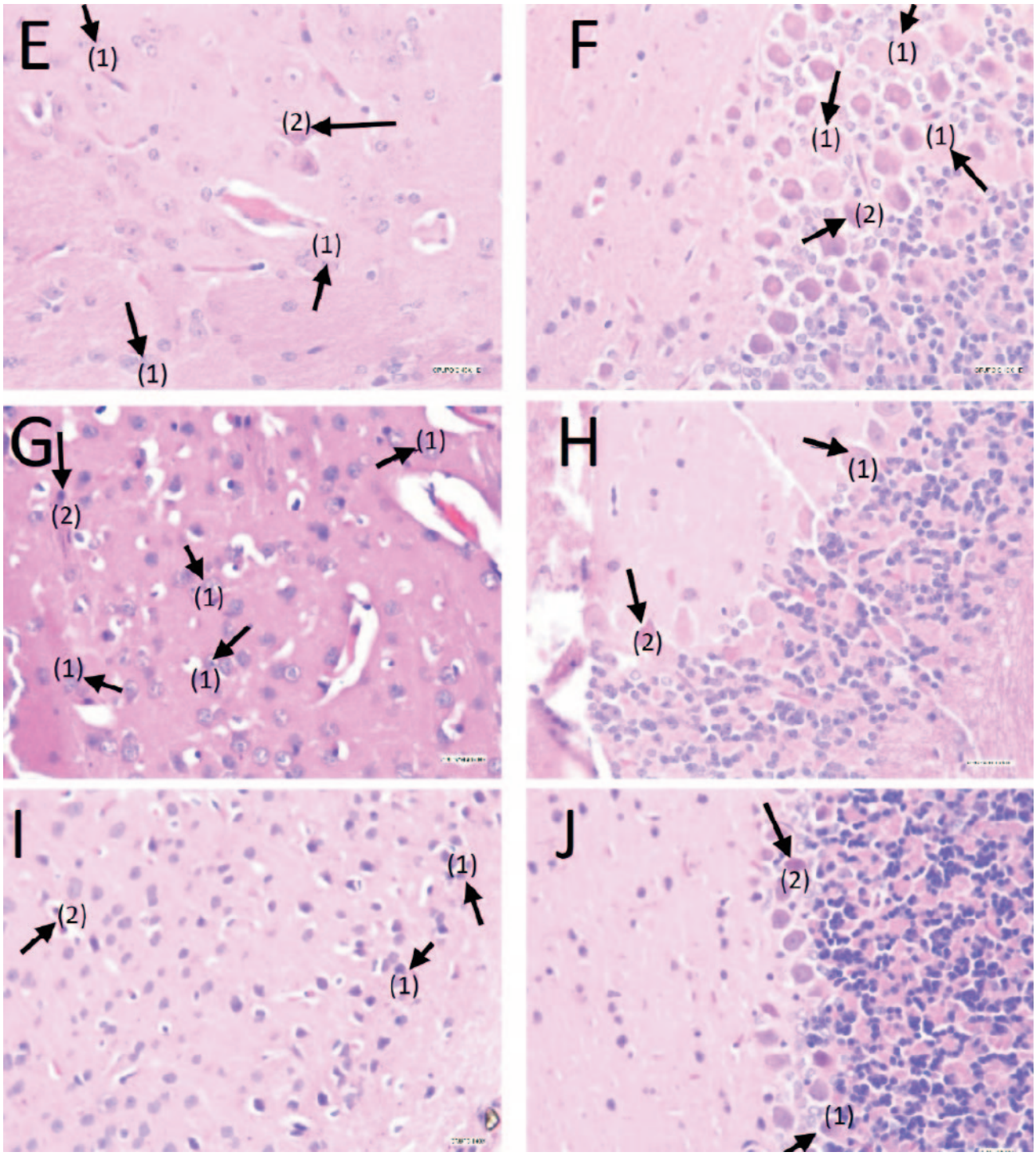
Group IV showed in the brain tissue lymphocytes distributed at the level of the ventricular and perivascular space, some cells with back-to-back distribution with hypercellularity and eosinophilia. The cerebellum showed vascular congestion in the subarachnoid space and diffuse cellular changes in several layers, as well as eosinophilia in the Purkinje layer and scarce cellularity in the medullary layer.

In group V brain, the subarachnoid space showed well distributed vessels and little eosinophilia. The medullary layer



In brain tissue of group I **(A)** cellularity was adequately distributed **(1)** and there was no visible alteration of blood brain barrier **(2)**, in cerebellum tissue Of group I **(B)** Purkinje cells **(1)** and molecular layer **(2)** without alteration. In brain tissue of group II **(C)** there was notable eosinophilia of neuronal cells **(1)** and vascular congestion in the subarachnoid space **(2)**. The cerebellum tissue of group II **(D)** showed cytoplasm with eosinophilia in Purkinje cells **(1)** and cellular edema **(2)**.

Figure 1. Hematoxylin-eosin **(HE)** 40X staining of brain **(A, C)** and cerebellum tissue **(B, D)** in control groups



In brain tissue of group III **(E)** hypercellularity **(1)** and eosinophilia of the neuronal cell **(2)** is appreciated. In cerebellum tissue of group III **(B)** there is an of Purkinje cells per field **(1)** eosinophilia in 50% in Purkinje cells **(2)**. In brain tissue of group IV *back-to-back* organization of cells **(1)** and cytoplasmic eosinophilia of neuronal cells **(2)** is shown. In cerebellum of group IV (H) 90% of hypercellularity is observed **(1)** and eosinophilia in Purkinje cells **(2)**. In brain tissue of group V, hypercellularity and scarce diffuse eosinophilia **(1)** is observed as well as slight vascular congestion of the blood-brain barrier **(2)**. In cerebellum, Purkinje cells organized in bilayer rows **(1)** with slight eosinophilia in few Purkinje cells **(2)**.

Figure 2. Hematoxylin-eosin (HE) 40X staining of brain (G, I) and cerebellum tissue (H, J) in treatment groups

had uniform thickness and slightly congestive vessels in all layers. In the cerebellum, the molecular layer presented hypocellularity, the Purkinje layer presented bilayer cells, with scarce eosinophilic cells and the medullary layer showed variable thickness with slightly congestive capillaries.

DISCUSSION

Our findings showed that cañihuaco administration exerted brain and cerebellum tissue protection against ethanol-induced damage. The various bioactive compounds present in cañihuaco could be related to the observed results. It has been shown that quercetin, in synergy with other nutraceutical substances such as kaempferol, induces crucial pathways to counteract oxidative stress, one of them is the Nrf2-ARE pathway as it prevents its ubiquitination and promotes its binding to DNA improving Nrf2 transcription, this pathway causes the expression of gamma glutamyl cysteine synthetase generating GSH available to prevent cell damage[15]. The observed phenomena may be linked to the elevated levels of glutathione (GSH) and the dose-response ratio of GSH to oxidized glutathione (GSSG) in the groups subjected to cañihuaco (III-V), with the highest dosage group exhibiting a more pronounced increase.

The escalating levels of protein sulfhydryl (SH) groups in cañihuaco-treated groups (III-V), correlating with increasing doses, can be attributed to the presence of quercetin in cañihua. Quercetin induces the expression of glutaredoxin, an enzyme essential for the glutathionylation process. This process involves the utilization of glutathione (GSH) to reduce oxidized protein SH groups, yielding oxidized glutathione and rejuvenated protein SH groups. The observed dose-response trend augmentation in protein SH groups suggests a direct relationship with the quercetin content, emphasizing the role of quercetin-induced glutaredoxin in enhancing the reduction of oxidized protein SH groups.

The observed reduction in tissue protein levels with increasing doses in the experimental groups (III-V) is likely attributable to the neuroprotective influence of quercetin. This effect is linked to the heightened expression of AMP-activated protein kinase (AMPK) at the neuronal level[17], AMPK, in turn, exerts a multifaceted impact by diminishing the generation of reactive oxygen species (ROS) through the inhibition of NADPH oxidase, nitric oxide synthase, and xanthine oxidase[18], Additionally, AMPK promotes the inactivation of TORC1 and directly phosphorylates ULK1 (Unc-51-like autophagy-activating kinase), thereby activating autophagy[19].

The preservation of nervous tissue in the cañihuaco-treated groups (III-V) may be attributed to the presence of ferulic acid in cañihua. Ferulic acid has demonstrated the ability to reduce microglial activation, as evidenced by decreased levels of IL-1β, IL-6, and TNF-α, thereby mitigating the inflammatory cascade associated with NF-κB signaling[20]. Another compound implicated in the neuroprotective effects is kaempferol, which inhibits the activation of toll-like receptor 4 (TLR4), NF-κB, and p38MAPK (p38 mitogen-activated protein kinases), consequently suppressing the activation of microglial cells involved in neuroinflammation[21].

Furthermore, other compounds present in cañihua, such as vanillic acid, likely play a role in the regulation of neuroinflammation by inhibiting the expression of JNK (c-Jun N-terminal kinases), a pathway known to activate NF-κB. Consequently, vanillic acid suppresses inflammatory mediators, including TNF-α, IL-1β, and NOS-2 (nitric oxide synthase 2) in the cortex and hippocampus[22]. Additionally, cañihua contains linolenic acid, which may contribute to the preservation of nervous tissue in the treated groups (IV-VI). Linolenic acid is known to favor the expression of Bcl-xL proteins, a part of the Bcl-2 protein family responsible for preventing apoptosis by inhibiting the expression of caspase 3[23]. This dual action on inflammatory pathways and anti-apoptotic mechanisms could explain the observed low inflammatory component and the preservation of nervous tissue in the cañihuaco-treated groups.

Within the encountered limitations, it's important to acknowledge that the orogastric route may not represent a typical form of consumption when extrapolated to a more natural setting. Furthermore, the omission of other pertinent biochemical indicators of ethanol metabolism, such as catalase (CAT), limits our ability to fully elucidate the underlying mechanisms involved. Additionally, the study's design restricts its extrapolation to humans. Nevertheless, despite these constraints, the present study lays the groundwork for future research in this domain, offering valuable insights that can inform and guide subsequent investigations.

CONCLUSION

In the face of ethanol-induced aggression, the administration of *Chenopodium pallidicaule* (cañihuaco) flour suspension at doses of 200, 400, and 800 mg/kg exhibits a dose-response trend reduction in histological damage in the brain and cerebellum. Additionally, it enhances the levels of protein SH groups, suggesting a potential neuroprotective effects.

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Desarrollo de mermelada de flor de Jamaica (*Hibiscus sabdariffa*) en diferentes estados (natural y deshidratada)

Development of Jamaica flower (*Hibiscus sabdariffa*) jam in different states (natural and dehydrated)

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RESUMEN

Introducción: *Hibiscus sabdariffa* es una planta con múltiples aplicaciones culinarias y medicinales debido a sus propiedades antioxidantes, vitaminas, minerales y compuestos fitoquímicos como antocianinas y flavonoides.

Objetivo: Desarrollar una mermelada de flor de Jamaica (*Hibiscus sabdariffa*) en diferentes estados (natural y deshidratada).

Materiales y métodos: Se utilizó un diseño experimental completamente al azar con un arreglo factorial A*B, donde el factor A fueron las concentraciones de flor de Jamaica (35%; 50% y 70%) y factor B corresponde a los métodos de procesamiento (estado natural y deshidratada). Para determinar diferencia significativa entre la media de los tratamientos se empleó una prueba de rangos múltiples de Tukey ($p<0,05$).

Resultados: Las diversas concentraciones de flor de Jamaica y los métodos de procesamiento tienen una influencia significativa ($p<0,05$) en las características fisicoquímicas de la mermelada, determinando valores de pH entre 2,70 y 4,00, acidez de 0,40% a 0,83%, humedad de 14,00% a 31,67%, ceniza de 0,20% a 0,70% y °Brix que oscilaron entre 15,23% y 64,30%. En cuanto al contenido de polifenoles totales, se observó que los tratamientos con flor de Jamaica en estado natural (196,26 - 215,98 mg eq. Ácido gálico/100g) mostraron un efecto significativo ($p<0,05$) en comparación con los elaborados con flor de Jamaica deshidratada, que presentaron valores más bajos (113,30 - 123,90 mg eq. Ácido gálico/100g). Asimismo, se evidenció una capacidad antioxidante con valores entre 13,60 mg mL^{-1} y 14,22 mg mL^{-1}. En la caracterización sensorial, la mermelada elaborada con 50% de flor de Jamaica en estado natural (T3) recibió valoraciones significativamente superiores ($p<0,05$) en las categorías de sabor (4,37), textura (4,13) y aceptabilidad (4,63).

Conclusión: La flor de Jamaica en estado natural mejora significativamente las propiedades fisicoquímicas, polifenólica y la capacidad antioxidante de la mermelada. Además, ofrece un perfil sensorial más agradable, intensificando las categorías de olor, sabor, textura y aceptabilidad.

PALABRAS CLAVE

Antioxidantes, calidad sensorial, cálices, métodos de procesamiento, polifenoles.

ABSTRACT

Introduction: *Hibiscus sabdariffa* is a plant with multiple culinary and medicinal applications due to its antioxidant properties, vitamins, minerals and phytochemical compounds such as anthocyanins and flavonoids.

Objective: To develop a Jamaican flower (*Hibiscus sabdariffa*) jam in different states (natural and dehydrated).

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Materials and methods: A completely randomized experimental design with an A*B factorial arrangement was used, where factor A was the concentrations of hibiscus flower (35%; 50% and 70%) and factor B corresponds to the processing methods (natural and dehydrated). A Tukey's multiple range test ($p<0.05$) was used to determine the significant difference between the means of the treatments.

Results: The various concentrations of hibiscus flower and processing methods have a significant influence ($p<0.05$) on the physicochemical characteristics of the jam, determining pH values between 2.70 and 4.00, acidity from 0.40% to 0.83%, moisture from 14.00% to 31.67%, ash from 0.20% to 0.70% and °Brix that ranged from 15.23% to 64.30%. Regarding the content of total polyphenols, it was observed that the treatments with hibiscus flower in its natural state (196.26 - 215.98 mg eq. Gallic acid/100g) showed a significant effect ($p<0.05$) compared to those elaborated with dehydrated hibiscus flower, which presented lower values (113.30 - 123.90 mg eq. Gallic acid/100g). Likewise, an antioxidant capacity was evidenced with values between 13.60 mg mL^{-1} and 14.22 mg mL^{-1}. In the sensory characterization, the jam made with 50% hibiscus flower in its natural state (T3) received significantly higher values ($p<0.05$) in the categories of flavor (4.37), texture (4.13) and acceptability (4.63).

Conclusion: Natural hibiscus flower significantly improves the physicochemical, polyphenolic and antioxidant properties of the jam. In addition, it offers a more pleasant sensory profile, intensifying the categories of odor, flavor, texture and acceptability.

KEY WORDS

Antioxidants, sensory quality, calyxes, processing methods, polyphenols, polyphenols.

INTRODUCCIÓN

Hibiscus sabdariffa L, conocida comúnmente como flor de Jamaica, es una planta tropical silvestre de la familia Malvaceae[1]. Su cultivo se ha expandido ampliamente en regiones tropicales y subtropicales de todo el mundo, incluyendo países como India, Arabia Saudita, China, Malasia, Indonesia, Filipinas, Vietnam, Sudán, Egipto, Nigeria y México[1,2]. Esta planta es reconocida por diferentes nombres, tales como Bissap, Roselle y Ribena Malaysia[3]. Los cálices son ampliamente utilizados en aplicaciones cosméticas, alimentarias y medicinales. Su sabor, similar al del arándano, permite su incorporación en una variedad de productos como mermeladas, jaleas, salsas, vinos, encurtidos, especias, tés y cócteles[4].

La flor de Jamaica es valorada especialmente por sus propiedades nutricionales, destacando su alto contenido en antioxidantes, vitaminas y minerales. Entre los beneficios para la salud que se le atribuyen se encuentran propiedades bactericidas, antimicóticas, hipocolesterolémicas, diuréticas, antiinflamatorias y antihipertensivas[5]. El cultivo de Jamaica produce cálices frescos que, tras ser deshidratados, se utilizan principalmente para la preparación de bebidas frescas e infusiones[6].

Los cálices de la flor de Jamaica contienen compuestos bioactivos como ácido polifenólicos, flavonoides y antocianinas, que poseen una potente actividad antioxidante[7]. Además, su composición nutricional incluye 9,2% de humedad, 1,145% de proteínas, 2,61% de grasa, 12% de fibra, 6,90% de ceniza, 12,63 mg/100 g de calcio, 273,2 mg/100 g de fósforo, 8,98 mg/100 g de hierro, así como vitaminas como tiamina (0,117 mg/100 g), riboflavina (0,277 mg/100 g) y niacina (3,765 mg/100 g) [8]. Según Hanan et al. (2020), el color rojo intenso y el sabor ácido característicos de los cálices de Jamaica se deben a su contenido de antocianinas y ácidos orgánicos como el ácido cítrico, málico, tartárico e hibisco, los cuales también contribuyen al sabor distintivo de los productos elaborados a partir de esta planta[9].

Además de estos compuestos, la flor de Jamaica contiene otros fitoquímicos relevantes, como compuestos fenólicos, flavonoides, ácido ascórbico, beta-caroteno y polisacáridos[10]. Estas características hacen que la flor de Jamaica sea una materia prima prometedora para el desarrollo de productos alimenticios innovadores[10]. Su uso, tanto en su forma fresca como deshidratada, se ha extendido en diversas preparaciones, destacando especialmente por sus propiedades antioxidantes y los beneficios para la salud que aporta[11].

En algunas regiones, es común preparar mermeladas con los cálices de esta flor, mientras que en el mercado también se pueden encontrar concentrados líquidos y en polvo, destinados a la preparación de bebidas instantáneas y disponibles en sobres para infusiones. Varios estudios sobre el extracto acuoso de los cálices han reportado importantes beneficios para la salud[12].

En cuanto a su uso en la industria alimentaria, las mermeladas son conservas de frutas con un alto contenido de azúcar, elaboradas concentrando la pulpa de la fruta y añadiendo sacarosa. A menudo se incorpora pectina y otros aditivos, logrando un contenido total de sólidos solubles entre el 60% y el 70%[3]. En este contexto, el objetivo de la presente investigación fue desarrollar una mermelada de flor de Jamaica (*Hibiscus sabdariffa*) tanto en su forma natural como deshidratada.

MATERIALES Y MÉTODOS

Material vegetal

La materia prima se obtuvo de mercados locales del cantón Quinindé, provincia de Esmeraldas, Ecuador. La elaboración de la mermelada y caracterización de las muestras se realizó

en el laboratorio Agroindustrial de la Pontificia Universidad Católica del Ecuador - SEDE Esmeraldas (Campus Tachina) ubicado a una latitud: -79,6249446 y longitud 0,9730661.

Mediciones experimentales

Para la caracterización de las propiedades físico-químicas y tecnológicas de la mermelada se utilizaron los métodos analíticos descritos a continuación:

Características físico-químicas

pH: se determinó siguiendo la metodología establecida en la norma NTE INEN 1572. Se tomaron 5 g de la muestra y se disolvieron en 50 ml de agua destilada. La solución resultante se midió con un pH-metro calibrado con soluciones buffer de pH 4 y pH 7[13].

Acidez (%): se evaluó conforme a la norma NTE INEN 1572. Se pesaron 5 g de la muestra y se disolvieron en una mezcla de 50 ml de agua destilada y 5 gotas de fenolftaleína como indicador. La solución se tituló con NaOH 0,1 N hasta alcanzar el punto de equivalencia[13].

Humedad (%): se realizó siguiendo el procedimiento descrito en la norma NTE INEN 1572. Se tomaron 5 g de la muestra y se secaron en un horno a 105°C hasta obtener un peso constante. La pérdida de peso se calculó como porcentaje de humedad[13].

Ceniza (%): se utilizó la metodología de la norma NTE INEN 1572. Se pesaron 5 g de la muestra y se calcinó en un horno a 550°C hasta obtener un residuo blanco o gris claro. El peso del residuo se expresó como porcentaje de ceniza[13].

°Brix (°Bx): se midió de acuerdo con la norma NTE INEN 1572. Se tomaron 5 g de la muestra y se diluyeron en 50 ml de agua destilada. La solución resultante se midió con un refractómetro calibrado[13].

Determinación del contenido de polifenoles (mg equ. Ácido gálico /100g) y capacidad antioxidante (mg mL-¹)

El contenido de polifenoles se realizó según el método de referencia Cross, E. y Maringo, G. 19973/1982 en INIAP "Estación Experimental Santa Calalina, Quevedo Ecuador, mientras que, la capacidad antioxidante Para medir la capacidad antioxidante, se utilizó la prueba de absorbancia de radicales libres (DPPH)[14]

Caracterización sensorial

En la caracterización sensorial se evaluaron la categoría de olor, sabor, textura y aceptabilidad mediante una escala hedónica de 5 puntos donde 1 correspondía al descriptor no me gusta y 5 a me gusta mucho.

Manejo Experimental

Para la elaboración de las tres formulaciones de mermelada, se siguió el siguiente proceso: en primer lugar, se llevó a ebullición el agua junto con las flores de Jamaica. Posteriormente, en algunas formulaciones se añadió como pectina natural y se procedió con la adición del azúcar o miel para cada una de las formulaciones (Tabla 1).

Tabla 1. Formulación de la mermelada de flor de Jamaica

Ingredientes	Formulación I	Formulación II	Formulación III
	Cantidad %	Cantidad %	Cantidad %
Azúcar	45	30	10
Flor de Jamaica	35	50	75
Agua	20	20	20

Diseño experimental

Para la presente investigación se empleó un diseño experimental completamente al azar (DCA) con arreglo factorial de A*B, donde el factor A hace referencia las concentraciones de flor de Jamaica (35%; 50% y 70%) y el factor B corresponde a los métodos de procesamiento de la flor de Jamaica (estado natural y deshidratada). Obteniendo un total de 6 tratamientos con tres repeticiones, dado que este estudio busca establecer relaciones causa-efecto entre las variables evaluadas, es decir, determinar el proceso óptimo mediante la aplicación de distintos tratamientos. Para evaluar diferencias significativas estadísticamente entre las medias de los tratamientos, se utilizó la prueba de rangos múltiples de Tukey ($p < 0,05$) a través del software estadístico InfoStat. La descripción detallada de los tratamientos se encuentra en la Tabla 2.

Tabla 2. Descripción de los tratamientos de la investigación

Tratamientos	Descripción
T1	35 % Flor de Jamaica + estado natural
T2	35 % Flor de Jamaica + estado deshidratado
T3	50 % Flor de Jamaica + estado natural
T4	50 % Flor de Jamaica + estado deshidratado
T5	75 % Flor de Jamaica + estado natural
T6	75 % Flor de Jamaica + estado deshidratado

RESULTADOS Y DISCUSIÓN

Características fisicoquímicas

En la Tabal 3 se presentan los resultados fisicoquímicos determinados en la mermelada de flor de Jamaica (Hibiscus *sabdariffa*). Donde se observó que existió diferencia significativa (p<0,05) en los parámetros pH, acidez, humedad, ceniza y °Brix.

Los resultados de la determinación fisicoquímico indican que el T1 (35 % Flor de Jamaica + estado natural) presentó el mayor valor para pH con 4,00, mientras que el T2 (35 % + estado deshidratado) sitúo el pH más bajo con 2,70.

En cuanto a la acidez, el T5 (75 % Flor de Jamaica + estado natural) mostró la mayor acidez (0,83 %), mientras que T2 (35 % Flor de Jamaica + estado deshidratado) tuvo la menor acidez (0,40).

En relación al contenido de humedad se observó la mayor incidencia en el T1 (35% Flor de Jamaica + estado natural) con un valor de 31,67% a diferencia del T6 (75% Flor de Jamaica + estado deshidratado) que obtuvo una humedad inferior con 14,00%...

En cuanto a la variable ceniza se denotó que el mayor efecto se sitúo en el T6 (75% Flor de Jamaica + estado de deshidratada) con un valor promedio de 0,70%, mientras que T1 (35% Flor de Jamaica + estado de natural) mostró el menor contenido (0,20%).

Respecto al contenido de °Brix se denotó que el T1 (35% Flor de Jamaica + estado de natural) presentó la mayor concentración de sólidos solubles (64,30%), mientras que T6 (75% Flor de Jamaica + estado de deshidratada) tuvo el valor más bajo (15,23%).

Capacidad antioxidante y contenido de polifenoles totales de la mermelada de flor de Jamaica (Hibiscus sabdariffa)

En la Figura 1 se muestran los resultados del contenido de polifenoles totales. Donde se observó que los mayores valores se situaron en los tratamientos que se utilizó flor de Jamaica en estado natural presentando valores que oscilaron entre 196,26 mg equ. Ácido gálico /100g – 215,98 mg equ. Ácido gálico /100g. A diferencia de los tratamientos elaborados con flor de Jamaica deshidratas que obtuvieron los resultados más bajos, con un contenido entre 113,30 mg equ. Ácido gálico /100g a 123,90 mg equ. Ácido gálico /100g.

En cuanto a la capacidad antioxidante (Figura 2), se demostró que la mayor incidencia se obtuvo al elaborar mermelada a partir de flor de Jamaica en estado natural (13,60 mg mL^{-1} - 14,22 mg mL^{-1}) mientras que la flor de Jamaica en estado deshidratados disminuye significativamente la capacidad antioxidante del producto final con valores que oscilaron entre (6,56 mg mL^{-1} a 7.71 mg mL^{-1}).

Caracterización sensorial

En la Tabla 4 se presentan los resultados obtenidos en la caracterización sensorial, donde se observó que existió diferencia significativa (p<0,05) entre las categorías sensoriales evaluadas (olor, sabor, textura y aceptabilidad). Demostrando que la mermelada elaborada con 50% flor de Jamaica en estado natural (T3) permitió obtener un producto con mayor intensidad, resaltando en las categorías sabor (4,37), textura (4,13) y aceptabilidad (4,63). Mientras que al emplear el 35% de flor de Jamaica deshidratada (T2) intensifica en olor de las muestras.

Tabla 3. Resultados de la caracterización fisicoquímica de la mermelada de flor de Jamaica

Tratamientos	PH	Acidez	Humedad	Cenizas	°Brix
T1	4,00±0,1632^{C}	0,50±0,0816^{AB}	31,67±1,2472^{D}	0,20±0,0816^{A}	64,30±0,2449^{F}
T2	2,70±0,1632^{A}	0,40±0,0816^{A}	27,00±1,6329^{CD}	0,37±0,0471^{AB}	36,97 ±0,1247^{C}
T3	3,60±0,1632^{BC}	0,70±0,0816^{AB}	26,00±1,6329^{C}	0,47±0,0471^{BC}	56,20±0,1632^{E}
T4	3,27±0,1699^{B}	0,47±0,1247^{A}	18,00±1,6329^{AB}	0,70±0,0816^{D}	23,43±0,3299^{B}
T5	3,90±0,1632^{C}	0,83±0,094^{B}	20,00±1,6329^{B}	0,43±0,0471^{BC}	48,27±0,2494^{D}
T6	3,70±0,1632^{BC}	0,70±0,0816^{AB}	14,00±1,6329^{A}	0,60±0,0816^{CD}	15,23±0,2054^{A}
p-valor	0,01**	0,013*	0,026*	0,035*	0,01**

Letras mayúsculas iguales indica que los tratamientos no difieren entre sí, según la prueba de rangos múltiples de Tukey (p<0,05).

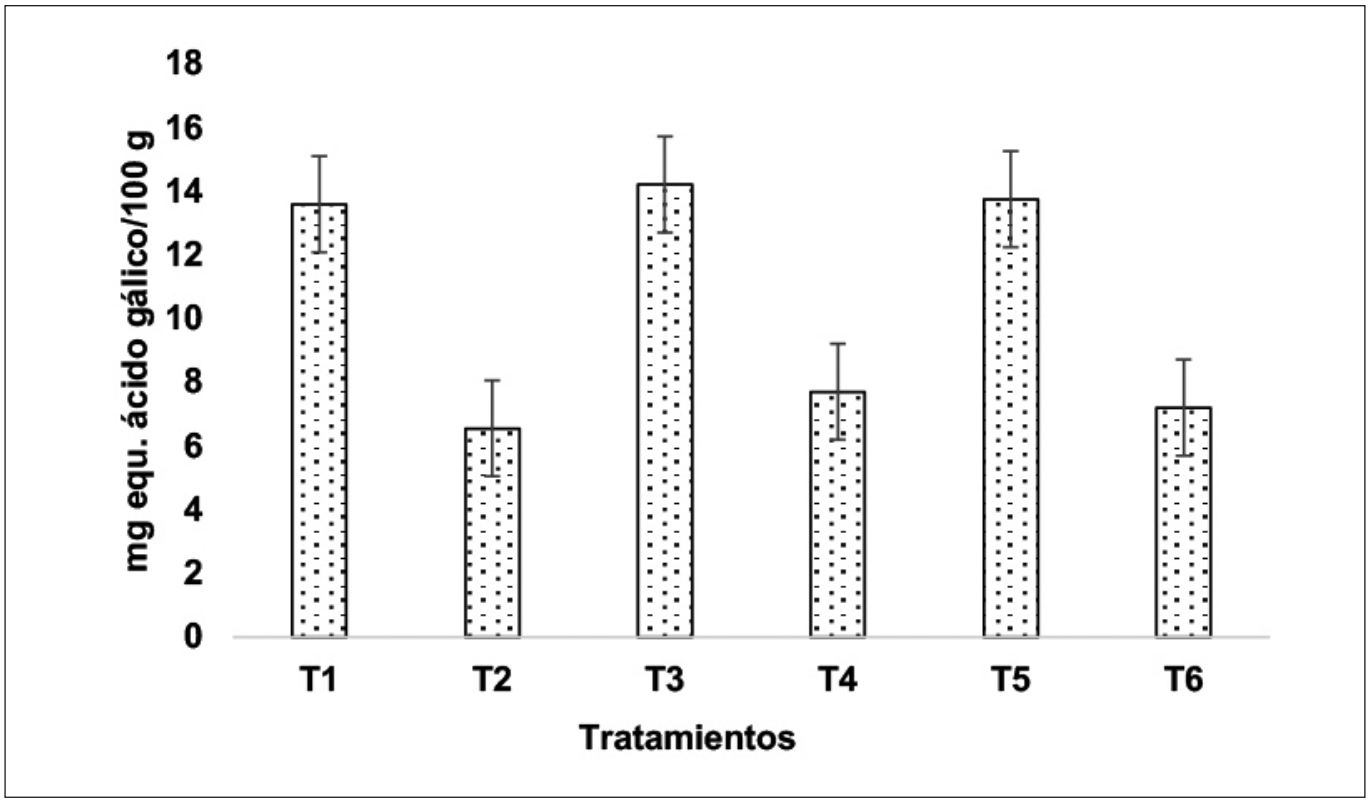

Figura 1. Resultados del contenido de polifenoles totales

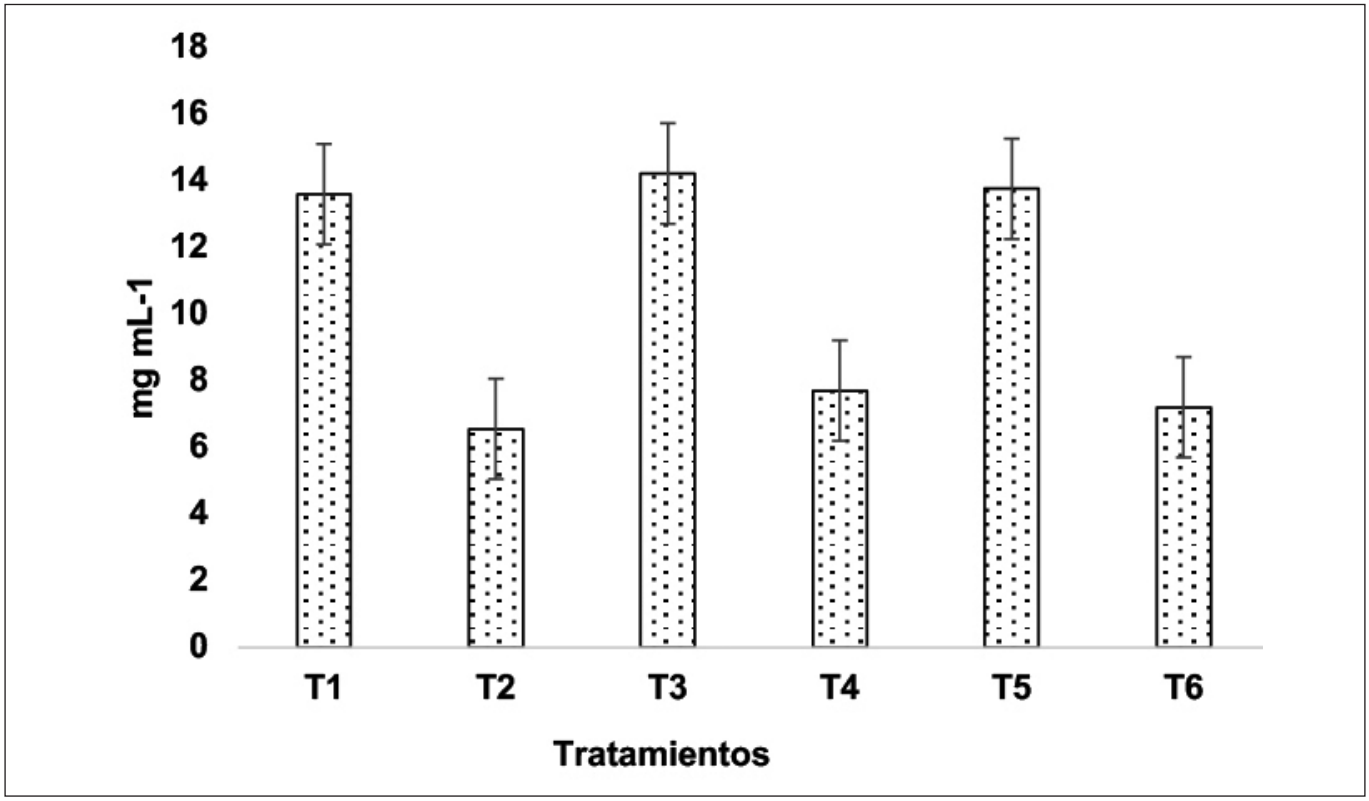

Figura 2. Resultados de la capacidad antioxidante

Tabla 4. Resultados de la caracterización sensorial de la mermelada

Tratamientos	Olor	Sabor	Textura	Aceptabilidad
T1	4,20±0,1632^{C}	4,13±0,1247^{C}	4,12±0,1027^{D}	4,17±0,1247^{B}
T2	4,07±0,1699^{BC}	4,13±0,1247^{C}	3,20±0,1471^{BC}	4,00±0,0816^{B}
T3	3,67±0,0942^{AB}	4,37±0,1699^{C}	4,13±0,1247^{D}	4,63±0,1247^{C}
T4	3,98±0,1433^{BC}	4,07±0,0942^{C}	3,07±0,0849^{AB}	4,33±0,1247^{BC}
T5	3,23±0,2054^{A}	3,18±0,1027^{B}	3,60±0,1632^{C}	3,47±0,0942^{A}
T6	3,57±0,1247^{AB}	2,67±0,1699^{A}	2,73±0,1247^{A}	3,47±0,1885^{A}
p-valor	0,050*	0,0056**	0,045*	0,495

Letras mayúsculas iguales indica que los tratamientos no difieren entre sí, según la prueba de rangos múltiples de Tukey (p<0,05).

DISCUSIÓN

Características fisicoquímicas

Esta variabilidad en los resultados se debe a que la materia prima en estado natural repercute con un mayor pH en el producto final, concordando con investigaciones donde se elaboró mermelada a partir de cálices frescos y secos de Jamaica (*Hibiscus sabdariffa)* y presentaron valores de 3,67 a 2,87 respectivamente[15], así como también, la mermelada de pétalos de rosa baladi (*Hibiscus rosa – sinensis)* obtuvo un pH que varió de 4,8 a 6,3 [9]. Por otro lado, estos resultados se encuentran dentro de lo estipulado en la Norma Técnica Ecuatoriana NTE INEN 419 que establece un pH entre 2,8 a 4,00 para mermeladas de frutas[16].

Según lo mencionado por la FAO (1997) establece que las mermeladas deben contener máximo 1 % de acidez[17]. Por otro lado, investigaciones previas han determinado una acidez de 0,98 % en mermelada mixta de flor de Jamaica y piña[18] Además, es necesario mencionar que existe una tendencia al utilizar la materia prima en estado natural incrementa acidez la acidez del producto, lo cual coincide con las observaciones de autores que mencionan que las materias primas en estado natural poseen un alto contenido de nitrógeno puede influir en el perfil ácido de los productos[19].

De esta manera, se demuestra que el estado de la materia prima influye significativamente en la variabilidad e este parámetro, observando que los tratamientos que un mayor porcentaje de materia estado deshidratado presentan un contenido de humedad significativamente menor, corroborando con lo informado por autores que destacan que la deshidratación reduce la humedad en productos alimentarios[20]. Además, los resultados obtenidos guardan por lo determinado por Esquivel et al. (2022) en su estudio sobre mermelada a base de flor de Jamaica con pulpa y cáscara de tuna (*Opuntia ficus-indica)* como fuente de pectina natural y obtuvo una humedad de 22%[6].

Se observo que el incremento en el contenido de ceniza está relacionado con la inclusión del mayor porcentaje de flor de Jamaica en estado deshidratada. Estos resultados son consistentes con investigaciones previas donde afirman que la deshidratación incrementa la concentración de minerales en los productos[21]. Por su parte, investigaciones donde han utilizado extracto de cáliz de *Hibiscus sabdariffa* en la elaboración de mermelada obtuvieron un contenido de ceniza de 0,20%[22].

Los niveles de °Brix no son consistentes con lo estipulado con la Norma Técnica Ecuatoriana NTE INEN 419, la cual establece un valor mínimo de 65ºbrix[13], pero sí coinciden con la Norma Nicaragüense NTON 0308609 (1981), quien establece que la concentración de azúcar para una mermelada cítrica es entre 62-70 Brix[23], siendo el T1 el mejor tratamiento con una media de 64,30°brix.

Capacidad antioxidante y contenido de polifenoles totales de la mermelada de flor de Jamaica (Hibiscus sabdariffa)

El contenido de polifenoles en calices de flor de Jamaica varía entre 170 ± 5,6 mg GAE 100 g-1 y 344,9 ± 33,6 mg [24]. Por otro lado, los compuestos polifenólicos de *los cálices de H. sabdariffa* se sitúa en 180,14 µg/mg, es importante indicar que la flor de Jamaica es una fuente potencial para extraer compuestos fenólicos que son importantes para aplicaciones alimentarias y farmacéuticas[25].

Estos resultados indican que la Flor de Jamaica en su estado natural tiene una mayor capacidad para neutralizar radicales libres, lo cual podría estar directamente relacionado con su mayor contenido de polifenoles, conocidos por su potente actividad antioxidante[21]. Además, estos resultados son similares a estudios donde han determinado un contenido de capacidad antioxidante ente en mermelada de frutos ro-

jos, donde se obtuvo un contenido de capacidad de antioxidante entre 11,4 7,71 mg mL^{-1} a 18,70 7,71 mg mL^{-1} en mermelada de frambuesa (*Rubus Idaeus*) y fresa (*Fragaria Vesca*) y mermelada de arándanos y frambuesa negra coreana respectivamente[26].

Caracterización sensorial

Los resultados sensoriales concuerdan con investigaciones previas que, aunque no determinaron diferencia significativa en su estudio donde evaluaron la calidad de mermelada elaborada a partir de cálices frescos y secos de Jamaica *(Hibiscus sabdariffa)* sin embargo observaron que la mayor preferencia se sitúo en el producto elaborado con cálices en estado fresco[27]. Las altas calificaciones sensoriales probablemente se atribuyan al atractivo color, sabor y textura de la materia prima, que se transmiten de manera efectiva en el producto final, según lo mencionado por Ghodke y Mane (2017) informaron resultados similares al incluir cálices frescos en la elaboración de mermelada de guayaba (*Psidium guajava*) y señalaron que la mermelada logró la mayor aceptabilidad sensorial general debido a su color y sabor vibrantes[28]. Por otro lado, Othman et al. (2008) demostraron que los cálices frescos de Jamaica son ricos en vitaminas y minerales, lo que aporta una variedad de características sensoriales que mejoran la calidad del producto final[29].

CONCLUSIONES

En el proceso de desarrollo y producción de mermelada, se observó que tanto la concentración como el estado de la flor de Jamaica tienen un impacto significativo en las características fisicoquímicas del producto final. Se encontró que la flor de Jamaica en su estado natural incrementa progresivamente parámetros como pH, acidez, humedad y °Brix. A diferencia, cuando se utiliza la flor de Jamaica deshidratada, se registró un aumento en el contenido de cenizas. Por otro lado, se evidenció que la mermelada elaborada con 75% de flor de Jamaica en estado natural presentó elevados niveles de polifenoles y una notable capacidad antioxidante. En cuanto a los atributos sensoriales, se concluye que la mermelada elaborada con 50% de flor de Jamaica en su estado natural (T3) mejoró significativamente el sabor, textura y aceptabilidad. Finalmente, se observó que al usar 35% de flor de Jamaica deshidratada (T2), el olor de las muestras se intensificó, lo que podría influir en la percepción sensorial de los consumidores.

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Comparación de los efectos de los pseudocereales sobre la composición corporal en un modelo murinométrico

Comparison of the effects of pseudocereals on body composition in a murinometric model

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RESUMEN

Introducción: Los pseudocereales andinos son de gran importancia debido al buen contenido nutricional y efectos que produce sobre la salud. Se comparó los efectos del consumo de los pseucereales sobre la composición corporal en un modelo murinométrico**.**

Metodología: Se efectuó un estudio experimental aleatorizado en 15 ratas machos Sprague-Dawley con un rango de edad inicial de 27 a 30 días de edad. Se evaluó las variables murinométricas de peso (g) y longitud total (cm). La composición corporal (CC) se determinó por medio de ecuaciones de regresión, y se calculó la masa grasa (MG) y masa libre de grasa (MLG). Se conformaron tres grupos de estudio: grupo control (GC) sin consumo de proteína, grupo experimental 1 (GE1) con suplemento de proteína caseína, y grupo experimental 2 (GE2) producto lácteo fortificado con adición de granos andinos (quinua y cañihua).

Resultados: Se verificaron diferencias significativas entre el pre y post test en los 3 grupos de estudio. En el GC los valores disminuyeron 3,5g de MLG y 3,6g de MG (p<0,003), en el GE1 aumentó la MLG en 20,2g (p<0,001) y la MG en 22g (p<0,001). En el GE2, aumentó la MLG en 24g (p<0,001) y 26g en la MG (p<0,001). Cuando se compararon tras el test, no hubo diferencias significativas entre el GE1 y GE2 (p= 0,07 y 0,09) en la MG y MLG, sin embargo, si entre el GE1 y GE2 con el GC en la MLG (p=0,001) y MG (p=0,001)**.**

Conclusiones: La suplementación con pseudocereales (quinua y cañihua) y con caseína durante 21 días produjo incrementos importantes sobre la masa grasa y masa libre de grasa en animales de experimentación (ratas Sprague-Dawley). En consecuencia, la ingesta de pseudocereales andinos podría mejorar la composición corporal, presentando un gran potencial de aplicación en la industria alimentaria.

PALABRAS CLAVE

Granos, ganancia ponderal, alimentación, análisis dietético.

ABSTRACT

Background: Andean pseudocereals are of great importance due to their good nutritional content and health effects. The effects of pseucereal consumption on body composition were compared in a murinometric model.

Methodology: A randomized experimental study was carried out in 15 male Sprague-Dawley rats with an initial age range of 27 to 30 days old. The murinometric variables of weight (g) and total length (cm) were evaluated. Body composition (BC) was determined by regression equations, and fat mass (FM) and fat-free mass (FFM) were calculated. Three study groups were formed. The control group (CG) without protein intake, experimental group 1 (EG1) with casein protein supplement, and experimental group 2 (EG2) with protein supplement based on quinoa and cañihua extracts**.**

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Results: Significant differences were verified between the pre- and post-test in the three study groups. In the CG, the values decreased 3.5g of FFM and 3.6g of FM (p<0.003), in EG1, FFM increased by 20.2g (p<0.001) and FM by 22g (p<0.001). In EG2, it increased FFM by 24g (p<0.001) and 26g in FM (p<0.001). When compared between post-tests, there were no significant differences between EG1 and EG2 (p= 0.07 and 0.09) in FM and FFM, however, there were significant differences between EG1 and EG2 with CG in FFM (p=0.000) and FM (p=0.000)**.**

Conclusions: Supplementation with pseudocereals (quinoa and cañihua) and casein for 21 days produced significant increases in fat mass and fat-free mass in experimental animals (Sprague-Dawley rats). Consequently, the intake of Andean pseudocereals could improve body composition, presenting a great potential for application in the food industry**.**

KEY WORDS

Grains, weight gain, feeding, dietary analysis

INTRODUCCIÓN

Los pseudocereales andinos son plantas dicotiledóneas productoras de semillas que se consumen como granos y pertenecen a las familias de los *Amaranthaceae*, como el amaranto (*Amaranthus sp.*), la cañihua (*Chenopodium pallidicaule*) y la quinua (*Chenopodium quinua*)[1]. Estos cereales son ricos en nutrientes y son de gran importancia debido al buen contenido nutricional y efectos que produce sobre la salud[1].

La región andina de América del Sur se caracteriza por su biodiversidad y riqueza vegetal y comprende los territorios de Colombia, Ecuador, Perú y Bolivia[2]. De hecho, Perú y Bolivia son dos de los países sudamericanos tradicionalmente líderes en la producción de quinua y cañihua, que son conocidos por sus beneficios nutricionales y adaptabilidad a las condiciones climáticas de alta altitud.

En general, la quinua (*Chenopodium quinoa Willd.)* es un grano rico en nutrientes originario de América del Sur y consumido en todo el mundo como un alimento saludable, a veces incluso denominado "superalimento[3]. Es tolerante al estrés ambiental con un alto valor nutricional y de cultivo a nivel mundial para el consumo y la nutrición humana[4]·. Mientras tanto, la cañihua presenta un mayor contenido proteico que el amaranto y la quinua[5], siendo su contenido 16% más en la cañihua que en la quinua[6].

En los últimos años, la tendencia del mercado alimentario hacia productos saludables se ha ido incrementando[7]. Por ejemplo, recientemente se ha destacado que la quinua se caracteriza por presentar oportunidades de mercado como alimentos libres (sin lácteos, ni gluten), alimentos naturales (para reducir el consumo de carne), alimentos funcionales (benéficos a la salud), y alimento energético (aportan energía duradera)[8]. La quinua y la cañihua son dos granos andinos que han ganado popularidad en todo el mundo debido a sus numerosos beneficios nutricionales y su versatilidad en la cocina. Ambos se caracterizan por presentar una fuente importante de proteínas, lípidos, vitaminas y otros nutrientes.

En general, algunos de los motivos por los cuales se toman los suplementos nutricionales, son básicamente para ayudar a la recuperación del entrenamiento, el mantenimiento o mejora de la salud, la mejora del rendimiento deportivo, mejorar funciones inmunes[9,10], y una de las proteínas que su usan con frecuencia es la caseína. Esta proteína se encuentra en la leche, y se caracteriza por su lenta digestión y absorción[11].

En suma, basados en que la caseína es una proteína de liberación lenta encontrada en la leche, puede tener varios efectos en la composición corporal, por lo que es posible que el producto lácteo fortificado con adición de granos andinos (quinua, y cañihua) preparado a base galletas podrían reflejar cambios importantes en la composición corporal de ratas. Por lo tanto, el objetivo de este estudio fue comparar los efectos del consumo del producto lácteo fortificado con adición de granos andinos sobre la composición corporal en un modelo murinométrico.

METODOLOGÍA

Tipo de estudio y muestra

Se efectuó un estudio experimental aleatorizado en 15 ratas machos Sprague-Dawley con un rango de edad inicial de 27 a 30 días de nacimiento. Estas son caracterizadas como pre-puberes (< 30 días)[12]. La edad aproximada de los animales fue de 29,0±1,2dias, el peso corporal de 86,0±2,8g y la longitud de 24,9±0,9cm. Después de tres días de aclimatación en un laboratorio, las ratas fueron asignadas aleatoriamente a cada uno de los grupos de estudio.

Se conformaron tres grupos de estudio, donde se administró una dieta general a todos los grupos, por ejemplo, grupo control (GC) sin proteína, grupo experimental 1 (GE1) con proteína caseína, y grupo experimental 2 (GE2) con producto lácteo fortificado con adición de granos andinos (quinua y cañihua). El estudio fue aprobado por el Comité de ética de la UCSM – 117-2022.

Suplementación de los grupos

Los animales se alojaron en jaulas de acero inoxidable (uno por jaula) en un laboratorio con temperatura y humedad controlada (20-22 °C, 30-50 % de humedad relativa) y ciclos de luz de 12 horas) y con alimentación y agua *ad libitum* (Labina, Purina). El aserrín de cada jaula se cambió dos veces por semana.

Los tres grupos consumían sus alimentos durante tres veces por día (en la mañana de 7 a 8 a.m., al medio día de 13

a 14 horas y por la noche de 18 a 19 horas), y durante tres semanas (21 días). El consumo de alimentos fue de 20 g en un día, y el agua fue ad libitum. Las dietas de cada grupo fueron:

- GC: alimentación sin proteína: carbohidratos procedentes de almidón de maíz, grasa (10%) el mismo que fue manteca de cerdo (9%) y (1%) de aceite de girasol, fibra como celulosa 2.5 %, Mezcla de Vitaminas y Minerales 5%.
- GE1: alimentación a base de caseína: caseína en polvo o el producto lácteo se mezclaron junto con los demás alimentos a los cuales se agregó en una mínima proporción agua hasta conseguir una consistencia blanda (se podría denominar papilla)
- GE2: alimentación a base del producto lacteo fortificado con granos andinos (quinua y cañihua): Proteínas (10%), carbohidratos (72,5%), grasa (10%), fibra (5%), mezcla de vitaminas y minerales (2,5%). Se utilizó leche en polvo y cereal molido, luego se añadió 1 ml de yogurt para juntar todo y, finalmente, se formaron pequeñas bolas de 1 cm, resultando pequeñas galletas según estudio previo[13].

Técnicas y procedimientos

Las evaluaciones somáticas se efectuaron en el pre y post test. La medición del peso y longitud de las ratas se efectuaron según las recomendaciones de Cossio-Bolaños y cols.[14]. El peso (g) se midió utilizando una balanza analítica de marca Scaltec modelo SAC-62, con una precisión de 1 g, y para la longitud total se utilizó un parquímetro de aluminio graduado en milímetros (mm) (Harpenden, Inglaterra), midiendo desde el hocico hasta la punta de la cola.

La superficie corporal (SC) fue calculad por medio de la ecuación propuesta por Cano-Rabano y cols.[15], donde [SC = 0,1*Peso vivo*0,685].

Los indicadores de la composición corporal se han inferido a través de ecuaciones de regresión. Se utilizó las ecuaciones de masa libre de grasa MLG y masa grasa MG propuestas por Cossio-Bolaños et al.[16]. MLG = 19,9+(0,453*Peso total) + (0,114*edad) R^2= 0,94, y MG = -31,6+(0,361*Peso total) - (0,345*edad) R^2= 0,73.

Estadística

Se verificó la normalidad de los datos por medio del test de Shapiro-Wilk. Se analizó la estadística descriptiva de media aritmética (X) y desviación estándar (DE). La diferencia entre el pre y post test se verificó por medio del test t para muestras relacionadas. La diferencia entre los posts test se verificó por medio del análisis de varianza (ANOVA, de dos vías) y la prueba de especificidad de Tukey. Todo el análisis estadístico se efectuó en SPSS 16,0 para Windows, adoptando un nivel de significación p<0.05.

RESULTADOS

Las variables somáticas que caracterizan a los tres grupos de estudio se muestran en la tabla 1. No hubo diferencias entre los tres grupos en la edad (p=0,862 y 0,963) y la longitud de las ratas (p= 0,308 y 0,957). Entre el GC y GE1 en el peso y SC no hubo diferencias significativas (p= 0.061 y 0.062). Sin embargo, si hubo diferencias entre el GC y GE2 y GE1 y GE2 en el peso y la SC (p= 0,00 y 0.019).

Las comparaciones entre el pre y post test de los tres grupos de estudio se observan en la tabla 2. Se han detectado diferencias significativas en los tres grupos y en los dos compartimientos corporales (MLG y MG). Por ejemplo, en el GC, los valores disminuyeron 3,5g de MLG y 3,6g de MG (p< 0.003), en el GE1 aumentó la MLG en 20,2g (p<0,001) y la MG en 22g (p<0,001). En el GE2, aumentó la MLG en 24g (p<0,001) y 26g en la MG (p<0,001).

Las comparaciones entre los valores medios y desviaciones de la MLG y MG de los posts test se observan en la figura 1. En la MLG y MG, no se observaron diferencias estadísticamente significativas entre el GE1 y GE2 (p= 0,07 y 0,09). Sin embargo, si hubo diferencias significativas entre el GE1 y GE2 con el GC en la MLG (p=0,001) y MG (p=0,001).

Tabla 1. Características somáticas de la muestra estudiada

Variables	GC		GE1		GE2		p		
	X	DE	X	DE	X	DE	GC-GE1	GC-GE2	GE1-GE2
Edad (días)	28,8	0,8	29,2	1,3	29,0	1,4	0,862	0,963	0,963
Peso (g)	91,5	2,1	86,4	1,6	80,0	4,8	0,061	**0,001**	**0,019**
Longitud (cm)	25,1	1,0	25,3	0,5	24,3	1,3	0,957	0,445	0,308
SC (m^2)	6,3	0,2	5,9	0,1	5,5	0,3	0,062	**0,001**	**0,019**

SC: Superficie corporal, X: promedio, DE: Desviación estándar, GC: Grupo control, GE: Grupo experimental.

Tabla 2. Efectos de la suplementación de proteína sobre la composición corporal de ratas

Grupos	Pre Test		Post Test		p (t)
	X	DE	X	DE	
GC					
MLG (g)	64,00	1,00	60,50	1,60	**0,003**
MG (g)	27,50	1,10	23,60	1,80	**0,003**
GE1					
MLG (g)	61,60	0,80	81,80	1,70a	**<0,001**
MG (g)	24,80	0,80	46,80	1,81b	**<0,001**
GE2					
MLG (g)	58,51	2,32	82,50	5,01a	**<0,001**
MG (g)	21,51	2,51	47,50	5,41a	**<0,001**

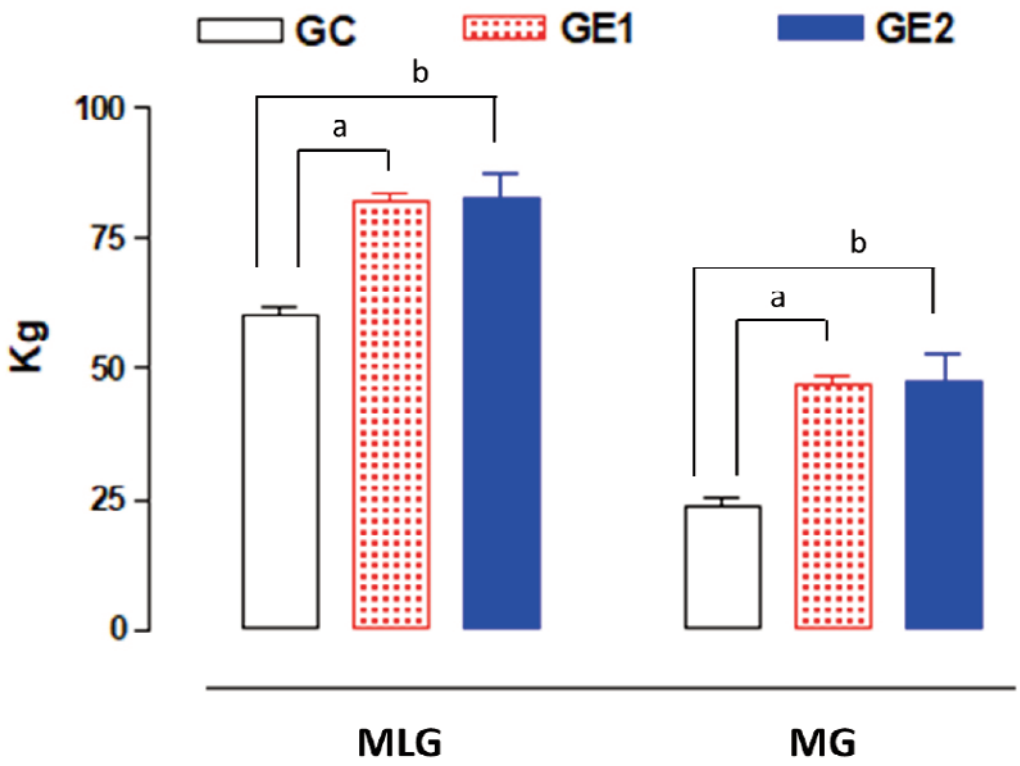
X: promedio, DE: Desviación estándar, GC: Grupo control, GE: Grupo experimental, MLG: Masa libre de grasa, MG: Masa grasa.

DISCUSIÓN

El objetivo del estudio fue comparar la suplementación de un producto lácteo fortificado con adición de granos andinos (extracto de quinua y cañihua) sobre sobre composición corporal en ratas Sprague-Dawley. Los resultados indican que la suplementación con estos pseudocereales andinos (a base de quinua y cañihua) han incrementado los compartimientos corporales de MG y MLG al igual que la caseína.

En general, estudios previos han considerado que el consumo de quinua y cañihua ha sustituido la falta de proteína animal en muchas zonas altoandinas y siguen siendo las principales fuentes de proteína, dada su composición química equilibrada de aminoácidos esenciales, similar a la caseína y la proteína de la leche[17].

La quinua y la cañihua pueden utilizarse en mezclas de alimentos de alto valor nutritivo, puesto que hace más de 30 años se ha verificado que el índice de eficiencia proteica (PER) de la quinua-cañihua-frijol fueron cercanos al de la caseína (2,36 y 2,59)[18] e incluso, presenta valor biológico de aminoácidos comparable al de la leche[19].



MLG: Masa libre de grasa, MG: Masa grasa, a: diferencia significativa en relación al GE1, b: diferencia significativa en relación al GE 2.

Figura 1. Comparación de los valores del post test de la composición corporal en los tres grupos de estudio

Varios estudios recientes consideran que el contenido proteico de los granos de quinua y la cañihua son mayores a los de otros cereales y puede utilizarse como alternativa al de las proteínas de la leche[20,21].

De hecho, la suplementación de ambos pseudocereales en este estudio ha evidenciado cambios significativos en la MG y MLG. Otros estudios en humanos administrando proteínas vegetales han reportado cambios importantes en la MLG en muestras de adultos mayores[22,23], ya que la pérdida de masa muscular es un fenómeno común en los adultos mayores y está asociada con la sarcopenia conforme la edad aumenta. Además, en niños y adolescentes aumenta la masa muscular durante la infancia y la adolescencia, especialmente durante los períodos de rápido crecimiento, por lo que en regiones geográficas donde existe carencia o falta de nutrientes puede afectar negativamente el desarrollo muscular durante la etapa del crecimiento y desarrollo[24].

A menudo la desnutrición proteico-energética (DEP) es una condición típica de los países en desarrollo debido a una ingesta dietética insuficiente en la que las personas tienen una ingesta dietética muy pequeña de proteínas, energía o ambas[25] y se reconoce como uno de los principales problemas de salud mundial[26].

En la actualidad, aproximadamente 1 de cada 8 personas sufre desnutrición crónica[27], mientras que la diabetes, la obesidad y otros trastornos metabólicos han alcanzado proporciones epidémicas globales[28]. Por lo que la suplementación a partir de pseudocereales andinos se está volviendo cada vez más importantes con la llegada del cambio climático, el crecimiento acelerado de la población humana, el aumento de las enfermedades metabólicas y el aumento de la edad media de la población[29]. Por ello, futuros estudios deben interesarse en investigar el efecto de la extrusión sobre la disponibilidad de proteínas y minerales en los granos andinos, pues tanto la quinua, como la cañihua pueden ofrecer una alternativa como alimento saludable y beneficioso para la salud. Incluso, la quinua es una alternativa de alimentación para la población con necesidades especiales como los celíacos[30].

Este estudio presenta algunas potencialidades que merecen ser consideradas, dado que es uno de los primeros estudios que se efectúa analizando la composición corporal de ratas Sprague-Dawley. Además, el tipo de estudio experimental permitió controlar algunas variables extrañas, lo que sugiere su generalización a otros contextos. La limitación principal de este estudio experimental radica en la restricción del número de animales utilizados, lo que podría influir en la representatividad de los resultados. Además, la evaluación de la composición corporal se basó únicamente en variables murinométricas, lo que podría limitar la precisión o la comprensión completa de los efectos observados. Además, nos limitamos a investigar ratas machos consideradas pre-púberes, por lo que los resultados obtenidos podrían presentar algún tipo de sesgo en los resultados.

Esto sugiere la necesidad de realizar estudios adicionales que incluyan una variedad más amplia de ratas de ambos sexos para obtener una comprensión más completa de los efectos observados. Resaltamos también que los hallazgos obtenidos en este estudio sugieren que la suplementación con el producto lácteo fortificado con granos andinos puede tener beneficios para la composición corporal en ratas, con lo cual, no se puede asumir automáticamente que estos resultados se apliquen a los humanos. Se necesitarían estudios clínicos específicos en humanos para evaluar la seguridad y eficacia de esta intervención en una población humana.

CONCLUSIONES

La suplementación de un producto lácteo fortificado con adición de granos andinos (quinua y cañihua) durante 21 días produjo incrementos importantes sobre la masa grasa y nasa libre de grasa en animales de experimentación (ratas Sprague-Dawley). En consecuencia, la ingesta de pseudocereales andinos podría mejorar la composición corporal, presentando un gran potencial de aplicación en la industria alimentaria.

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Association between serum lactate levels and refeeding syndrome in critical Ill patients

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ABSTRACT

Aim: To analyze the relationship between blood lactate levels and the development of refeeding syndrome (RFS) in critically Ill patients.

Methods: This prospective cohort study enrolled 141 patients aged 18 years and older who were admitted to the intensive care unit (ICU) of the Hospital Clínica San Francisco for at least 48 hours between January and June 2019. RFS was defined as a 30% decrease in serum phosphorus within 48 hours after the initiation of nutritional support. Serum lactate, SOFA, APACHE II, nutritional risk (NRS-2002), and nutritional status (SGA) were measured upon ICU admission.

Results: 53.8% (n = 83) were male, and 34.8% (n = 49) developed RFS. The primary diagnoses were sepsis and neurocritical conditions, with an overall mortality rate of 18.4%. Among patients with RFS, 85.7% (n = 41) were identified as having a nutritional risk at admission, and 53.1% (n = 26) had moderate malnutrition. Patients with RFS experienced longer ICU stays (12 vs. 7 days, p = 0.006) and longer hospital stays (22 vs. 15 days, p = 0.007) compared to those without RFS. Patients with RFS had significantly higher serum lactate levels compared to those without RFS (1.62 vs. 2.14 mmol/l; p=0.002).

Conclusions: In the present study, serum lactate level is associated with the development of RFS in critically ill patients.

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KEYWORDS

Lactate; Refeeding syndrome; Metabolic rehabilitation; Intensive care unit; Clinical nutrition.

INTRODUCTION

Refeeding syndrome (RFS) is a potentially serious metabolic disorder that occurs when nutritional therapy is initiated after a prolonged period of fasting or significantly reduced nutrient intake[1]. RFS is characterized by electrolytes imbalances, such as decreased phosphate, magnesium, and potassium levels[2]. Symptoms typically occur within 2 to 5 days of refeeding and vary in severity, ranging from asymptomatic or mild to severe, with an increased risk of mortality[1]. This probability largely depends on the patient's degree of malnutrition and the presence of comorbidities.

The absence of a standardized definition and the nonspecific nature of RFS symptoms complicate its diagnosis and make it challenging to determine its prevalence and incidence. Reported prevalence varies widely, from 0.43% to 34% among intensive care unit (ICU) patients[3,4]. In high-risk populations, including patients with severe malnutrition or hospitalized cancer patients, RFS prevalence has been reported at 48% and 25%, respectively[5].

Various criteria have been established over the years to evaluate the risk of RFS, including those from Friedli et al.[6], the American Society of Parenteral and Enteral Nutrition (ASPEN)[7], and the National Committee for Clinical Excellence (NICE)[8]. These guidelines take into consideration common indicators such as body mass index (BMI), percentage of weight loss, previous caloric intake, serum potassium, phosphate, or magne-

sium levels, and assessment of subcutaneous fat, muscle mass, and associated comorbidities.

Historically, aggressive refeeding has been linked to serious complications. In 1981, the first deaths due to excessive parenteral feeding were reported, and in 1988, severe hypophosphatemia was identified as a primary cause of RFS[9]. This electrolyte imbalance can lead to cardiac dysfunction, neuromuscular disorders, and hematological abnormalities[10,11]. Similarly, severe hypomagnesemia may result in cardiac arrhythmias, neuromuscular disturbances, abdominal discomfort, and seizures[12]. Hypokalemia has been described as a cause of hypotension, cardiac arrest, arrhythmias, gastrointestinal disorders, neuromuscular symptoms, and kidney damage[13].

Lactate is commonly used as a marker of tissue hypoxia[14]. However, in critically ill patients in the acute stage, altered glucose metabolism often leads to elevated lactate levels[15], suggesting a potential relationship between lactate concentrations and the development of RFS. This study aimed to analyze the relationship between serum lactate levels and the onset of refeeding syndrome in critically ill patients.

METHODS

Study design

This prospective, observational, and analytical cohort study was carried out in patients admitted to the ICU of Hospital Clínica San Francisco, located in Guayaquil. The study spanned six months, from January to June 2019.

Subjects

Participants were selected through non-probabilistic convenience sampling. Eligibility criteria included patients aged over 18 with an ICU stay of at least 48 hours and a requirement or indication for nutritional support. Patients with end-stage renal failure requiring dialysis and those with severe hypophosphatemia on admission (<2 mg/dL) were excluded. During the study period, 217 patients were admitted to the ICU, and 141 met the inclusion criteria, forming the study sample. Figure 1 provides a flow chart of the studied population.

Nutritional risk

Nutritional risk was assessed in the first 48 hours of ICU admission using the Nutritional Risk Assessment 2002 (NRS-2002) tool. A score of ≥3 indicating a risk of malnutrition[16].

Nutritional status

Following nutritional risk screening, the nutritional status assessment was carried out by the ICU medical staff using the Subjective Global Assessment (SGA) tool was used to evaluate nutritional status[17]. The SGA classifies patients into three categories: (A) well-nourished, (B) suspected malnutrition or moderate malnutrition, and (C) severe malnutrition, based on

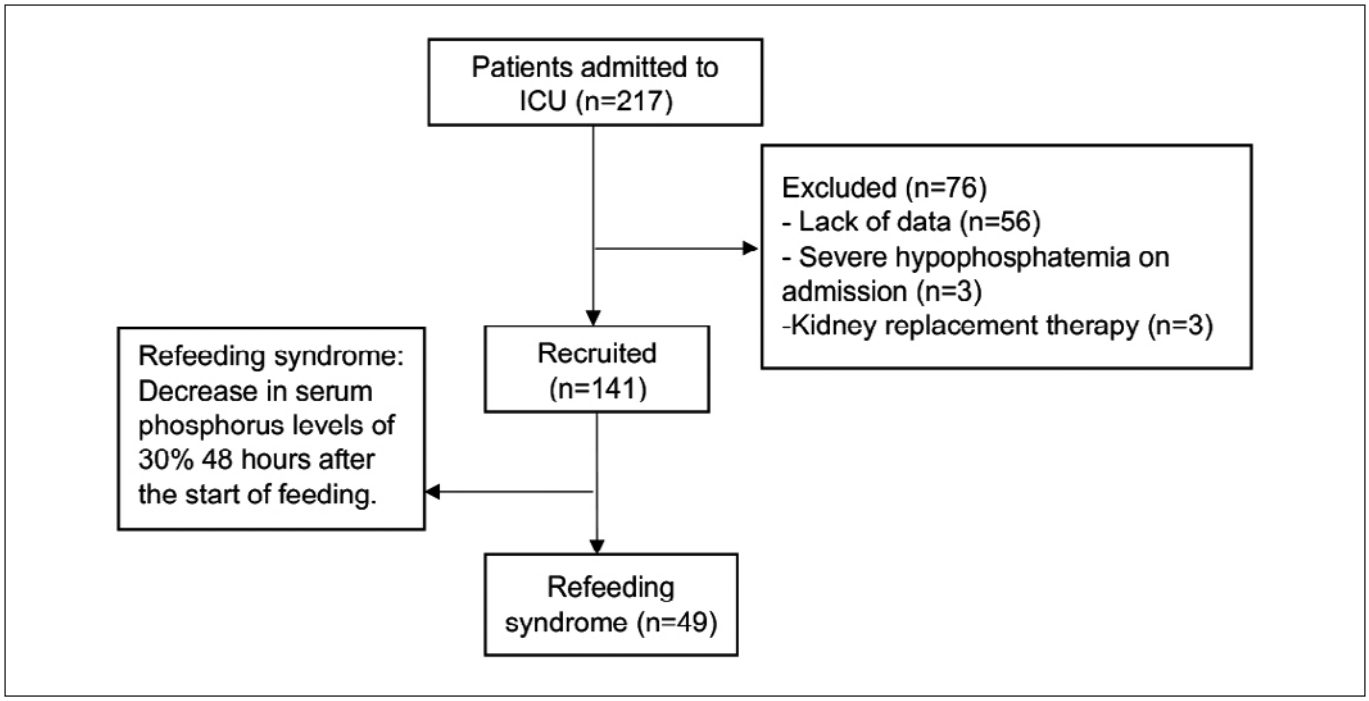


Figure 1. Flowchart of the participants of the study

weight loss, changes in habitual intake, subcutaneous tissue loss, and muscle mass loss.

Severity and mortality

The presence and evolution of multiorgan failure were assessed using the Sequential Organ Failure Assessment (SOFA) score[18], as well as with the Acute Physiology and Chronic Health Evaluation II (APACHE II)[19] to classify the disease severity and predict patient mortality. These assessments were performed within the first 24 hours of ICU admission.

Refeeding syndrome definition

Prior to initiating nutritional support (oral, enteral, or parenteral), plasma levels of phosphorus, potassium, and magnesium were measured and then monitored daily for the first four days of ICU admission. Refeeding syndrome (RFS) was defined as a decrease in serum phosphorus levels of at least 30% within 48 hours of initiating nutritional support, following the ASPEN 2020 criteria[7]. Serum lactate was measured at ICU admission using spectrophotometry.

Statistical analysis

Data for this study were collected from the hospital's electronic medical records and subsequently compiled into an Excel file. Statistical analyses were conducted using SPSS version 24 for Windows. All variables were summarized using descriptive statistics. Qualitative variables are expressed as counts (percentages), and quantitative variables were expressed as means ± standard deviation (SD) or as medians with their respective ranges, depending on the distribution. For comparisons between patients who develop refeeding syndrome and those who do not, Student's t-test, Mann-Whitney U test, or Wilcoxon test were used as appropriate. A p-value of <0.05 was considered statistically significant.

Ethical considerations

Clinical and laboratory data were extracted from the hospital's computerized clinical history system. Informed consent was secured from each patient before their admission to the ICU, and authorization was granted by the institution to conduct the study.

Results

The mean age of the patients was 64 ± 18.8 years, ranging from 21 to 96 years, with 53.8% (n = 83) being male. The primary causes of ICU admission were sepsis (33.3%, n = 47) and neurocritical diseases (17.7%, n = 25). Hypertension was the most common comorbidity, present in 55.3% of patients. The average ICU stay was 8.6 ± 11.1 days, and the average hospital stay was 17.6 ± 15.3 days, with a maximum stay of 93 days. The mean APACHE II score was 11.8 ± 6.3, with an estimated mortality of 15%. The mortality rate at discharge was 17.7% (n = 25). Invasive mechanical ventilation was used in 22% (n = 31) of patients.

Oral nutrition was the most common feeding method, used in 54.6% (n=77) of patients, followed by enteral nutrition (39%, n=55) and parenteral nutrition (7.8%, n=11). Only one patient received a combination of nutritional support methods.

RFS was observed in 34% (n = 49) of the sample. The demographic and clinical characteristics of patients with and without RFS are shown in Table 1. Patients with RFS had a significantly longer ICU stay (12 ± 9.1 vs. 7 ± 5.3 days; p = 0.006) and higher SOFA and APACHE II scores than those without RFS (Table 1). Among patients with sepsis, those who developed RFS had a higher median SOFA score than those without RFS (6.25 vs. 4.50; p = 0.017).

In the RFS group, 85.7% (n = 42) were identified as having nutritional risk upon ICU admission, while 26.5% (n = 13) were classified as having severe malnutrition according to SGA criteria. The most common feeding method among patients with RFS was enteral nutrition (55%), followed by oral feeding (34.6%, n = 17). Of the 11 patients who began parenteral nutrition, 5 developed RFS. The mean values for phosphorus, potassium, magnesium, and lactate at admission were 3.7 ± 1.1 mg/dL, 4.3 ± 3.2 mg/dL, 1.9 ± 0.4 mg/dL, and 1.6 ± 0.9 mmol/L, respectively (Table 2). A statistically significant difference in serum lactate levels at admission was found between patients with and without RFS (1.6 vs. 2.1 mmol/L; p = 0.002), as illustrated in Figure 2.

DISCUSSION

This study describes the association between serum lactate levels upon ICU admission and the onset of RFS. Our results indicate a significant association between these variables, though similar data are not yet reported in the scientific literature.

The association between lactate levels and RFS observed in our study could result from altered thiamine metabolism, a characteristic of this syndrome[20]. Thiamine (vitamin B1) is essential in its active form as a cofactor in converting pyruvate to acetyl-CoA before entering the tricarboxylic acid cycle for ATP production[21]. Thiamine deficiency, often present in malnutrition and alcohol use, can also arise from factors such as advanced age[22], comorbidities (e.g., liver dysfunction, heart failure), surgery (e.g., bariatric), acidosis, sepsis, trauma, high carbohydrate load[23], and RFS. All of these factors may coexist in critically ill patients[24], reducing thiamine levels[25].

In critical ill undergoing refeeding, a lack of thiamine impairs aerobic metabolism, leading to insufficient ATP produc-

Table 1. Demographic, Clinical Characteristics, and Outcomes of patients with and without Refeeding Syndrome

Variables	Total (n = 141)	No RFS (n = 92)	RFS (n = 49)	p-value
Sex, n (%)				
Female	58 (41.1)	35 (38)	23 (46.9)	0.024*
Male	83 (58.9)	57(61.9)	26 (53.1)	0.035*
Age (years), mean ± SD	64 ± 18.8	70 ± 19.4	63 ± 15.1	0.038*
Diagnostic categories, n (%)				
Sepsis	47 (33.3)	29 (31.5)	18 (36.7)	0.043*
Neurocritical Patients	25 (17.7)	12 (13)	13 (26.5)	0.003*
Cardiovascular	30 (21.3)	24 (26.1)	6 (12.2)	0.035*
Hypovolemia	13 (9.2)	9 (9.8)	4 (8.16)	0.670
Trauma	13 (9.2)	9 (9.8)	4 (9.16)	0.670
Oncological	13 (9.2)	6 (6.5)	7 (14.3)	0.541
Comorbidities, n (%)				
Hypertension	78 (55.3)	51 (55.4)	27 (55.1)	0.678
Type 2 diabetes	44 (31.2)	29 (31.5)	15 (30.6)	0.879
Acute myocardial infarction	13 (9.2)	7 (7.6)	3 (6.1)	0.768
ND-CKD	8 (5.7)	8 (8.6)	2 (4.1)	0.051
Cirrhosis	11 (7.8)	5 (5.4)	6 (12.2)	0.040*
Discharge Status, n (%)				
Alive	116 (82.3)	76 (82.6)	40 (81.6)	0.721
Deceased	25 (17.7)	16 (17.3)	9 (18.4)	0.863
ICU Readmission	11 (7.8)	6 (6.5)	5 (10.2)	0.049*
APACHE II Score, mean ± SD	11.8 ± 6.3	11 ± 6.9	14 ± 5.8	0.008*
SOFA Score, mean ± SD	2.1 ± 1.9	1 ± 1.3	3 ± 1.1	0.019*
ICU Stay (days), mean ± SD	8.6 ± 11.2	7 ± 5.3	12 ± 9.1	0.006*
Hospital Stay (days), mean ± SD	17.6 ± 15.3	15 ± 12.9	22 ± 15.2	0.007*
Mechanical ventilation, n (%)	31 (22)	18 (19.6)	13 (26.5)	0.032*
Nutritional Risk, n (%)				
No Risk	36 (25.5)	29 (31.5)	7 (14.3)	0.030*
At Nutritional Risk	105 (74.5)	63 (61.9)	42 (85.7)	0.045*
Nutritional Status, n (%)				
Well-nourished	39 (27.6)	29 (38)	10 (46.9)	0.030*
Moderate malnutrition	78 (55.3)	52 (61.9)	26 (53.1)	0.025*
Severe malnutrition	24 (17)	11 (11.9)	13 (26.5)	0.009*

*$p < 0.05$.
RFA, Refeeding syndrome; SD, Standard deviation; ND-CKD, Non-dialytic chronic kidney disease; ICU, Intensive care unit.

Table 2. Biochemical Markers over the first four days of Refeeding Syndrome

Biochemical Markers	Day 1	Day 2	Day 3	Day 4
Phosphorus (mg/dL)	3.7 ± 1.1	3.4 ± 0.8	3.1 ± 1.0	3.0 ± 1.0
Potassium (mg/dL)	4.3 ± 3.2	4.0 ± 0.6	3.9 ± 0.7	4.0 ± 3.7
Magnesium (mg/dL)	1.9 ± 0.4	1.9 ± 0.4	1.9 ± 1.8	0.3 ± 0.3

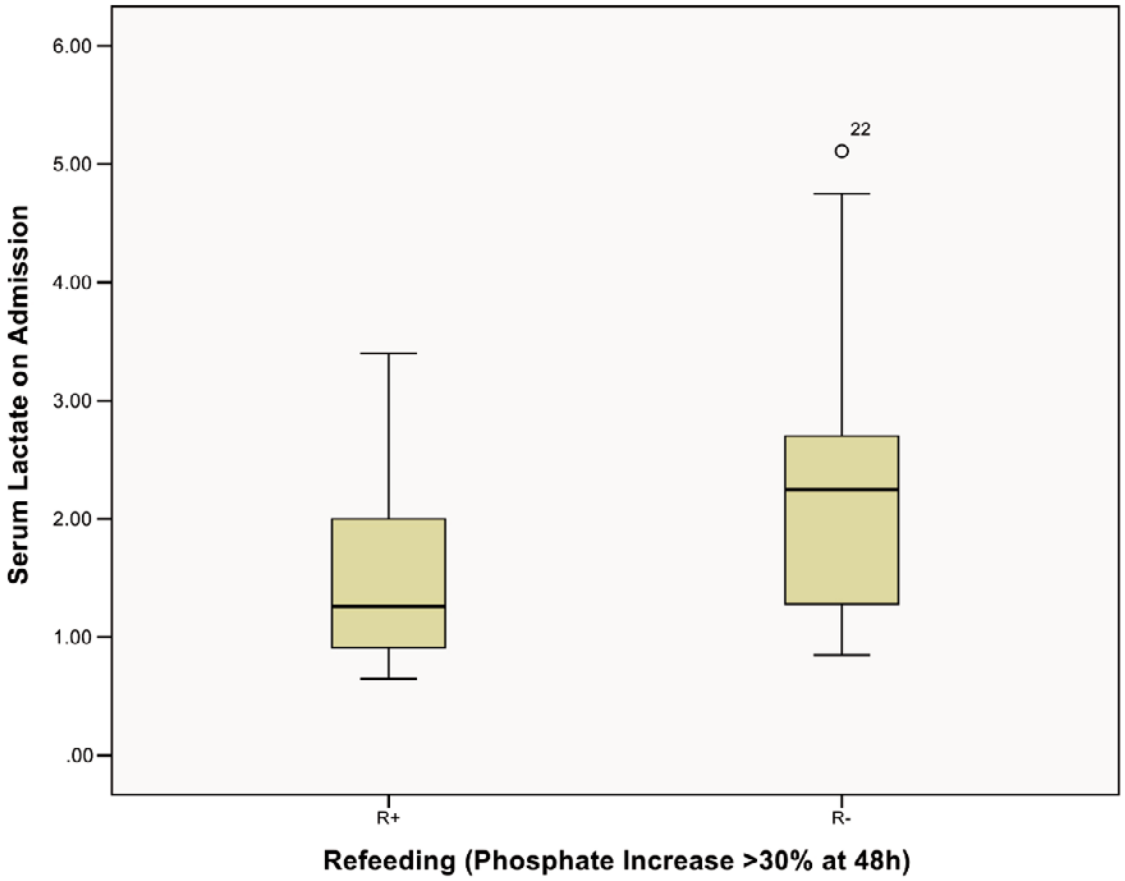
Values are presented as means ± standard deviations.

tion[26]. Consequently, pyruvate is converted to lactate in the absence of thiamine as a cofactor for the Krebs cycle, resulting in hyperlactatemia and metabolic acidosis.

On the other hand, hypomagnesemia has been reported as a common condition even in non-critical patients[27]. In this study, we found a significant decrease in plasma magnesium levels over the first four days of RFS.

The prevalence of RFS in this study was 34.7%. However, de Vargas et al. reported a 43.3% prevalence of RFS in patients on parenteral nutrition in a Brazilian hospital[28]. In contrast, Coşkun et al. reported a 52.1% prevalence of RFS in ICU patients receiving parenteral and enteral nutrition[29].

Symptoms of RFS usually appear within 2 to 5 days of refeeding and vary in severity based on preexisting malnutrition and comorbidities[4]. Monitoring serum phosphorus levels is thus essential for early RFS detection. In a study by Goyale et al., a 30% decrease in baseline phosphorus levels was observed 36 hours after initiating parenteral nutrition, with an RFS prevalence of 62%[30]. Olthof et al., however, reported a 36.4% incidence of RFS in critically ill patients, defining it as hypophosphatemia (<0.16 mmol/L below 0.65 mmol/L) within 72 hours of starting nutritional support[26].



R+: Patients with Refeeding Syndrome; R-: Patients without Refeeding Syndrome.

Figure 2. Serum lactate levels upon admission in patients with and without refeeding syndrome

Gonçalves et al. found a significant a strong negative correlation between thiamine and lactate in patients with diabetes (r= −0.711, p= < .001) and a moderate negative correlation in critically ill patients without diabetes (r = −0.489, p= < .001)[31]. Additionally, Moskowitz et al. observed an inverse relationship between thiamine and lactate levels (p=0.002) in a cohort of 38 patients with diabetic ketoacidosis[32]. Although these findings are relevant, there is no existing evidence specifically linking lactate levels and RFS.

Our study found a statistically significant association between serum lactate levels and RFS, particularly with lactate levels exceeding 2 mmol/L. Although we used the same RFS definition as Goyale et al.[30], differences in nutritional support types aligned with findings by Coşkun et al.[29] However, contrasting results were observed by Zeki et al., who reported a higher RFS incidence in patients on enteral rather than parenteral nutrition[33].

Patients who developed RFS in this study had significantly longer ICU stays. The pooled length of stay in patients with RFS has been reported at 25.5 (95% CI, 20.2-30.9) days[34]. Coşkun et. al also reported longer ICU stays (median: 12 [3–68] vs. 8.5 [3–41] days; p=0.025) and higher mortality in RFS patients (p=0.037)[29]. Nonetheless, in the present report, no significant differences in mortality or ICU stay were observed. Olthof et al. likewise found no significant differences in mortality or median ICU stay between patients with and without RFS, although they noted a non-significant trend toward shorter hospital stays (28 vs. 24 days; p=0.066)[26].

In our study, patients with RFS had significantly higher APACHE II scores. Nevertheless, this difference lacks clinical significance, as it reflects a similar estimated mortality percentage. Coşkun et al., in a retrospective ICU study involving enteral and parenteral nutrition, also found no significant difference in APACHE II scores between patients with and without RFS[29].

A higher SOFA score (6.2 vs. 4.5; p=0.017) was observed in patients with sepsis and RFS compared to those without RFS. In a related observational study on adults receiving enteral nutrition, 42.6% of patients developed RFS and demonstrated higher SOFA scores compared to those without RFS (0.9 ± 0.7 vs, 0.6 ± 0.7)[35]. In addition, Tongyoo et al. found that a SOFA score >12 was associated with reduced RFS risk (OR = 0.45; 95% CI = 0.23-0.88; p = 0.020)[36].

This study has several limitations, including the absence of standardized ICU nutritional support protocols and caloric targets for the studied population. Additionally, patients were not categorized into clinically relevant subgroups, which limits analysis of factors contributing to differences between RFS and non-RFS patients. The study's retrospective design and relatively small sample size also limit the generalizability of findings to other populations with sepsis and RFS. These limitations highlight the need for larger prospective studies with randomized groups and well-defined inclusion criteria to better identify and understand RFS in critically ill patients.

This study is the first to examine the relationship between serum lactate levels and RFS development. Likewise, it provides relevant information on prognostic indicators and disease severity in RFS patients, which can serve as a reference in the clinical and nutritional management of critically ill patients.

CONCLUSION

RFS is a common and serious complication in critically ill patients, linked to higher rates of morbidity and mortality. Sepsis, malnutrition, nutritional risk at admission, and the type of nutritional support appear to be significant risk factors for RFS development. Our findings indicate a prevalence of RFS that is notably higher than reported in general malnutrition literature. Enteral nutrition was the most common form of support among patients with RFS, followed by oral and parenteral feeding. Additionally, patients who developed RFS had significantly longer ICU stays, higher SOFA and APACHE II scores, and higher mortality rates compared to those without RFS. More studies with larger sample sizes are required to generalize these findings.

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Interacción entre el ion cúprico y el fruto del camu camu (*Myrciaria dubia*): Generación de radicales libres

Interaction between cupric ion and camu camu fruit (*Myrciaria dubia*): Generation of free radicals

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RESUMEN

Introducción: El camu camu, fruto de la selva peruana, tiene un elevado contenido de vitamina C. Esta vitamina es altamente antioxidante, pero, se torna prooxidante en presencia de metales de transición generando radicales libres.

Objetivo: Investigar la reactividad de compuestos bioactivos del camu camu con iones cúpricos.

Materiales y métodos: La reactividad de los iones cúpricos con el extracto acuoso de camu camu se evaluó mediante el método de sustancias reactivas al ácido tiobarbitúrico (TBARS). Se utilizaron los efectos de las concentraciones de Cu^{2+} comprendidas entre 0,010 y 0,060 mM. Para inhibir la formación de TBARS se evaluó la capacidad antioxidante de tiourea, EDTA y manitol. El contenido de ácido ascórbico en camu camu se determinó mediante la técnica de Jagota. Se utilizó la estadística inferencial empleando el coeficiente de correlación de Pearson (r) y la regresión lineal simple.

Resultados: Los iones cúpricos reaccionaron con el extracto acuoso de camu camu a través de un incremento de la generación de TBARS en función del tiempo. La presencia de varias concentraciones de Cu^{2+} en el medio de reacción aumentó la generación de TBARS a través de una cinética de saturación. La potencia antioxidante para inhibir la generación de TBARS por efecto del cobre sobre el camu camu disminuyó en el siguiente orden EDTA> tiourea> manitol, cuyas constantes de protección fueron 9.6 x 10^{-6} M, 4.2 x 10^{-5} M y 4.7 x 10^{-3} M, respectivamente.

Conclusiones: El estudio mostró que la reactividad de los iones cúpricos con camu camu generó TBARS y el EDTA, tiourea y manitol mostraron actividad antioxidante a través de una reacción dependiente de la concentración. Estos radicales libres generados deben tomarse en cuenta al indicarse algunas combinaciones de alimentos en la dieta.

PALABRAS CLAVE

Cinética antioxidante, vitamina C, frutas, formación de TBARS, EDTA.

ABSTRACT

Introduction: Camu camu, a fruit from the Peruvian jungle, has a high content of vitamin C. This vitamin is highly antioxidant, but becomes pro-oxidant in the presence of transition metals, generating free radicals.

Objective: To investigate the reactivity of bioactive compounds, such as vitamin C, of camu camu with cupric ions.

Materials and methods: The reactivity of the cupric ions with the aqueous extract of camu camu was evaluated by thiobarbituric acid reactive substances (TBARS) method. The effects of Cu^{2+} concentrations ranged from 0.010 to 0.060 mM were observed. In order to inhibit the formation of TBARS the antioxidant capacity of thiourea, EDTA and

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mannitol was evaluated. The ascorbic acid content in camu camu was determined by the Jagota assay. Inferential statistics were used using the Pearson correlation coefficient (r) and simple linear regression.

Results: The cupric ions reacted with the aqueous extract of camu camu through an increased generation of TBARS as a function of time. The presence of various concentrations of Cu^{2+} in the reaction medium increased the generation of TBARS through saturation kinetics. The antioxidant potency to inhibit the generation of TBARS by the effect of copper on camu camu decreased in the following order EDTA> thiourea> mannitol, whose protection constants were 9.6 x 10^{-6} M, 4.2 x 10^{-5} M y 4.7 x 10^{-3} M, respectively.

Conclusions: The study showed that the reactivity of the cupric ions with camu camu generated TBARS and EDTA, thiourea and mannitol showed antioxidant activity through a concentration-dependent reaction. These generated free radicals should be taken into account when indicating some food combinations in the diet.

KEYWORDS

Antioxidant kinetics, vitamin C, fruits, TBARS formation, EDTA.

INTRODUCCIÓN

El camu camu, fruto que se cultiva en la selva del Perú tiene como principal característica poseer un elevado contenido de vitamina C. Esta vitamina es conocida por tener una alta capacidad antioxidante, efecto que se torna en prooxidante cuando se encuentra en un medio de reacción con metales de transición como el fierro o cobre.

El estrés oxidativo es una condición patológica caracterizado por un desequilibrio entre la generación de radicales libres y los compuestos antioxidantes, con predominio de los primeros, esta situación podría conducir progresivamente a una patología[1-4]. El ser humano dispone de un sistema antioxidante constituido por proteínas como la transferrina, ceruloplasmina, superóxido dismutasa, catalasa, etc., y compuestos no proteicos como el ácido úrico, glutatión reducido, etc., sistema que no es lo suficientemente eficiente para impedir la generación de radicales libres o bloquear su efecto nocivo sobre componentes celulares o vías de señalización celular, por cuyo motivo, debe incorporar en su dieta alimentos que le proporcionen agentes antioxidantes para reforzar su sistema antioxidante.

Las frutas y verduras son alimentos que pueden brindar diversos elementos antioxidantes tanto en cantidad como en calidad[2]. Un considerable número de publicaciones muestran la composición y eficiencia de los compuestos antioxidantes en estos alimentos, los que son una importante fuente de flavonoides, polifenoles, vitamina C, licopeno, antocianinas, b-caroteno, etc.

La vitamina C es un antioxidante que el ser humano no puede biosintetizar, por lo que depende de la dieta[5], siendo fuentes importantes de esta vitamina el limón, naranja, acerola, camu camu, entre otras. El contenido de esta vitamina en el camu camu alcanza valores que superan los dos gramos por cada 100 g de la parte comestible de esta fruta, motivo por el cual es una importante fuente del nutriente en referencia.

Se ha descrito que la vitamina C reacciona con metales de transición, como el hierro y el cobre, generando radicales libres, especialmente el radical hidroxilo[6] que es el más dañino para el ser humano. En trabajos previos hemos mostrado que el zumo de camu camu en presencia de ión férrico genera radicales libres, que podrían inhibirse con los antioxidantes EDTA, manitol y la tíourea. El objetivo del presente estudio fue investigar la reactividad de compuestos bioactivos del camu camu con iones cúpricos.

MATERIALES Y MÉTODOS

Diseño y Población de Estudio

El estudio es de tipo analítico, experimental, prospectivo y longitudinal. El fruto camu camu (*Myrciaria dubia*) se adquirió en INIA (Instituto Nacional de Innovación Agraria – Pucallpa - Perú), la que fue transportada por vía aérea a Lima, y luego al Laboratorio de Bioquímica Clínica y Nutricional del Instituto de Investigación de Bioquímica y Nutrición Alberto Guzmán Barrón de la Facultad de Medicina de la Universidad Nacional Mayor de San Marcos, donde se guardó en una congeladora a -8° C. Se descongeló la fruta y se procedió a separar la parte comestible que se utilizó para preparar un homogenizado al 25% con agua bidestilada utilizando un Potter-Elvehjem de vidrio, luego se centrifugó a 1,500 rpm durante 40 minutos en una centrífuga clínica a cuyo término se separó el sobrenadante que fue utilizado para realizar las determinaciones analíticas.

Variables y mediciones

Variables

Independiente: Extracto acuoso del camu camu – ion cúprico

Dependiente: Generación de radicales libres (TBARS)

Mediciones

Determinación de vitamina C

Determinación de Especies Reactivas al Ácido Tiobarbitúrico (TBARS), que indica la generación de radicales libres.

Reactivos químicos

El ácido tiobarbitúrico y desoxirribosa se adquirieron de la Sigma Chemical Company, el peróxido de hidrógeno, cloruro

ferroso, cloruro férrico, ácido ascórbico, etilendiamino tetraacético (EDTA), tíourea, fosfato monopotásico, ácido tricloroacético, manitol y sulfato de cobre fueron adquiridos de la empresa Merck Darmstadt.

Determinación de vitamina C

El contenido de vitamina C en el sobrenadante del camu camu se determinó utilizando la técnica propuesta por Jagota[7], para cuyo propósito se midió una alícuota del sobrenadante anteriormente obtenido se adicionó 0.5 mL de ácido tricloroacético al 10%, luego 0.2 mL del reactivo de Folin-Ciocalteu al 10% y finalmente agua para llevarlo a un volumen final de 2.0 mL. Se dejó en reposo durante 10 minutos y la densidad óptica se leyó en un espectrofotómetro a 760 nm, paralelamente se preparó un blanco que no tenía muestra. Para la expresión cuantitativa de los resultados experimentales se elaboró una curva de calibración con vitamina C.

Determinación de especies reactivas al ácido tiobarbitúrico (TBARS)

La determinación de las especies reactivas al ácido tiobarbitúrico (TBARS) se realizó utilizando la técnica propuesta por Gutteridge[8], para cuyo propósito el medio de reacción en un volumen de 2.0 mL contenía tampón fosfato de potasio 50 mM pH 7.4, sulfato de cobre 0.05 mM, desoxirribosa 2.8 mM y el sobrenadante del camu camu: 12.5 mg/mL. Se incubó a 37°C durante 20 minutos a cuyo término se adicionó 1.0 mL de ácido tricloroacético al 10% y 1.0 mL de ácido tiobarbitúrico al 1%, posteriormente se sometió a ebullición durante 15 minutos y se leyó a 532 nm en un espectrofotómetro. Paralelamente se preparó un blanco que no tenía muestra.

Todas las soluciones se prepararon con agua bidestilada. La solución de sulfato de cobre se preparó el mismo día en que se realizaron los experimentos. Todas las determinaciones analíticas se realizaron por triplicado.

Análisis Estadístico

De acuerdo a la naturaleza del tema correspondió utilizar la estadística inferencial de Coeficiente de correlación de Pearson (r) y la Regresión lineal simple (Ecuación lineal: Y= a + bX).

Donde: X= Extracto acuoso de camu camu – ion cúprico. Y= Generación de radicales libres (TBARS). Los datos se procesaron utilizando el programa informático Excel.

RESULTADOS

El camu camu es un alimento que posee uno de los más elevados contenidos de vitamina C de los frutos conocidos; la concentración de esta vitamina en las muestras que hemos utilizado en los experimentos que se describen a continuación, tenía un valor de 2,100 ± 180 mg/100 g de la parte comestible de la fruta.

La generación de radicales libres en función del tiempo se realizó en un medio de ensayo que contenía 12.5 mg/mL del extracto acuoso de camu camu a un pH de 7.4 con una concentración 0.05 mM de Cu^{2+}; este comportamiento del fruto se produjo a través de un proceso caracterizado por describir una curva de naturaleza hiperbólica durante los primeros 30 minutos de reacción (resultado no mostrado), que posteriormente adquirió un incremento de la absorbancia que fue de naturaleza aparentemente lineal hasta los 60 minutos en que duró la observación.

Con la finalidad de mostrar el comportamiento del camu camu en un medio de reacción que contenía iones cúpricos en diferentes concentraciones, se elaboró un medio de ensayo constituido por una concentración fija del fruto en presencia de concentraciones variables de ion cúprico comprendidas entre 10 y 60 uM. La descomposición de la desoxirribosa indica la intensidad en que son generados los radicales libres a través de la formación de especies reactivas al ácido tiobarbitúrico. Este experimento nos permite observar un incremento de la absorbancia a 532 nm, comportamiento que fue de naturaleza hiperbólica conforme se aprecia en la figura 1.

Cuando se regrafica este resultado en doble recíproca se obtiene una línea recta con un valor del Coeficiente de correlación de Pearson "r" de 0.9989 como se muestra en el inserto de la figura 1, donde también puede observarse que la recta tiene un intercepto en el eje de ordenada, lo que permite calcular una absorbancia de 1.607 a una concentración infinita de Cu^{2+}; estos resultados se ajustan a la siguiente ecuación.

$$\frac{1}{Abs.} = \frac{K}{X[Cu]} + \frac{1}{X}$$

Donde: Abs. = Absorbancia de la interacción del cobre y camu camu.

X = Absorbancia a una concentración infinita de cobre.

[Cu] = Concentración de cobre.

K = Constante cinética de interacción del cobre y camu camu.

El EDTA es un compuesto químico que tiene la propiedad de ligarse a diversos metales mediante enlaces de tipo quelato, característica que se aprovechó con la finalidad de observar el efecto que ejercería en un medio de reacción constituido por 12.5 mg/mL de camu camu, Cu^{2+} 0.05 mM y EDTA en concentraciones comprendidas entre 12.5 y 37.5 uM. La presencia de este compuesto en el medio de ensayo produjo una disminución en la absorbancia lo que indica que se está ejerciendo un efecto inhibidor de la generación de especies

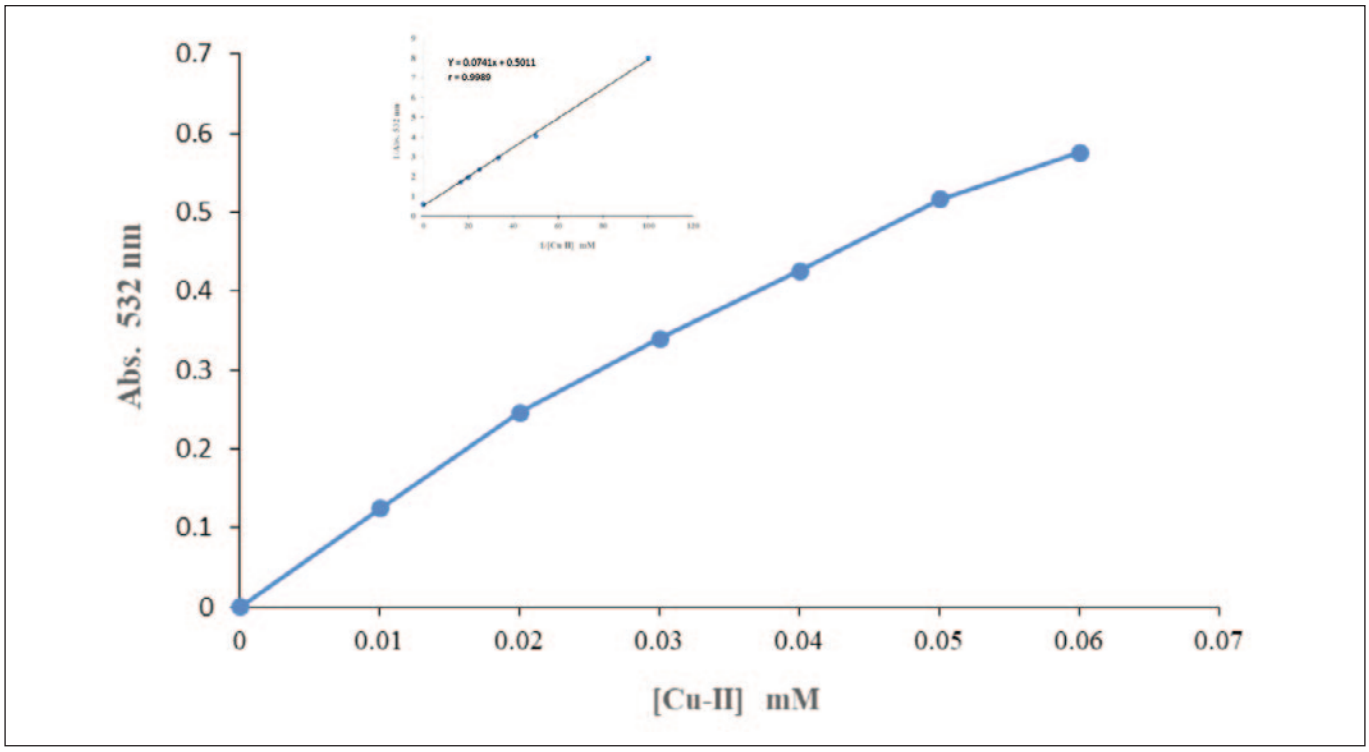

Figura 1. Cinética de reacción entre el camu camu (12.5 mg/mL) y diferentes concentraciones de ion cúprico en tampón fosfato 50 mM pH 7.4

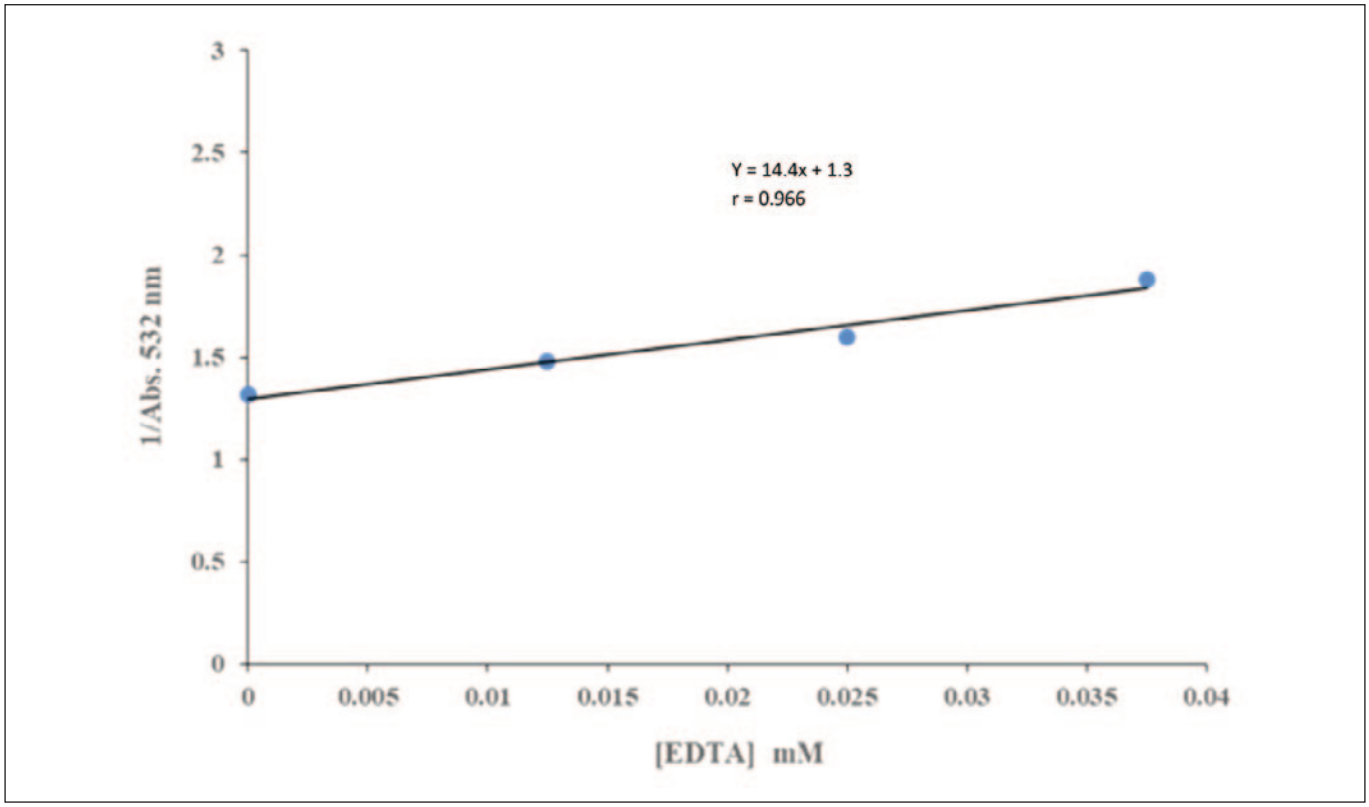

Figura 2. Graficación en recíproca simple del efecto de EDTA sobre la reacción del camu camu (12.5 mg/mL) y ion cúprico (0.05 mM) en tampón fosfato 50 mM pH 7.4

reactivas al ácido tiobarbitúrico, conforme puede observarse en la figura 2, en el que se grafica la inversa de la absorbancia en función de las concentraciones de EDTA, así mismo, se aprecia que este efecto es dependiente de la concentración del compuesto quelante con una correlación de Pearson de 0.9666. Las concentraciones de EDTA utilizadas en este experimento estuvieron por debajo de la concentración del ion cúprico y mostró una constante de inhibición de 9.6 x 10^{-6} M que se obtuvo de acuerdo con la siguiente ecuación:

$$\frac{1}{k°} = \frac{1}{k'} + \frac{[I]}{k'K}$$

Donde: k° = constante observada de la reacción en presencia del inhibidor EDTA (1/Abs. 532 nm).

k′ = constante de la reacción en ausencia de EDTA (Intercepto en eje de ordenadas).

K = constante de inhibición del EDTA.

I = concentración del compuesto inhibidor (EDTA).

La tíourea en un medio de ensayo constituido por 12.5 mg/mL de camu camu en presencia de Cu-II 0.05 mM, ejerció un efecto inhibidor en concentraciones comprendidas entre 0.025 y 0.15 mM, tal como se observa en la figura 3, donde se grafica la inversa de la absorbancia en función de la concentración de tíourea; en este gráfico es posible apreciar adicionalmente que la recta muestra una desviación positiva cuando se utiliza una concentración 0.15 mM de tíourea, es decir, una concentración tres veces mayor que la del Cu^{2+}. La constante de inhibición calculada para la tíourea fue de 4.2 x 10^{-5} M.

Un comportamiento análogo al obtenido con la tíourea se observó en un medio de ensayo similar al descrito anteriormente, es decir, constituido por camu camu, Cu^{2+} y concentraciones de manitol en un rango comprendido entre 7.5 y 25 mM. En este experimento se aprecia un efecto inhibidor de la generación de radicales libres ejercido por manitol. La respuesta observada está caracterizada por una desviación positiva que ocurre cuando la concentración de manitol es 25 mM, como se muestra en la figura 4 en la que se grafica la inversa de la absorbancia en función de la concentración de manitol; este gráfico sirvió para calcular una constante de inhibición de 4.7 x 10^{-3} M para este compuesto. La concentración de manitol que produce la desviación positiva corresponde a una concentración cinco veces mayor que la del Cu^{2+}.

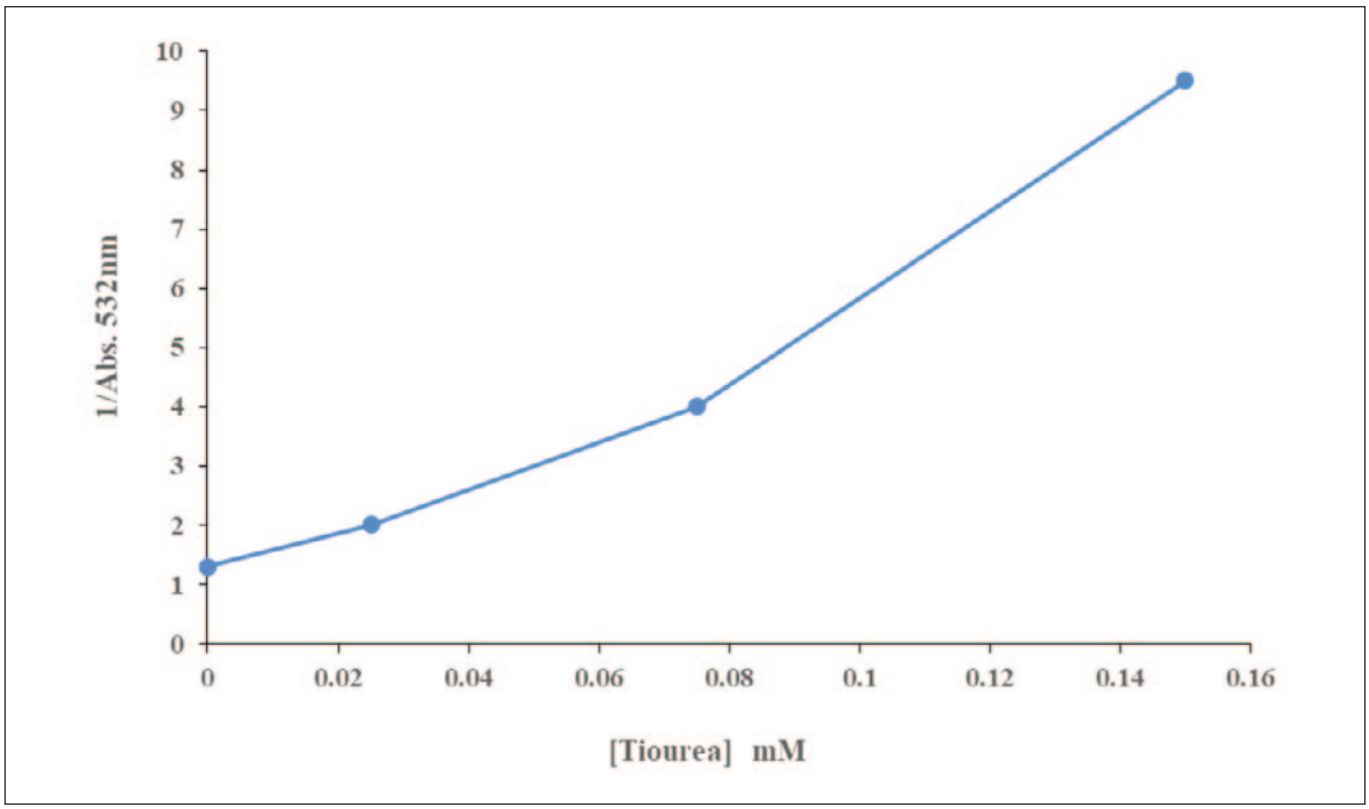

Figura 3. Recíproca simple del efecto antioxidante de tíourea sobre la reacción entre camu camu (12.5 mg/mL) y ion cúprico (0.05 mM) en tampón fosfato 50 mM pH 7.4

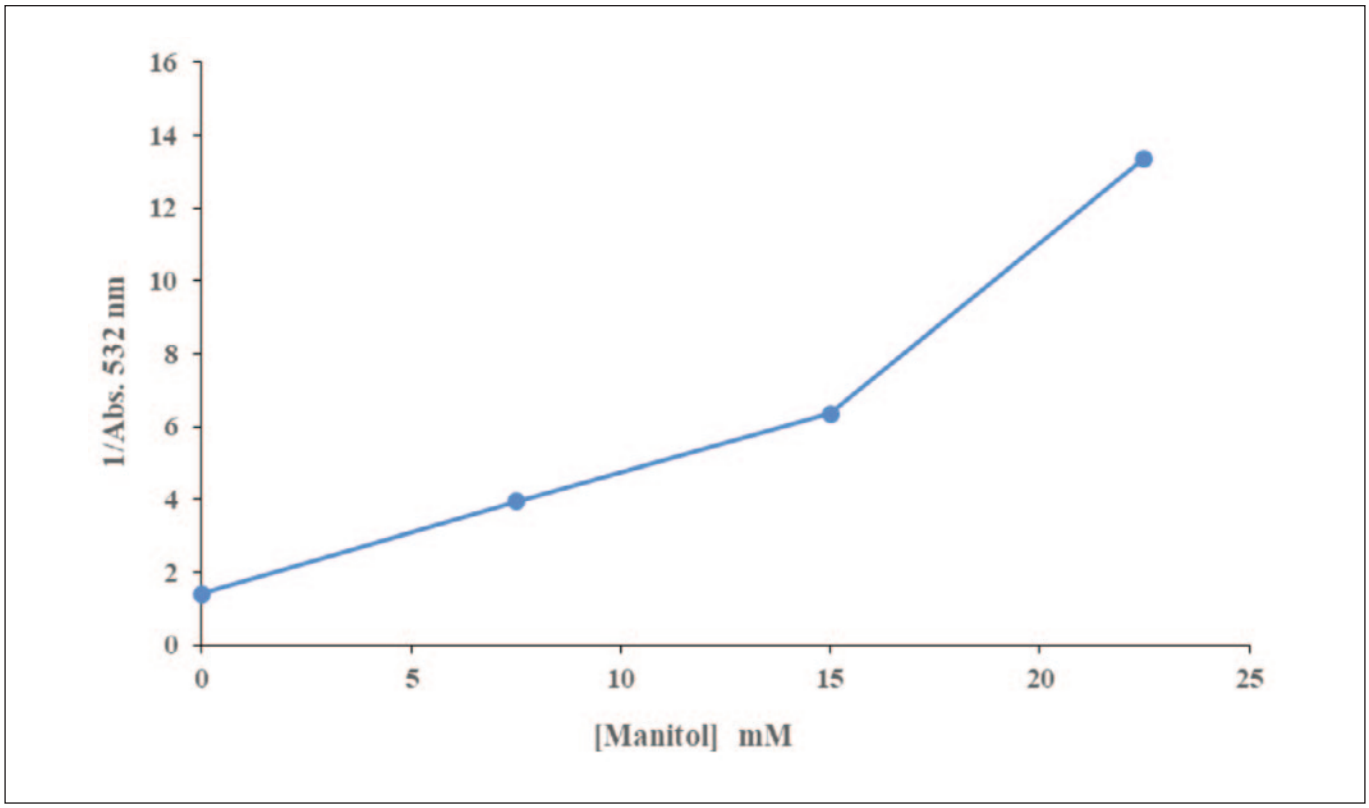

Figura 4. Recíproca simple del efecto de manitol sobre la reacción de camu camu (12.5 mg/mL) con ion cúprico (0.05 mM) en tampón fosfato 50 mM pH 7.4

DISCUSIÓN

Se ha mostrado anteriormente que 25 mg de camu camu reacciona muy rápidamente con una concentración 0.1 mM de Fe^{3+} generando radicales hidroxilo en función del tiempo[9]. Esta reacción alcanza un valor máximo a los 2 minutos y permanece invariable hasta los 10 minutos. En cambio, la reacción del camu camu con una concentración 0.05 mM de Cu^{2+}, en las mismas condiciones experimentales, reacciona de una manera menos intensa que con el Fe^{3+}; además, describe un tipo de efecto caracterizado por mostrar una curva de naturaleza hiperbólica durante los primeros 30 minutos, comportamiento que, considerando el diseño experimental, no es posible explicar su naturaleza.

Diversos estudios sobre la cinética y el mecanismo de la reacción que ocurre entre Cu^{2+} y ácido ascórbico, admiten que la reacción es bastante compleja pero sugieren una diversidad de reacciones intermedias[6] que podríamos simplificarla admitiendo la formación del radical L-ascorbato (HA·)[10], la formación de peróxido de hidrógeno y la reducción del Cu^{2+} a Cu^{+} por el ácido ascórbico.

El hecho de que en un medio de reacción constituido por camu camu y concentraciones crecientes de Cu^{2+} se incremente la generación de radicales hidroxilo de manera hiperbólica sugiere un proceso de saturación, comportamiento que se corrobora al obtener una línea recta al regraficar en doble recíproca estos resultados, lo que implica la existencia de una etapa limitante en la generación de los radicales hidroxilo. Para este tipo de reacción algunos autores sugieren un mecanismo de esfera interna cuya etapa limitante sería la formación de radical ascorbato[10]. Este comportamiento es similar al obtenido en un sistema constituido por camu camu y Fe^{3+} descrito anteriormente[9].

La reacción de descomposición de la desoxirribosa que se produce cuando reacciona el camu camu con el Cu^{2+} a pH 7.4, debe ocurrir de una manera análoga a la que sucede cuando en el medio de reacción conformado por seroalbúmina modificada por el reactivo de Ellman o ácido 5,5′-ditiobis(2-nitrobenzoico) (DTNB). El DTNB es un compuesto que de manera selectiva reacciona con los grupos sulfhidrilo de las proteínas formando un enlace disulfuro, este enlace fue escindido por el sistema ascorbato/Cu^{2+} liberando TNB (tionitrobenzoato)[6]. Esta reacción fue inhibida por catalasa, lo que indicaría que en la secuencia de reacciones se formaría peróxido de hidrógeno y al ser descompuesto por la enzima impediría la formación de radicales hidroxilo, conforme se ha descrito anteladamente por otros autores.

La presencia de manitol en el medio de ensayo anteriormente mencionado produce una inhibición del 16%, efecto

que no es tan eficiente como el ejercido por la tíourea que a una concentración menor ocasiona una inhibición considerablemente mayor (86%). Así mismo, el EDTA en una concentración estequiométrica con el Cu^{2+} inhibe casi completamente la ruptura de la albúmina-TNB por los radicales hidroxilos generados por el sistema ascorbato/Cu^{2+}. Este mismo sistema, no es inhibido por la superóxido dismutasa, hecho que muestra que en la secuencia de reacciones antes descrita no se formaría el anión superóxido[6]. El sistema de reacción constituido por camu camu y Cu^{2+}, que es similar al anteriormente citado, es inhibido de una manera bastante limitada por el manitol conforme lo indica su elevada constante de protección.

Se ha mostrado que el Cu^{2+} tiene la capacidad de promover la generación de radicales hidroxilo, para cuyo propósito es necesario la presencia de peróxido de hidrógeno y un agente reductor como el ascorbato; así mismo, la reducción de Cu^{2+} puede llevarse a cabo por acción del anión superóxido generado por el sistema hipoxantina y xantina oxidasa[11] y en consecuencia formar radicales hidroxilo. Es decir, el Cu^{2+} sería reducido por el anión superóxido formando Cu^{+} compuesto que reaccionaría con el peróxido de hidrógeno que se origina por la oxidación del ascorbato por oxígeno en presencia de Cu^{2+}. En el medio de ensayo que hemos utilizado no se formaría el anión superóxido debido a la inexistencia de un sistema generador de este radical libre.

La angiotensina I reacciona de manera selectiva con el sistema ascorbato/Cu^{2+}, modificándose uno de los residuos de histidina por acción de los radicales hidroxilo generados por el sistema antes mencionado[12]. Esta reacción es inhibida por la presencia de la enzima catalasa o del EDTA, lo que sugiere que en la reacción anterior se formaría peróxido de hidrógeno, pero el manitol ni el dimetilsulfóxido[12] pudieron evitar el efecto ejercido por el sistema ascorbato/Cu^{2+}, en cambio, en las reacciones que participa el camu camu el manitol ejerce un discreto efecto inhibidor.

El daño oxidativo ejercido por el Cu^{2+} se ha atribuido a su propiedad para generar radicales hidroxilo cuando está en presencia de ascorbato, peróxido de hidrógeno o conjuntamente con ascorbato y peróxido de hidrógeno, este efecto es inhibido de una manera bastante significativa por la tíourea, acción que es dependiente de la concentración de este compuesto. El manitol y dimetilsulfóxido ejercieron un efecto inhibidor muy discreto, los autores interpretan estos resultados admitiendo la reacción de quelación entre la tíourea y el Cu^{+} que formaría un complejo inactivo tíourea-cobre[13]. El efecto inhibitorio que ejercen la tíourea y el manitol sobre la reacción que se produce entre el Cu^{2+} y el camu camu sugiere que este proceso ocurre a través de la generación de radicales hidroxilo, afirmación que se sustenta por el hecho de que ambos compuestos son conocidos inhibidores de la acción nociva de los radicales hidroxilo, siendo el más eficiente la tíourea ya que tiene una constante de inhibición de dos órdenes de magnitud menor que el manitol.

La acetilcolinesterasa[14] es fuertemente inhibida por el sistema ascorbato/Cu^{2+}, proceso donde el ascorbato jugaría una doble función, reduciría al ion cúprico a ion cuproso, así mismo, se oxidaría por el oxígeno en presencia de Cu^{2+} para formar peróxido de hidrógeno compuesto que reaccionaría con el ion cuproso a través de la reacción de Fenton para generar el radical hidroxilo, que probablemente interaccionaría con la enzima ocasionando su inactivación; en este sistema de reacciones solamente el manitol ejerció un efecto protector pero a una elevada concentración que fue superior a 1 M, comportamiento que es similar al que observamos con el camu camu.

Se sugiere que el ascorbato suprima la generación del anión superóxido, sin embargo este mecanismo es dependiente de la localización de ascorbato en concentraciones elevadas en una célula, específicamente en los lugares donde actúan las NADPH oxidasas[15] que son las más importantes generadoras del anión superóxido, por cuyo motivo, es poco probable que el ascorbato tenga un rol relevante en atenuar la formación de especies reactivas de oxígeno durante el ejercicio físico y pueda afectar las vías de señalización redox celular.

Se ha observado que la administración simultánea de epigalocatequina galato, cobre y dietilditiocarbamato ejercen un efecto que es letal para los ratones, efecto que los autores sugieren que sea debido a que el dietilditiocarbamato podría actuar como un ionóforo que incrementaría los niveles hepáticos del cobre redox-activo, que promovería la auto-oxidación de la epigalocatequina galato para producir estrés oxidativo y toxicidad[16]; así mismo, produce una incrementada lipoperoxidación, daño al ADN y apoptosis celular.

Diversos compuestos utilizados como suplementos dietéticos pueden reaccionar con el cobre y niveles fisiológicamente relevantes de peróxido de hidrógeno, así como, comportarse como elementos pro-oxidantes generando radicales hidroxilo, cuya producción es dependiente de la naturaleza del compuesto antioxidante siendo el más eficiente para este tipo de reacciones la cisteína y en menor grado el ascorbato y glutatión reducido[17]. El cobre tiene la propiedad de ligarse a la albúmina sérica formando albúmina-Cu^{2+} siendo rápidamente reducido por ascorbato con una constante de segundo orden de 0.54 mM^{-1} min^{-1}, generándose como producto albúmina-Cu^{+} el que es posteriormente reoxidado por el oxígeno[18]; por cuyo motivo, es probable que las personas que padecen la enfermedad de Wilson, caracterizada por una elevada concentración plasmática de cobre no ligado a ceruloplasmina, tengan bajos niveles de ascorbato debido en parte a un proceso de oxidación que ocurriría por acción del complejo albúmina-Cu^{2+}.

Se tiene conocimiento que el tratamiento del cáncer comprende la terapia catalítica, que consiste en la generación de

radicales libres que se forman por la reacción que ocurre entre el ascorbato, un metal de transición como el cobre, en presencia de un extracto de planta medicinal[19]. El efecto citotóxico ejercido por el ascorbato en presencia de metales de transición conduce a la ruptura oxidativa del ADN ejercida por los radicales libres generados, lo que serviría para controlar el cáncer. La vitamina C es un nutriente de particular importancia en el ser humano[20-22] que participa en una amplia diversidad de procesos metabólicos, por cuyo motivo, es necesario realizar investigaciones más exhaustivas que permitan conocer apropiadamente funciones aún desconocidas de esta vitamina.

Hay evidencias que muestran un consumo inadecuado de vitamina C en pacientes que padecen de cáncer quienes fueron atendidas en un centro oncológico de referencia del Brasil[23]; situación similar se pudo apreciar en pacientes adultos mayores institucionalizados en Santiago de Chile, quienes presentaron niveles plasmáticos de vitamina C deficientes[24], por cuyo motivo la ingesta de alimentos con un aporte considerable de esta vitamina como es el camu camu sería de gran importancia en la mejora del estatus nutricional de los pacientes en referencia.

La facilidad que tiene el Cu^{2+} para reaccionar con el camu camu a través de la generación de radicales hidroxilo implica el cuidado que es necesario tener en consideración cuando se ingiere una fruta con elevado contenido de vitamina C y alimentos o medicamentos que tengan como uno de sus compuestos activos a metales de transición como el fierro o cobre, conforme ocurre con los pacientes que padecen de anemia ferropénica a quienes se les prescribe una sal ferrosa y se les recomienda que ingieran una bebida preparada con limón o naranja por el contenido de vitamina C, con el propósito de mejorar la absorción de hierro a nivel intestinal.

CONCLUSIONES

El ácido L-ascórbico contenido en el camu camu (*Myrciaria dubia*) reaccionaría con el Cu^{2+} generando radicales hidroxilo, este tipo de interacción es dependiente de la concentración de Cu^{2+} comportamiento caracterizado por describir una curva hiperbólica que implicaría la formación de un complejo intermedio limitante de dicho proceso. La tíourea, manitol y EDTA inhibieron la reacción antes citada, siendo el EDTA el compuesto más eficiente con una constante de protección de 9.6×10^{-6} M.

El alto contenido de vitamina C del camu camu le proporcionaría una alta capacidad antioxidante, pero, en presencia del cobre lo tornaría prooxidante generando radicales libres, lo que debería tomarse en cuenta para las decisiones al indicar algunas combinaciones de alimentos en la dieta.

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Formulation and sensory characterization of andean bread enriched with olluco flour (*ullucus tuberosus*)

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RESUMEN

Introducción: El pan es un alimento básico que aporta carbohidratos, proteínas y micronutrientes esenciales. Recientemente, ha aumentado el interés por harinas alternativas, como las de tubérculos, debido a sus beneficios para la salud, como su mayor contenido de fibra y almidón resistente, que favorecen la saciedad y mejoran el control glucémico.

Metodología: Este estudio evaluó la aceptabilidad sensorial de la harina de olluco, un tubérculo peruano, en la elaboración de pan. Se prepararon tres muestras con 30%, 50% y 70% de harina de olluco, evaluadas por un panel de diez expertos mediante una escala de Likert de 9 niveles y un diagrama de estrellas de 10 puntos. Para el análisis de los datos de la evaluación sensorial, se utilizaron los programas spps y excel.

Resultados: El análisis sensorial mostró que la inclusión de harina de olluco es viable, pero concentraciones superiores al 50% afectaron negativamente la aceptabilidad general. El pan con 30% de harina de olluco logró el mejor equilibrio entre valor nutricional y calidad sensorial.

Conclusiones: La incorporación de harina de olluco en pan es una estrategia prometedora para enriquecer productos horneados con ingredientes nutritivos. Las propiedades del olluco también permiten su aplicación en otras recetas, reduciendo calorías y mejorando la textura. Futuros estudios deben explorar formulaciones óptimas y aplicaciones más amplias.

PALABRAS CLAVE

Propiedades organolépticas, nutrición funcional, alimentos enriquecidos, valor nutricional, tradición culinaria.

ABSTRACT

Introduction: Bread is a staple food that provides carbohydrates, proteins, and essential micronutrients. Recently, there has been an increased interest in alternative flours, such as those from tubers, due to their health benefits, such as higher fiber and resistant starch content, which promote satiety and improve glycemic control.

Methodology: This study evaluated the sensory acceptability of olluco flour, a Peruvian tuber, in bread making. Three samples were prepared with 30%, 50%, and 70% olluco flour, assessed by a panel of ten experts using a 9-point Likert scale and a 10-point star diagram. For the analysis of the sensory evaluation data, the spps and excel programs were used.

Results: The sensory analysis showed that the inclusion of olluco flour is viable, but concentrations above 50% negatively affected overall acceptability. The bread with 30% olluco flour achieved the best balance between nutritional value and sensory quality.

Conclusion: The incorporation of olluco flour in bread is a promising strategy to enrich baked products with nutritious ingredients. The properties of olluco also allow for its application in other recipes, reducing calories and improving texture. Future studies should explore optimal formulations and broader applications.

KEYWORDS

Organoleptic properties, functional nutrition, fortified foods, nutritional value, culinary tradition.

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INTRODUCTION

Bread is one of the earliest staple foods and a significant energy source for humans[1]. It provides essential carbohydrates, proteins, and micronutrients[2]. Consumption varies widely, with the UK averaging 37 kg per capita annually and Turkey 150 kg. In Africa and Asia, consumption has increased due to convenience, while Europe has seen a decline. In the EU-27, total bread consumption is 19.75 million tons annually, or 39.3 kg per capita, comprising 7.3% of the food basket[3].The earliest records of yeast fermentation in bread date back to Ancient Egypt around 1300-1500 B.C. and China around 500-300 B.C. However, organized fermentation likely predates these records, with evidence suggesting early hominids fermented fruits with yeasts as far back as one million years ago[4]. This knowledge of fermentation spread from Egypt and Babylon to ancient Greece and Jewish cultures, and then to Rome, where bakers began kneading dough by hand. Professional bakers in Rome emerged around 168 B.C. after a conflict with King Perseus[5].

Bread has been made with various ingredients throughout history, with bread wheat (*Triticum aestivum*) being one of the most widely cultivated species globally[6]. A movement is emerging to use underutilized foods, like fruit peels and tubers such as Olluco, in bakery products[7]. A study incorporated 3.6% dried mango peels (Mangifera indica L.) into cookies to enhance nutrition. The enriched cookies had higher fiber and ash content but lower protein, with similar caloric values to control cookies. Sensory evaluation showed no significant differences in aroma, color, flavor, texture, or overall preference. These findings suggest mango peels can improve cookie nutrition without compromising sensory quality, highlighting their potential as a functional ingredient[8].

Tuber flours, particularly those derived from purple sweet potato, green banana, and taro, enhance the dietary fiber content of bread—especially resistant starch—while lowering the glycemic index(GI). These flours provide significant health benefits related to obesity and diabetes, with substantial evidence supporting their role in glycemic modulation[9]. Breads made with tuber flours contain considerably higher levels of dietary fiber and resistant starch compared to traditional wheat bread, which aids in glycemic control and promotes satiety. Resistant starch is particularly effective in reducing postprandial glucose spikes. Research consistently shows that breads made with tuber flour substitutions exhibit a lower GI. For example, purple sweet potato bread has a GI of 41.3, compared to 46.3 for wheat bread[10].

Tuber-based breads can assist in managing Type 2 diabetes and obesity by promoting satiety, lowering glycemic impact, and improving insulin response[11]. Both purple sweet potato and green banana flours demonstrate significant anti-diabetic potential. Optimal substitution ratios, such as 20–40%, achieve a balance between nutritional benefits and sensory acceptability. Higher substitution levels may lead to a denser texture or decreased consumer appeal[12].

The processing effects of techniques such as sourdough fermentation and heat-moisture treatment can enhance resistant starch levels and improve nutrient retention in tuber-based breads[13]. However, baking gelatinization may reduce the benefits of resistant starch in certain cases[14]. In summary, tuber flours, particularly those high in resistant starch, yield low-glycemic index(GI), fiber-rich bread formulations that offer significant advantages for managing obesity and diabetes when utilized effectively.

Starch is the most important food polysaccharide, primarily sourced from corn, cassava, potatoes, wheat, and rice. Despite global starch production exceeding 340.1 million tons in 2017, about 795 million people face food insecurity, and over 2 billion suffer from micronutrient deficiencies. While food production has increased, the Dietary Energy Supply (DES) in middle- and low-income countries, including parts of Latin America and the Caribbean, remains lower than in high-income countries. This has led to a growing interest in new nutrient sources to promote healthier lifestyles and support social and economic development. The Andean region is notable for its diverse roots and tubers, which are staple foods for the rural population due to their high starch content[15].

In Peru, unconventional tubers such as "mashua", "oca", and "olluco" have been cultivated since the time of the Incas. These plants are widely distributed in the highlands of South America and exhibit a variety of colors, including yellow, red, and purple. However, during storage, these tubers have a short shelf life of less than three months due to sprouting, which can alter their composition. The duration of storage depends on the specific variety and environmental conditions[16]. In Peruvian cuisine, these Andean tubers are commonly cooked and consumed. They are rich in essential dietary components, including starch, carotenoids, anthocyanins, and phenolic acids, with starch being the predominant component. These tubers are utilized in local dishes primarily because starch contributes to desirable texture and flavor properties. Furthermore, they serve various functional roles, such as thickening agents, colloidal stabilizers, gelling agents, fillers, and water retention agents. These functional characteristics largely depend on the content and ratio of amylose to amylopectin, the distribution of granule size, and the concentration of starch, among other properties[16].

Olluco (Ullucus tuberosus), also known as "papa lisa" or "melloco," is a vibrant and multicolored tuber cultivated by the indigenous people of the Andes for thousands of years[17]. Olluco was domesticated in the Andean region during the pre-Hispanic era approximately 5,500 years ago. It is commonly known as papa lisa, "olluco", or melloco in the central and

southern Andes, but it is best known as "olluco" in Spanish. Traditionally, the tuber is also recognized for its medicinal properties to treat burns and prevent scarring, although there is no known information about its efficacy, bioactive compounds, or mechanisms of action[18]. Its unique appearance and mild, slightly nutty flavor make it a highly valued ingredient in Peruvian cuisine[19]. Traditionally, Olluco is used in soups, stews, and salads[20], but recent culinary experimentation has expanded its applications to flour production. Olluco is an underutilized tuber from the Huancavelica highlands, found at various altitudinal levels[21].

Olluco typically grows at altitudes ranging from 2,800 to 3,800 meters above sea level, in areas somewhat sheltered from low temperatures. However, this tuber has also adapted to lower altitudes[22]. In tuberous plants, starch generally constitutes no more than 16-24% of their weight, with the remainder comprising water and other non-starch components[15]. The nutritional value of Olluco varies, as it contains carbohydrates (73.5% to 84.2%), proteins (8.5% to 15.7%), fats (0.1% to 1.4%), and fiber (0.5% to 5.0%). The primary sugars present are glucose, fructose, and sucrose, accounting for 13.1%, 11.1%, and 6.08%, respectively[22]. Olluco starch possesses desirable characteristics, such as high gel stability, making it suitable for food applications[23].

The skin of the Olluco displays a wide variety of colors, ranging from yellowish-white to magenta, and includes a broad spectrum of shades such as yellowish-green, yellow, orange, and pink. Betalains are water-soluble compounds found in a limited number of families within the Caryophyllales order, as well as in the genus Amanita of the Basidiomycetes. Their basic structure consists of a betalainic acid unit that condenses through the 3,4-dihydroxyphenylalanine (DOPA) cycle, along with derivatives of hydroxycinnamic acid and sugars, or amines and amino acid residues. This results in the formation of betacyanins (red/magenta) or betaxanthins (yellow/orange), respectively[24].

As bread has been a staple food in the human diet for centuries, there has been a growing interest in incorporating alternative flours into bread recipes in recent years to enhance their nutritional profiles and flavors. Therefore, we aim to investigate the potential of Olluco flour in bread-making, given its nutritional attributes, and to assess the degree of sensory acceptability based on the concentration of Olluco flour.

MATERIALS AND METHODS

In the present study, we formulated three samples of Olluco bread: Formula A (FA), Formula B (FB), and Formula C (FC). The bread was prepared using a combination of wheat flour and Olluco flour, which was produced in the laboratory from fresh Olluco (as illustrated in Figure 1). Additionally, milk, butter, sugar, salt, and eggs were incorporated into the recipes.

Process of Making Olluco Flour

To prepare Olluco flour, we first washed and sliced the Olluco using a mandoline. Next, we placed the slices in a dehydrator. The dehydration process for the Olluco slices takes approximately two days. After this period, we observed that about 40% of the initial volume is lost due to the high moisture content of the Olluco. Finally, the dehydrated Olluco slices were processed in a fine mill, where they were crushed and sifted to produce a fine Olluco flour (Figure 1). This flour exhibits a vibrant yellow color and retains the delightful aroma and flavor of Olluco, as illustrated in the accompanying figure. It is now ready to be used in the preparation of our bread.

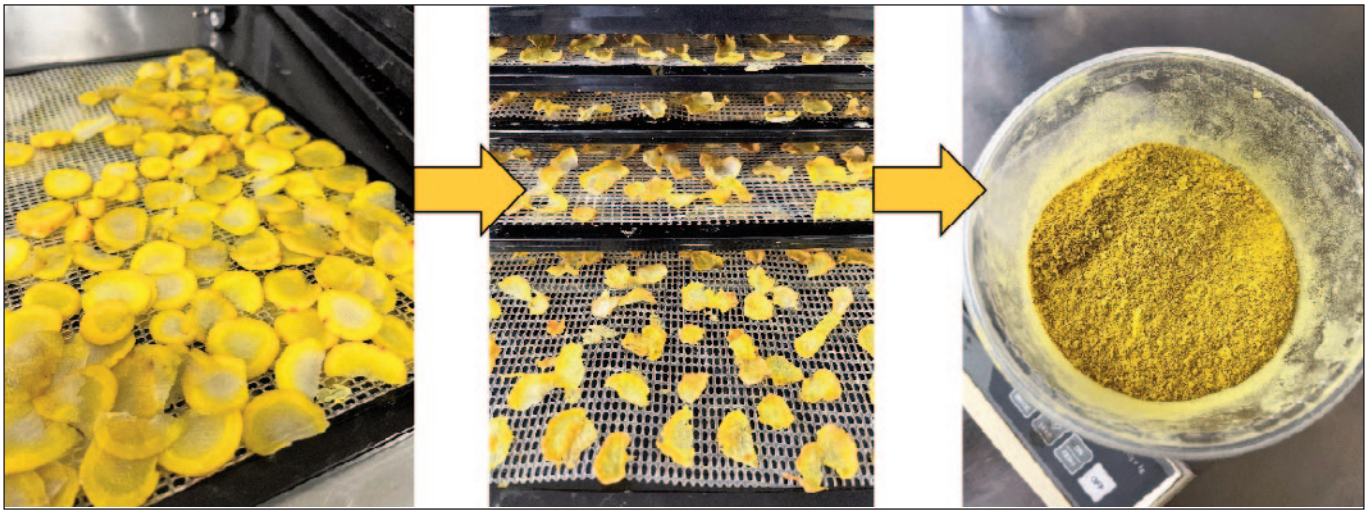


Figure 1. Process of making Olluco flour

Production of Olluco Bread dough

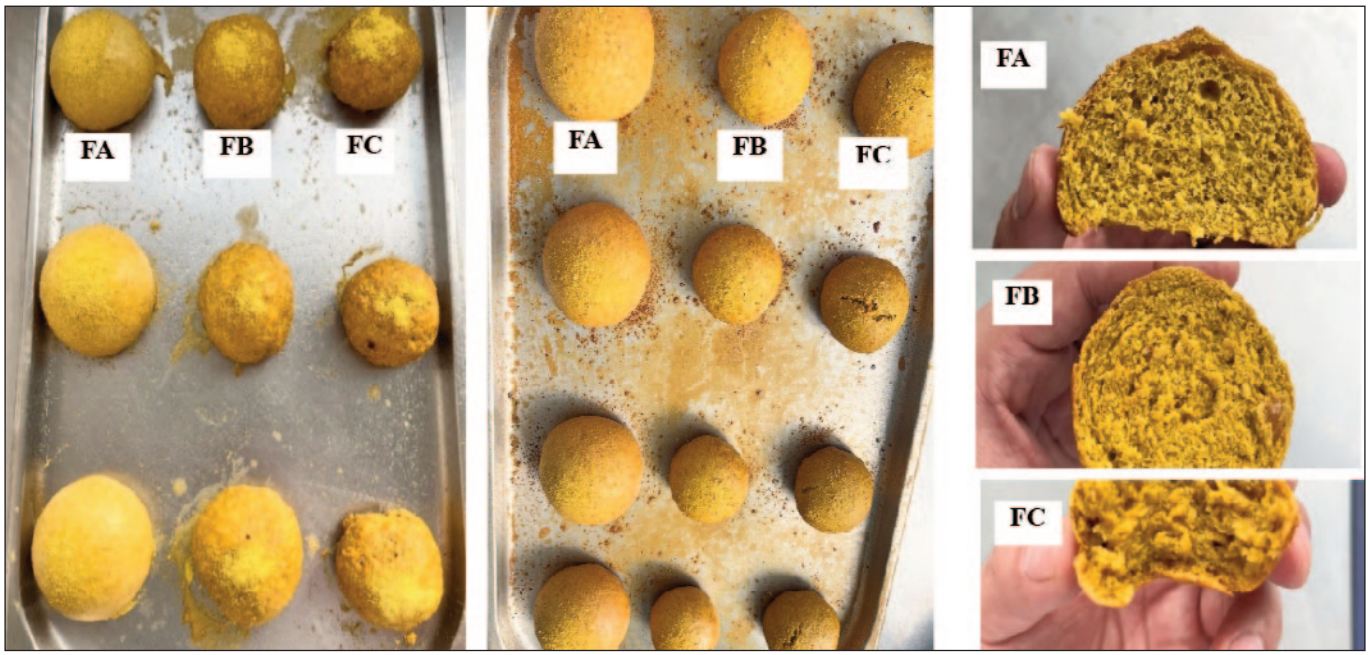


Figure 2. Images of Pre-Baking, Post-Baking and Crumb

Texture and baking characteristics

When incorporating Olluco flour into bread recipes, it is essential to consider its texture and baking characteristics. Olluco flour contains less gluten than wheat flour, which impacts the structure and elasticity of the bread. However, this can be mitigated by blending Olluco flour with wheat flour or by using additional binding agents. The result is typically a denser bread that remains moist and tender, featuring a distinctive crumb texture.

Formulation and Tests

To test various proportions of Olluco flour in our recipes, we began with a base recipe inspired by traditional potato bread. We then adjusted the amount of Olluco flour in three different ratios by combining it with wheat flour.

Among the three formulations, formulation A is distinguished by its superior flavor and texture. It exhibits minimal deviation from conventional bread and possesses a pleasant

Table 1. Ingredients of each Olluco Bread Formulations

Ingredients	Formulation (FA) 70% Wheat Flour, 30% Olluco flour	%	Formulation (FB) 50% Wheat Flour, 50% Olluco flour	%	Formulation (FC) 30% Wheat Flour, 70% Olluco Flour	%
Wheat Flour	840	51.22%	600	36.59%	360	21.95%
Olluco Flour	360	21.95%	600	36.59%	840	51.22%
Sugar	150	9.15%	150	9.15%	150	9.15%
Butter	100	6.10%	100	6.10%	100	6.10%
Salt	20	1.22%	20	1.22%	20	1.22%
Dry Yeast	20	1.22%	20	1.22%	20	1.22%
Eggs	150	9.15%	150	9.15%	150	9.15%
Total	1640	100%	1640	100%	1640	100%

taste profile. In contrast, formulation B offers a satisfactory flavor; however, its texture is challenging to maintain, resulting in a more crumbly consistency. Similarly, formulation C presents a flavor that is excessively intense due to the inclusion of Olluco flour.

Flavor and Aroma

A particularly fascinating aspect of incorporating Olluco flour into bread-making is its distinctive flavor and aroma. Olluco imparts a nuanced, nutty, and earthy taste to the bread, thereby enriching its overall flavor profile. Furthermore, the scent of freshly baked Olluco bread is both appealing and unique, providing a sensory experience for those interested in exploring novel culinary flavors.

Sensory Evaluation

A sensory evaluation of three bread samples made with Olluco flour (FA, FB, FC) was conducted with a panel of experts. This evaluation utilized both a Likert scale and a star diagram to identify additional sensory characteristics perceived by the expert panel. Furthermore, the sensory evaluation was conducted with an expert panel (n=10). The sensory evaluation utilized a nine-point scale: "Dislike Extremely", "Dislike Very Much", "Dislike Moderately", "Dislike Slightly", "Neutral", "Like Slightly", "Like Moderately", "Like Very Much" and "Like Extremely".

Statistical Methodology

In the analysis of sensory evaluation data, the Statistical Package for the Social Sciences (SPSS) software was employed. A normality test was conducted to determine whether the variables under investigation met the assumption of normality. Levene's test for equality of variances was utilized to evaluate the null hypothesis that the variances among the groups are equal. Following this, a homogeneity of variances test was performed, which indicated that the assessment of color would require a non-parametric approach due to the presence of a non-normal distribution. Subsequently, a one-way Analysis of Variance (ANOVA) and Tukey's post-hoc test were conducted. For the analysis of the color variable across the three samples exhibiting a non-normal distribution, the Kruskal-Wallis test was applied. For the remaining sensory characteristics, an ANOVA was performed, followed by Tukey's post-hoc test, to ascertain whether significant differences exist among the three olluco bread samples with respect to the sensory attributes of taste, flavor, texture, aroma, and overall acceptance. Additionally, Excel software was utilized to generate a star diagram representing the sensory attributes identified by the expert panel across the three samples of olluco bread.

RESULTS AND DISCUSSION

It is important to note that aroma, flavor, texture, and overall acceptance satisfy the assumption of homogeneity of variances. However, the color variable ($p<0.001$) does not meet this assumption; therefore, a non-parametric test, such as the Kruskal-Wallis test, was employed in this case.

Furthermore, after conducting a one-way ANOVA test, it was concluded that the significance value, $p<0.001$, is less than 0.05, leading to the rejection of the null hypothesis. Therefore, it can be inferred that there is a significant difference in the level of acceptance of the color among at least two of the three formulations of Olluco bread. However, there is no significant difference in the levels of acceptance regarding aroma, flavor, texture, and overall acceptance among at least two of the three formulations of Olluco bread.

The color analysis revealed significant differences among the formulations, with FC and FB, as well as FC and FA, showing notable variations. This is attributed to the fact that FB and FA were included in subset 2, while FC was part of subset 1. Conversely, no significant differences were observed in the color analysis between FB and FA, as both were contained within the same subset (subset 2). The panelists expressed a preference for FB and FA over FC, as evidenced by the higher scores: FC received a score of 5.40, while both FB and FA scored 8.10. According to the hedonic scale, the panelists favored the color of FB (7.30) and FA (8.10) significantly more than that of FC (5.40).

The means for groups within homogeneous subsets were analyzed using a Tukey HSD test across the three formulations of Olluco Bread. A significant difference in the means was observed only in the color analysis for the FC formulation (mean=5.40, $p<1.000$), while the FB formulation had a mean of 7.30 ($p<0.365$) and the second FC formulation had a mean of 8.10 ($p < 0.365$). In the aroma analysis ($p<0.292$), no significant differences were found among the three formulations, which yielded means of 6.10 for FC, 6.80 for FB, and 7.10 for the second FC. Similarly, in the taste analysis ($p<0.349$), no significant differences were detected among the formulations, with means of 6.20 for FC, 6.60 for FB, and 7.00 for the second FC. The texture analysis ($p<0.250$) also revealed no significant differences, with means of 6.00 for FC, 6.20 for FB, and 7.30 for the second FC. Finally, in the overall acceptance analysis ($p<0.504$), no significant differences were found among the three formulations, which had means of 6.50 for FC, 6.40 for FB, and 7.10 for the second FC.

Considering that the difference in means is significant at the 0.05 level, the results indicate that there is no significant difference in aroma between FA and FB, as the p-value exceeds 0.05. Similarly, there is no significant difference in aroma between FA and FC, with the p-value also greater than 0.05. The findings confirm that there is no significant differ-

Table 2. Descriptive statistics of Olluco Bread Formulations

		N	Mean	Standard deviation	Standard error	Confidence interval for mean at 95%.		Min.	Max.	Test	Sig.
						Lower limit	Upper limit				
Color	FA	10	8.10	.568	.180	7.69	8.51	7	9	Kruskal -Wallis	.001
	FB	10	7.30	.949	.300	6.62	7.98	6	9		
	FC	10	5.40	1.955	.618	4.00	6.80	3	8		
	Total	30	6.93	1.701	.310	6.30	7.57	3	9		
Aroma	FA	10	7.00	1.247	.394	6.11	7.89	5	9	ANOVA	.290
	FB	10	6.10	1.524	.482	5.01	7.19	4	9		
	FC	10	6.80	1.135	.359	5.99	7.61	4	8		
	Total	30	6.63	1.326	.242	6.14	7.13	4	9		
Taste	FA	10	7.10	.876	.277	6.47	7.73	6	8	ANOVA	.381
	FB	10	6.20	1.619	.512	5.04	7.36	3	8		
	FC	10	6.60	1.647	.521	5.42	7.78	4	9		
	Total	30	6.63	1.426	.260	6.10	7.17	3	9		
Texture	FA	10	7.30	1.418	.448	6.29	8.31	5	9	ANOVA	.232
	FB	10	6.20	1.549	.490	5.09	7.31	4	8		
	FC	10	6.00	2.261	.715	4.38	7.62	2	8		
	Total	30	6.50	1.815	.331	5.82	7.18	2	9		
Overall acceptance	FA	10	7.10	1.101	.348	6.31	7.89	5	8	ANOVA	.483
	FB	10	6.40	1.265	.400	5.50	7.30	4	8		
	FC	10	6.50	1.716	.543	5.27	7.73	3	8		
	Total	30	6.67	1.373	.251	6.15	7.18	3	8		

ence in aroma between FA and FC ($p > 0.05$). The difference in means is significant at the 0.05 level.

Furthermore, there is no significant difference in taste between FA and FB, as the p-value is greater than 0.05. There are no significant differences in taste between FA and FC, with the p-value exceeding 0.05. Additionally, there is no significant difference in taste between FB and FC ($p > 0.05$), as the p-value is greater than 0.05. In terms of texture, there is no significant difference between FA and FB, as the p-value is greater than 0.05. Likewise, there is no significant difference in texture between FA and FC, with the p-value exceeding 0.05. There is also no significant difference in texture between FB and FC ($p > 0.05$), as the p-value is greater than 0.05. Finally, there is no significant difference in overall acceptance between FA and FB, as the p-value is greater than 0.05. There is no significant difference in overall acceptance between FA and FC, with the p-value exceeding 0.05. Similarly, there is no significant difference in overall acceptance between FB and FC ($p > 0.05$), as the p-value is greater than 0.05.

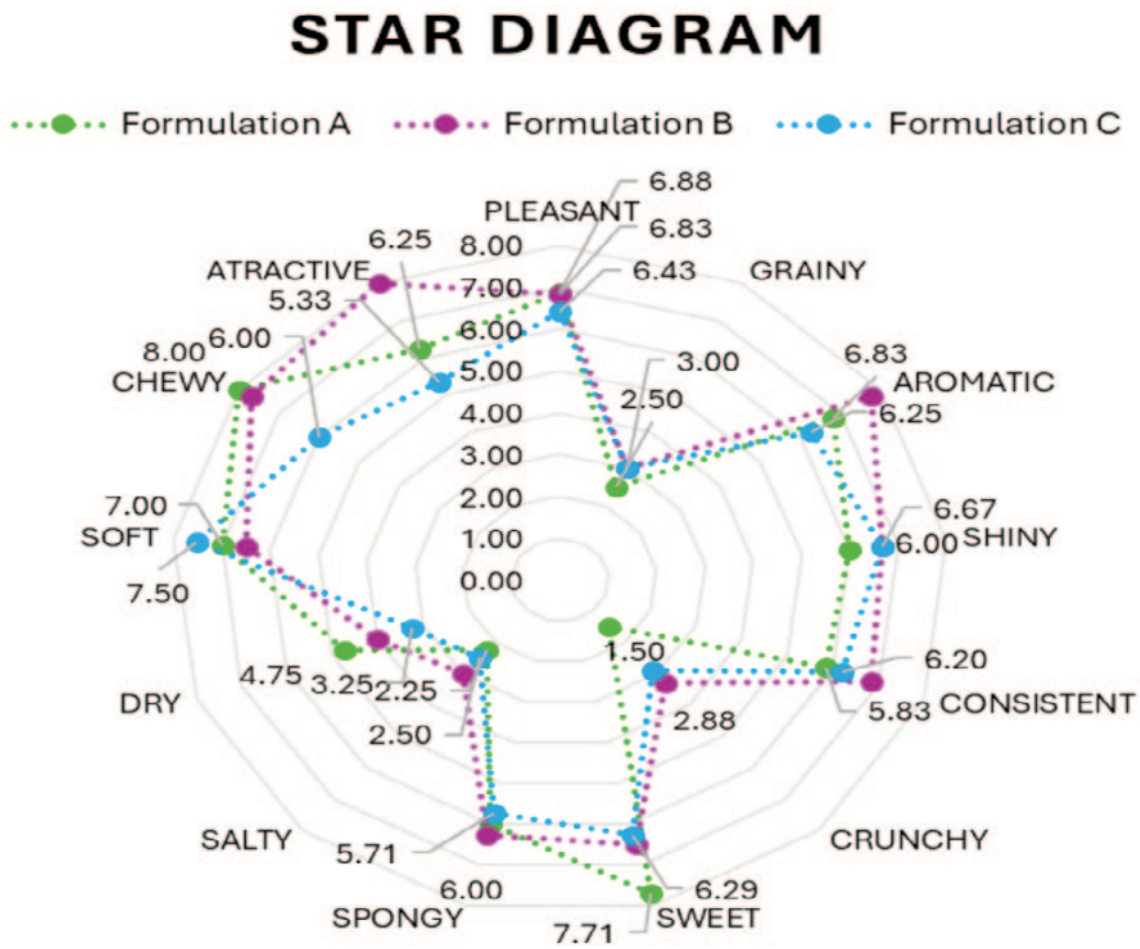
The star diagram illustrates the specific flavor characteristics evaluated by the expert panel. The most frequently noted characteristic was the sweet flavor in formulation FA of the Olluco bread, in contrast to formulations FB and FC. Another notable characteristic associated with Olluco flour is its aroma, with formulation FB being the most aromatic, followed

Table 3. Multiple comparisons (HSD de Tukey) statistics of Olluco Bread Formulations

Dependent variable	(I) Samples	(J) Samples	Mean difference (I-J)	Standard error	Sig.	Confidence interval for mean at 95%	
						Lower limit	Upper limit
Aroma	FA	FB	.900	.587	.292	-.56	2.36
		FC	.200	.587	.938	-1.26	1.66
	FB	FA	-.900	.587	.292	-2.36	.56
		FC	-.700	.587	.468	-2.16	.76
	FC	FA	-.200	.587	.938	-1.66	1.26
		FB	.700	.587	.468	-.76	2.16
Taste	FA	FB	.900	.638	.349	-.68	2.48
		FC	.500	.638	.716	-1.08	2.08
	FB	FA	-.900	.638	.349	-2.48	.68
		FC	-.400	.638	.807	-1.98	1.18
	FC	FA	-.500	.638	.716	-2.08	1.08
		FB	.400	.638	.807	-1.18	1.98
Texture	FA	FB	1.100	.797	.365	-.88	3.08
		FC	1.300	.797	.250	-.68	3.28
	FB	FA	-1.100	.797	.365	-3.08	.88
		FC	.200	.797	.966	-1.78	2.18
	FC	FA	-1.300	.797	.250	-3.28	.68
		FB	-.200	.797	.966	-2.18	1.78
Overall acceptance	FA	FB	.700	.619	.504	-.84	2.24
		FC	.600	.619	.603	-.94	2.14
	FB	FA	-.700	.619	.504	-2.24	.84
		FC	-.100	.619	.986	-1.64	1.44
	FC	FA	-.600	.619	.603	-2.14	.94
		FB	.100	.619	.986	-1.44	1.64

by FA and FC. The grainy texture was the least favored sensory attribute, receiving a score of 3 for both FB and FC, and 2.5 for FA. The most visually appealing presentation was achieved with formulation FB, which received a score of 8, compared to 6.5 for FA and 5.33 for FC.

Among the earliest studies on the sensory evaluation of Olluco, research conducted by Busch et al. (2000) assessed its characteristics. Only four panelists reported an unusual mouthfeel 15 minutes after the sensory evaluation, which may have been attributed to the low levels of saponins that can produce an aftertaste. Some panelists also detected an earthy flavor, mistakenly assuming that the tubers had not been thoroughly washed. However, it is customary in the preparation of traditional Peruvian dishes to rinse Olluco with water after chopping, prior to cooking. Conversely, New Zealand panelists expressed a preference for the red tubers over the yellow, green, and multicolored varieties, although they appreciated the flavors, texture, mealiness, and sweet-



Formulation (FA)-(70% Wheat Flour/30% Olluco flour). Formulation (FB) (50% Wheat Flour/50% Olluco flour) and Formulation (FC) (30% Wheat Flour/70% Olluco Flour)

Figure 3. Star Diagram

ness of all the evaluated cultivars, without demonstrating a clear preference for any specific type[25]. Notably, due to the distinctive flavor of Olluco, the formulation that received the least acceptance in our study was formulation C, which contained 70% Olluco flour and 30% wheat flour.

There are very few studies that incorporate olluco or olluco flour into various preparations, such as yogurt. The study conducted by Pérez et al., 2022 evaluated the enrichment of skim yogurt with 0.9% olluco flour through a sensory evaluation involving 20 semi-trained panelists, utilizing a 5-point hedonic scale. In contrast, our study employed a nine-point scale for sensory evaluation with a panel of experts. Notably, the most accepted product in our study was formulation A, which contained 30% Olluco flour, despite its higher Olluco content. Furthermore, Pérez's study found that the addition of Olluco flour to yogurt reduced fermentation time and resulted in a higher concentration of colony-forming units of lactic acid bacteria (CFU/g), thereby enhancing its probiotic contribution[26].

Another study conducted by Campos-Montiel et al. (2021) evaluated bread made with flour from a Peruvian tuber similar to olluco, specifically oca. They performed a sensory evaluation of gluten-free English bread made with oca flour, selecting 80 untrained judges and employing a 5-point hedonic scale. In contrast, our research utilized expert judges and a 9-point hedonic scale. The formulations that enhanced texture without compromising physical characteristics contained 6.6% and 13.2% oca flour. It is noteworthy that the amount of oca flour used in their study is significantly lower than the quantities we incorporated in our olluco bread study, where we used 30%, 50%, and 70% olluco flour across three formulations. Campos-Montiel's results indicated that the formula with 13.2% oca flour was the most preferred in the sensory evaluation, while in our study, the most accepted formula

contained 30% olluco flour. Regarding flavor and aroma, the 13.2% formulation was favored for its sweet aroma and balanced flavor. Similarly, in our study, all three formulations received high scores for sweet flavor. However, the evaluations of the three formulations concerning aroma contrast with those reported by Campos-Montiel, who noted low ratings for aroma due to the influence of the starches and the hydrocolloid used[27].

A study conducted by Manano et al. (2021) investigated the effects of cassava flour on bread quality through seven formulations: a control (0%), and experimental groups with 10%, 20%, 30%, 40%, 50%, and 60% cassava flour. The results indicated that the inclusion of cassava flour adversely affected the quality of the bread compared to the control, as evidenced by a reduction in bread volume. In terms of crust color evaluation, the scores ranged from 6.88 to 4.63, whereas our study yielded higher average scores for formulations FC, FB, and FA, with scores of 5.40, 7.30, and 8.10, respectively. Regarding flavor, the Manano study reported scores between 7.13 and 4.25, in contrast to our findings, which showed higher scores for FB (6.20), FC (6.60), and FA (7.10). For crumb texture, Manano et al. recorded scores from 6.5 to 4.63, while our study achieved higher scores of FC (6.00), FB (6.20), and FA (7.30). The overall acceptability in the Manano study ranged from 8.13 to 4.5, compared to our average scores of FC (6.50), FB (6.40), and FA (7.10). Notably, the formulation with 20% cassava flour exhibited the highest acceptability in the Manano study, whereas our study identified the formulation with 30% olluco flour as the most acceptable. Additionally, Manano observed a decline in sensory scores as the proportion of cassava flour increased[28].

In a study conducted by Jacinto et al. (2020), a sensory evaluation was performed on gluten-free breads made with potato peel flour, pumpkin seed flour, and quinoa flour. Three bread formulations were created using 2.5%, 5.0%, and 7.5% of each alternative flour. The formulation containing 5.0% of the alternative flours received the highest sensory acceptance, confirming that bread formulas with a lower percentage of olluco flour, similar to those in our study, or other types of flour, tend to achieve the highest overall acceptability[29]. A similar study conducted by Elkatry et al. (2023) evaluated the sensory characteristics of Arabic bread made with wheat flour, sweet potato flour, and sweet potato peel flour. Notably, the only samples that showed improvements in their evaluations were those formulated with 20% sweet potato flour, which received higher ratings for chewiness, roundness, and crumbliness. In contrast, our study found that the consistency, fluffiness, and softness of the three olluco flour formulations were rated positively, with scores ranging from 5.3 to 7.5. Additionally, the formulation containing sweet potato peel flour demonstrated increased chewiness and aroma, with evaluations exceeding a score of 6.25 across all three formulas[30].

CONCLUSIONS

We can conclude that incorporating olluco flour into bread formulations is viable; however, it is advisable to use percentages lower than 50% to enhance acceptability. The nutritional properties of olluco make this bread a significant alternative for enriching baked goods with underutilized ingredients globally, as it is a native Peruvian product. The physical characteristics of olluco also open up opportunities for various applications beyond flour, including the incorporation of cooked olluco in diverse recipes. There remains much to explore regarding the use of olluco flour in multiple preparations to reduce calories and improve texture. The research on bread made with olluco flour unveils a myriad of culinary possibilities, ranging from enhanced nutritional value to the exploration of unique flavors and textures. While incorporating olluco flour into bread recipes may necessitate some experimentation and adaptation, the outcomes are both satisfying and enriching. Moreover, this exploration highlights the significance of preserving and celebrating the culinary traditions of Peruvian cultures. As we continue to investigate alternative flours and ingredients, olluco flour undoubtedly merits a prominent position in our culinary experiments, as it not only produces delicious bread but also fosters a deeper connection with diverse food cultures.

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Nourishing diversity: exploring the relationship between food variety and anemia status among women workers

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ABSTRACT

Introduction: Anemia in working women is a significant health issue as it can reduce productivity, concentration and well-being. High workload, unbalanced food consumption patterns, and limited access to sources of iron and other micronutrients increase the risk of anemia.

Objective: This study aims to analyze food diversity related to the type and amount of food consumed by anemic and non-anemic women workers.

Method: This study used a cross-sectional design involving 140 women workers in rubber plantations in Seluma Regency, Bengkulu Province, Indonesia. Samples were taken using stratified random sampling technique. Anemia status was determined through biochemical examination and food consumption data was collected through 24-hour food recall method and minimum dietary diversity for women (MDD-W) indicator. The relationship between variables was analyzed using the correlation test.

Results: The prevalence of anemia among women workers was 35%, women workers with primary education had a higher prevalence of anemia (71.4%) compared to those with secondary education (18.1%). In the lowest income quintile the prevalence of anemia reached 42.9%, while in the highest income quintile it was only 20.6%. Women workers without anemia had better food consumption diversity (73.9%) than the anemia group (26.1%).

Conclusion: Education level, income and diverse food consumption had a significant relationship with anemia status. Consumption of tempeh, chicken liver, sardines and green leafy vegetables such as moss, moringa and melinjo leaves support iron sufficiency and play a role in preventing anemia

KEYWORDS

Iron, micronutrients, nutritional deficiency, women's health.

INTRODUCTION

Anemia is a global health problem that is directly related to the Sustainable Development Goals (SDGs), especially SDG 3 which focuses on health and well-being. Anemia in women of childbearing age is an important indicator that reflects malnutrition and underlying health problems. The main causes of anemia in this group are low nutrient intake, infections, and health conditions that can inhibit iron absorption[1]. Iron is an essential component of heme, the part of hemoglobin that binds oxygen. When iron levels in the body decrease, hemoglobin production also decreases, which in turn leads to a reduced ability of blood to transport oxygen to body tissues. This results in a decline in overall body function, affecting energy, physical endurance and cognitive health[2]. Anemia occurs when hemoglobin levels in the blood are lower than normal (<120 g/L) and is the main indicator for detecting iron deficiency. Iron deficiency anemia occurs when an adequate number of red blood cells cannot be maintained due to iron deficiency[3]. In 2021, it is estimated that about 33.7% of women aged 15-49 years worldwide suffer from anemia[1]. In Indonesia, the prevalence of anemia among women of childbearing age who were pregnant in 2018 reached 48.9%[4]. Despite some changes, the prevalence of anemia among women of childbearing age is still high in some regions. The main factors leading to this are iron deficiency and limited access to nutritious food[5].

Working women, especially those who do physical work such as in plantations, have a higher risk of developing anemia. This is due to working conditions that are often unhealthy

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and difficult to access[6]. In addition, conditions such as menstruation and pregnancy in women require an increase in adequate iron intake. If these needs are not met, then women become more susceptible to anemia[7]. Anemia also affects productivity, especially in those who perform heavy manual work. The reduction in productivity due to anemia has been recorded at 17%, and women workers are 1.4 to 2.6 times more likely to suffer from anemia than male workers[8].

Inadequate consumption of iron-containing foods is a major pathway to iron deficiency anemia because iron intake cannot meet the needs of hemoglobin and erythrocyte synthesis[9]. Increased dietary diversity has been shown to be associated with adequate micronutrient intake in women[10]. Studies on dietary diversity and iron deficiency anemia in women of childbearing age show that dietary diversity is a major factor influencing iron deficiency anemia[11,12], but these studies have not further examined the types of food consumed and associated with anemia conditions in women workers. Therefore, it is necessary to further study food diversity related to the type and amount of food consumed by anemic and non-anemic women workers to become a guideline in handling iron deficiency anemia in women workers.

RESEARCH METHOD

This study used a cross-sectional design and was conducted from February to April 2024 in a rubber plantation located in Seluma Regency, Bengkulu Province, Indonesia. This location was chosen because it has more than 200 women rubber tappers, as well as the willingness of the company to collaborate in the implementation of the study. The sample in this study consisted of women workers aged between 19 and 36 years who met the criteria for participation, namely not being pregnant and willing to become respondents by signing an informed consent letter. The sample size was determined based on the one-proportion estimation formula with an absolute level of precision[13]. Based on the calculation results, a sample size of 140 women workers was obtained. This study was approved by the Faculty of Public Health, Universitas Airlangga with permit number 41/EA/KEPK/2024. Prior to participation, each women worker who agreed to take part in this study received a full explanation of the purpose and procedures of the study, and they then gave written consent to participate. Measurement of hemoglobin level, which serves as an indicator of anemia status, was performed using a hematology analyzer type Mindray BC-10 [14]. In determining the severity of anemia, a person is considered not anemic if the blood hemoglobin level reaches or exceeds 120 g/L. Mild anemia is defined by hemoglobin levels in the range of 110-119 g/L, while moderate anemia is characterized by hemoglobin levels between 80-109 g/L. Severe anemia occurs when the hemoglobin level is below 80 g/L [3].

Data on respondent characteristics including age, education level and income were collected through a structured questionnaire. To determine the type and amount of food consumed, a food consumption survey was conducted using the 24-hour food recall method with a multiple-pass approach. This method is carried out by recording all foods and beverages consumed by respondents within the previous 24 hours, starting from the first food or drink consumed in the morning to the last food or drink in that period[15]. The types of food consumed were categorized by food group to assess the diversity of food consumption according to the Minimum Dietary Diversity for Women (MDD-W) indicator. Food types mentioned by respondents during the food consumption survey were classified according to food groups at the end of the interview. Micronutrient adequacy was considered achieved if a woman consumed at least five of the ten predefined food groups within 24 hours with a minimum consumption requirement of 15 grams per food type to be counted in the score. The scoring of this indicator is dichotomous, meaning that it yields a "yes" or "no" answer regarding the achievement of minimum food consumption diversity. If a woman consumes at least five of the ten recommended food groups in a 24-hour period, then the scoring result is "yes", indicating that the level of food consumption diversity has been achieved. Conversely, if the number of food groups consumed is less than five, the assessment is "no"[16]. For the amount of food consumed, it is calculated based on the median value of the consumption portion of each type of food within 24 hours.

Data processing and analysis were performed using the Statistical Program for Social Sciences (SPSS) software version 26 and Microsoft Excel Windows version 2019. A Mann Whitney U-test was conducted to determine the difference between two independent samples, the relationship between variables was analyzed using the Spearman rank correlation test that considers the level of significance, where a p-value <0.05 indicates a statistically significant relationship between the variables tested[17].

RESULT

Anemia status of women workers is obtained through examination of blood hemoglobin (Hb) levels, the average hemoglobin level of women workers was 126.2 g/L, with the lowest level being 101 g/L and the highest reaching 153 g/L. Based on severity, 35% of women workers were found to be anemic, of which 33.6% were in the mild anemia category and 1.4% in the moderate anemia category, with no women workers with severe anemia. Based on this percentage of anemia coverage, anemia among women workers is classified as a moderate public health problem[18].

Table 1 illustrates the characteristics of women workers in relation to anemia status. In the age variable, the proportion of anemia in different age groups does not show significant differences. For example, in the 19-25 age group, 25% of women workers are anemic, while in the 31-36 age group, the prevalence of anemia is slightly higher at 34.3%. In con-

Table 1. Characteristics of women workers

Variables	Anemia status		Total n (%)	*p* value
	Anemia n (%)	Non-anemic n (%)		
Age (year)				
19-25	2 (25.0)	6 (75.0)	8 (100)	0.979[1]
26-30	23 (37.1)	39 (62.9)	62 (100)	
31-36	24 (34.3)	46 (65.7)	70 (100)	
Education				
Primary education (6 years)	15 (71.4)	6 (28.6)	21 (100)	0.000[1]
Lower secondary education (9 years)	21 (44.7)	26 (55.3)	47 (100)	
Upper secondary education (12 years)	13 (18.1)	59 (81.9)	72 (100)	
Income				
Quintile 1	15 (42.9)	20 (57.1)	35 (100)	0.069[2]
Quintile 2	11 (31.4)	24 (68.6)	35 (100)	
Quintile 3	16 (44.4)	20 (55.6)	35 (100)	
Quintile 4	7 (20.6)	27 (79.4)	35 (100)	

1Mann Whitney U test.

trast, education level showed significant differences. Women workers with primary education (6 years) had a high prevalence of anemia, at 71.4%, compared to those with upper secondary education (12 years) who were only 18.1% anemic. The majority of women workers with upper secondary education, 81.9%, were not anemic. In the income variable, although the difference in anemia status between groups was not significant, an interesting trend was observed. In the lowest income quintile (quintile 1), 42.9% of women workers were anemic, while in the highest income quintile (quintile 4), only 20.6% were anemic. In contrast, the majority of women workers in the highest quintile, 79.4%, were not anemic.

More than half of the women workers did not meet the minimum dietary diversity. Non-anemic women workers had better food consumption diversity (73.9%) than anemic women workers (26.1%) and the difference was statistically significant (table 2). Variations in food consumption in terms of both types and amounts of food among anemic and non-anemic women workers are presented in table 3.

Table 2. Diversity of food consumption

Variable	Anemia status		Total n (%)	*p* value*
	Anemia n (%)	Non-anemic n (%)		
Diversity of food consumption				
Meet minimum food consumption diversity (≥5 food groups)	6 (26.1)	17 (73.9)	23 (100)	0.001
Does not meet minimum food consumption diversity (<5 food groups)	43 (36.8)	74 (63.2)	117 (100)	

*Mann Whitney U test.

Table 3. Food consumption pattern

Food group, food item	Food consumption						Iron per 100g EPW (mg)	*p* value[2]
	Anemia (n = 49)			Tidak anemia (n = 91)				
	Yes n (%)	No n (%)	Portion[1] (g)	Yes n (%)	No n (%)	Portion[1] (g)		
Grain, white rout and tubers, plantains	49 (100)	0 (0.0)		91 (100)	0 (0.0)			1.000
Glotinous rice	0 (0.0)	49 (100)	0	1 (1.1)	90 (98.9)	50	3.4	
Vermicelli, dried	1 (2.0)	48 (98.0)	50	1 (1.1)	90 (98.9)	10	1.8	
Ketupat	0 (0.0)	49 (100)	0	1 (1.1)	90 (98.9)	60	0.2	
Yellow noodles	1 (2.0)	48 (98.0)	120	6 (6.6)	85 (93.4)	130	1.3	
Rice	49 (100)	0 (0.0)	200	91 (100)	0 (0.0)	250	0.4	
Rice flour	0 (0.0)	49 (100)	0	4 (4.4)	87 (95.6)	40	0.8	
Wheat flour	9 (18.4)	40 (81.6)	20	21 (23.1)	70 (76.9)	15	1.3	
Noodles, dried	4 (8.2)	45 (91.8)	75	9 (9.9)	82 (90.1)	75	3.9	
Potato	3 (6.1)	46 (93.9)	60	6 (6.6)	85 (93.4)	52	0.7	
Sago palm	3 (6.1)	46 (93.9)	60	4 (4.4)	87 (95.6)	60	0.1	
Cassava	4 (8.2)	45 (91.8)	200	9 (9.9)	82 (90.1)	180	1.1	
Plantain	2 (4.1)	47 (95.9)	125	7 (7.7)	84 (92.3)	150	0.8	
Beans, peas and lentil	17 (34.7)	32 (65.3)		69 (75.8)	22 (24.2)			0.000
Mungbeans	1 (2.0)	48 (98.0)	10	2 (2.2)	89 (97.8)	30	7.5	
Tempeh	14 (28.6)	35 (71.4)	50	43 (47.3)	48 (52.7)	80	4.0	
Tofu	4 (8.2)	45 (91.8)	50	24 (26.4)	67 (73.6)	100	2.2	
Nuts and seeds	1 (2.0)	48 (98.0)		12 (13.2)	79 (86.8)			0.031
Peanut	1 (2.0)	48 (98.0)	10	12 (13.2)	79 (86.8)	17	4.1	
Dairy	0 (0.0)	49 (100)		0 (0.0)	91 (100)			1.000
Meat, poultry and fish	43 (87.7)	6 (12.3)		67 (73.6)	24 (26.4)			0.053
Beef	0 (0.0)	49 (100)	0	2 (2.2)	89 (97.8)	30	2.8	
Beef sausage	0 (0.0)	49 (100)	0	1 (1.1)	90 (98.9)	40	1.1	
Chicken	5 (10.2)	44 (8.,8)	60	14 (15.4)	77 (84.6)	60	1.5	
Chicken liver	0 (0.0)	49 (100)	0	3 (3.3)	88 (96.7)	30	15.8	
Chicken gut	0 (0.0)	49 (100)	0	1 (1.1)	90 (98.9)	30	8.4	
Fried anchovy	5 (10.2)	44 (89.8)	30	5 (5.5)	86 (94.5)	30	1.7	
Mullet fish	1 (2.0)	48 (98.0)	73	0 (0.0)	91 (100)	0	0.4	
Salt fish, dried	11 (22.4)	38 (77.6)	35	20 (21.9)	71 (78.1)	40	0.0	
Skipjack fish	2 (4.1)	47 (95.9)	67	4 (4.4)	87 (95.6)	80	2.9	
Cork fish	0 (0.0)	49 (100)	0	1 (1.1)	90 (98.9)	75	2.0	
Cutlassfish	0 (0.0)	49 (100)	0	6 (6.6)	85 (93.4)	60	2.2	
Carp fish	2 (4.1)	47 (95.9)	67	0 (0.0)	91 (100)	0	2.0	
Tilapia	2 (4.1)	47 (95.9)	72	3 (3.3)	88 (96.7)	80	1.0	
Long jawed mackarel fish	1 (2.0)	48 (98.0)	80	0 (0.0)	91 (100)	0	0.8	

Abbreviations: EPW, edible portion weight; g, gram; mg, milligram. [1] Using the 5th percentile. [2] Mann Whitney U test.

Table 3 continuation. Food consumption pattern

Food group, food item	Food consumption						Iron per 100g EPW (mg)	*p* value[2]
	Anemia (n = 49)			Tidak anemia (n = 91)				
	Yes n (%)	No n (%)	Portion[1] (g)	Yes n (%)	No n (%)	Portion[1] (g)		
Scad fish	3 (6.1)	46 (93.9)	40	6 (6.6)	85 (93.4)	60	0.5	
Catfish	0 (0.0)	49 (100)	0	1 (1.1)	90 (98.9)	80	1.6	
Fresh sardines	3 (6.1)	46 (93.9)	58	8 (8.8)	83 (91.2)	80	2.9	
Sepat fish	1 (2.0)	48 (98.0)	60	0 (0.0)	91 (100)	0	0.4	
Mackarel tuna fish	11 (22.4)	38 (77.6)	75	6 (6.6)	85 (93.4)	85	1.7	
Fresh anchovy	0 (0.0)	49 (100)	0	1 (1.1)	90 (98.9)	65	3.9	
Shrimp	0 (0.0)	49 (100)	0	1 (1.1)	90 (98.9)	25	8.0	
Eggs	12 (24.5)	37 (75.5)		28 (30.8)	63 (69.2)			0.434
Broiler eggs	12 (24.5)	37 (75.5)	40	28 (30.8)	63 (69.2)	65	3.0	
Quail eggs	0 (0.0)	49 (100)	0	1 (1.1)	90 (98.9)	45	3.1	
Dark green leafy vegetables	30 (61.2)	19 (38.8)		66 (72.5)	25 (27.5)			0.171
Spinach	5 (10.2)	44 (89.8)	77	13 (14.3)	78 (85.7)	80	0.5	
Leunca leaves	1 (2.0)	48 (98.0)	40	4 (4.4)	87 (95.6)	50	6.1	
Moringa leaves	2 (4.1)	47 (95.9)	55	1 (1.1)	90 (98.9)	65	6.0	
Pumpkin leaves	3 (6.1)	46 (93.9)	60	0 (0.0)	91 (100)	0	2.5	
Melinjo leaves	0 (0.0)	49 (100)	0	1 (1.1)	90 (98.9)	25	4.2	
Fiddlehead ferns leaves	2 (4.1)	47 (95.9)	80	8 (8.8)	83 (91.2)	80	2.3	
Papaya leaves	0 (0.0)	49 (100)	0	5 (5.5)	86 (94.5)	50	0.8	
Cassava leaves	10 (20.4)	39 (79.6)	72	27 (29.7)	64 (70.3)	75	1.3	
Genjer leaves	0 (0.0)	49 (100)	0	4 (4.4)	87 (95.6)	65	2.1	
Chinese convolvulus leaves	5 (10.2)	44 (89.8)	80	11 (12.1)	80 (87.9)	80	2.3	
Sauropus leaves	2 (4.1)	47 (95.9)	55	3 (3.3)	88 (96.7)	55	3.5	
Chives fresh	0 (0.0)	49 (100)	0	1 (1.1)	90 (98.9)	50	1.1	
Other vitamin A–rich fruit and vegetables	5 (10.2)	44 (89.8)		16 (17.6)	75 (82.4)			0.245
Mangos	0 (0.0)	49 (100)	0	2 (2.2)	89 (97.8)	120	1.0	
Papaya	0 (0.0)	49 (100)	0	4 (4.4)	87 (95.6)	150	1.7	
Tomatoes	5 (10.2)	44 (89.8)	25	13 (14.3)	78 (85.7)	25	0.6	
Carrot	4 (8.2)	45 (91.8)	21	11 (12.1)	80 (87.9)	55	1.0	
Sweet potato yellow	0 (0.0)	49 (100)	0	5 (5.5)	86 (94.5)	120	0.4	
Other vegetables	36 (73.5)	13 (26.5)		76 (83.5)	15 (16.5)			0.158
Beansprouts	3 (6.1)	46 (93.9)	30	2 (2.2)	89 (97.8)	50	1.3	
Fresh bean	4 (8.2)	45 (91.8)	32	8 (8.8)	83 (91.2)	60	0.5	
Papaya flower	2 (4.1)	47 (95.9)	27	1 (1.1)	90 (98.9)	35	4.2	
Sweet corn	2 (4.1)	47 (95.9)	55	6 (6.6)	85 (93.4)	55	0.5	
Oyster mushrooms	0 (0.0)	49 (100)	0	2 (2.2)	89 (97.8)	75	0.7	

Abbreviations: EPW, edible portion weight; g, gram; mg, milligram. [1] Using the 5th percentile. [2] Mann Whitney U test.

Table 3 continuation. Food consumption pattern

Food group, food item	Food consumption						Iron per 100g EPW (mg)	*p* value[2]
	Anemia (n = 49)			Tidak anemia (n = 91)				
	Yes n (%)	No n (%)	Portion[1] (g)	Yes n (%)	No n (%)	Portion[1] (g)		
Banana flower	1 (2.0)	48 (98.0)	113	1 (1.1)	90 (98.9)	120	0.1	
Broadbeans	0 (0.0)	49 (100)	0	2 (2.2)	89 (97.8)	80	0.7	
Yardlong beans	10 (20.4)	39 (79.6)	71	22 (24.2)	69 (75.8)	75	0.6	
Cauliflower	1 (2.0)	48 (98.0)	30	0 (0.0)	91 (100)	0	1.1	
Cucumber	1 (2.0)	48 (98.0)	83	3 (3.3)	88 (96.7)	75	0.8	
Cabbage	5 (10.2)	44 (89.8)	40	11 (12.1)	80 (87.9)	50	0.5	
Kundur	0 (0.0)	49 (100)	0	1 (1.1)	90 (98.9)	125	0.5	
Chayote	3 (6.1)	46 (93.9)	85	2 (2.2)	89 (97.8)	70	2.5	
Turnip	1 (2.0)	48 (98.0)	60	0 (0.0)	91 (100)	0	0.6	
Leunca fresh	0 (0.0)	0 (0.0)	0	1 (1.1)	90 (98.9)	50	1.0	
Melinjo fresh	1 (2.0)	48 (98.0)	30	1 (1.1)	90 (98.9)	15	2.8	
Squash	2 (4.1)	47 (95.9)	72	1 (1.1)	90 (98.9)	85	0.9	
White paria	2 (4.1)	47 (95.9)	45	1 (1.1)	90 (98.9)	60	0.9	
Papaya unripe	0 (0.0)	49 (100)	0	2 (2.2)	89 (97.8)	100	0.4	
Jackfruit raw	0 (0.0)	49 (100)	0	3 (3.3)	88 (96.7)	100	0.5	
Stinky bean	2 (4.1)	47 (95.9)	50	6 (6.6)	85 (93.4)	65	1.6	
Bamboo shoots	6 (12.2)	43 (87.8)	120	8 (8.8)	83 (91.2)	130	0.5	
Rimbang fresh	1 (2.0)	48 (98.0)	35	3 (3.3)	88 (96.7)	45	0.6	
Chinese cabbage	1 (2.0)	48 (98.0)	52	7 (7.7)	84 (92.3)	80	1.1	
Eggplant	5 (10.2)	44 (89.8)	80	16 (17.6)	75 (82.4)	85	0.4	
Other fruit	19 (38.8)	30 (61.2)		30 (32.9)	61 (67.1)			0.493
Dragon fruit	1 (2.0)	48 (98.0)	120	2 (2.2)	89 (97.8)	150	0.9	
Sweet oranges	1 (2.0)	48 (98.0)	60	2 (2.2)	89 (97.8)	100	0.4	
Avocado	1 (2.0)	48 (98.0)	50	1 (1.1)	90 (98.9)	150	0.9	
Duku	2 (4.1)	47 (95.9)	125	4 (4.4)	87 (95.6)	110	0.9	
Durian fresh	1 (2.0)	48 (98.0)	150	0 (0.0)	91 (100)	0	0.4	
Coconut flesh	0 (0.0)	49 (100)	0	1 (1.1)	90 (98.9)	120	1.4	
Langsat	0 (0.0)	49 (100)	0	2 (2.2)	89 (97.8)	125	1.1	
Longan	0 (0.0)	49 (100)	0	1 (1.1)	90 (98.9)	100	0.5	
Mangosteen	0 (0.0)	49 (100)	0	1 (1.1)	90 (98.9)	100	0.8	
Jackfruit ripe	0 (0.0)	49 (100)	0	1 (1.1)	90 (98.9)	150	0.9	
Banana ambon	1 (2.0)	48 (98.0)	160	1 (1.1)	90 (98.9)	120	0.2	
Banana kepok	2 (4.1)	47 (95.9)	150	4 (4.4)	87 (95.6)	150	0.5	
Banana uli	1 (2.0)	48 (98.0)	120	0 (0.0)	91 (100)	0	0.9	
Ramboosteen	11 (22.4)	38 (77.6)	150	13 (14.3)	78 (85.7)	200	0.5	
Sapodilla	0 (0.0)	49 (100)	0	1 (1.1)	90 (98.9)	100	1.0	

Abbreviations: EPW, edible portion weight; g, gram; mg, milligram. [1] Using the 5th percentile. [2] Mann Whitney U test.

Table 4. Correlation of education, income and food consumption with anemia status (Hb level)

Variables	Median (IQR)	Anemia status*	
		r	*p*
Education	1.600.000,00 (600.000,00)	0.347	0.000
Income	3.000.000,00 (1.500.000,00)	0.248	0.003
Diversity of food consumption	5 (1)	0.212	0.012
Consume beans, peas and lentil	1 (1)	0.342	0.000
Consume nuts and seeds	0 (0)	0.087	0.308

* Spearman rank correlation test.

All women workers consumed grain white rout and tubers, such as rice, with a higher portion in the non-anemic group (250 grams) than in the anemic group (200 grams). The food groups of bean peas and lentil as well as nuts and seeds showed significant differences. Women workers without anemia consumed more foods such as tempeh and tofu with a portion of 80 grams of tempeh containing 3.2 mg of iron, compared to the anemic group who only consumed 50 grams (2.0 mg of iron). Mungbeans, although little consumed, contributed the highest iron (7.5 mg for 100 grams), mainly consumed by the non-anemic group. Likewise, peanuts were consumed more by the non-anemic group with an iron contribution of 4.1 mg in 100 grams. In the animal food group, the consumption pattern shows the dominance of food consumption that contributes to iron intake in non-anemic women workers. Consumption of chicken liver as one of the highest sources of iron (15.8 mg for 100 grams) was only found in the non-anemic group. Fresh sardines were also consumed more by the non-anemic group, with a portion of 80 grams contributing 2.3 mg of iron, compared to the anemic group who only consumed 58 grams. Other types of fish, such as skipjack, fresh anchovies, and shrimp, were also consumed more frequently by non-anemic women workers.

Dark green leafy vegetables also showed a higher consumption pattern in the non-anemic group. Iron-rich leunca leaves (6.1 mg for 100 grams) were consumed more frequently by the non-anemic group than the anemic group. Other dark green leafy vegetables such as moringa leaves, melinjo leaves and katuk which contribute to iron intake are also consumed by women workers although in small amounts. Vitamin A-rich fruits and vegetables such as papaya, red tomatoes and carrots were consumed more frequently by the non-anemic group although with a small additional iron contribution. Meanwhile, other vegetable groups that contribute to iron intake such as chayote, melinjo fruit and papaya flower were found in the consumption pattern of women workers.

Table 4 presents the relationship between education level, income, and various aspects of food consumption with anemia status as measured by hemoglobin (Hb) levels. Correlation analysis showed a significant positive relationship between education level and anemia status, indicated by a correlation value (r) of 0.347 and $p < 0.001$. The analysis showed a significant positive relationship between income and anemia status, with a correlation value of 0.248 and a p value of 0.003. This indicates that higher income is associated with improved anemia status among female workers. Diverse food consumption was also analyzed, the correlation between diverse food consumption and anemia status showed a significant positive relationship, with a correlation value of 0.212 and a p value of 0.012. This indicates that more diverse food consumption tends to contribute positively to the improvement of anemia status. Meanwhile, the analysis showed a highly significant positive relationship between the consumption of this type of food and anemia status, with a correlation value of 0.342 and a p value of <0.001. This finding indicates that consumption of lentils and legumes plays an important role in improving anemia status. No significant association was found between consumption of these food types and anemia status.

DISCUSSION

Anemia, especially in the mild category, often goes undetected and can affect an individual's quality of life. Anemia can result in a variety of health problems, including fatigue, decreased endurance, and impaired concentration. Education and income levels are factors that influence anemia status. Women with low education have less access or opportunity to obtain information about proper nutrition and how to maintain a balanced food consumption pattern. This lack of knowledge can lead to suboptimal food consumption decisions such as low consumption of iron-rich foods[19]. Likewise, income can influence food consumption decisions. Studies on food consumption diversity in low- and middle-income countries conclude that there is inadequate consumption of diverse foods and micronutrient intake in most women[20]. Individuals with low incomes prioritize food quantity over nutritional quality, choosing cheaper and less varied foods when their income is limited[21,22]. Conversely, individuals with good disposable income have higher dietary diversity[23].

Iron in food consists of two types: heme iron found in animal foods such as red meat, fish and poultry, and non-heme iron found in plant foods such as beans, legumes and green leafy vegetables. Heme iron is absorbed more efficiently (15-35%) than non-heme iron (2-10%)[24]. Vitamin C and amino acids in the diet can increase the absorption of non-heme iron[25]. The mechanism occurs through increasing the solubil-

ity of non-heme iron and reducing its form to ferrous iron which is more easily absorbed by the body. Once absorbed through the gut, iron enters the intestinal mucosal cells and is bound by the protein ferritin as a form of temporary storage. Iron is then released into the bloodstream and transported by transferrin to the bone marrow, where red blood cell formation occurs. Iron is used in the production of hemoglobin, a protein in red blood cells responsible for carrying oxygen from the lungs to the rest of the body. Iron deficiency inhibits hemoglobin production leading to anemia and decreased oxygen-carrying capacity[26]. In addition to the need for iron, several other micronutrients also play a role in the prevention and treatment of anemia. Vitamin A, for example, helps mobilize iron from reserves in the body and vitamin B12 and folic acid are important for the formation of healthy red blood cells[27].

Anemia status is closely related to the diversity of food consumption. A less diverse diet has the potential to cause deficiencies in several important micronutrients such as iron and vitamin A which are associated with the risk of anemia[28]. There is a significant correlation between inadequate food consumption and low iron status, low consumption of iron-containing foods ultimately increases the risk of anemia[29]. The higher the food diversity, the more likely it is that women can meet their micronutrient needs[30]. The results showed that non-anemic women workers had better food consumption diversity than anemic women workers, with statistically significant differences. All respondents consumed grain white roots and tubers, but there was variation in other food types. The non-anemic group consumed more beans peas and lentils such as tempeh and tofu, with a larger portion of tempeh than the anemic group. Mung bean consumption, although limited, made a significant iron contribution and was more dominant in the non-anemic group. In the nuts and seeds group, peanuts were more frequently consumed by non-anemic women workers. Animal food consumption also showed a dominant pattern in the non-anemic group, especially chicken liver which was only consumed by this group. Fresh sardines, skipjack, fresh anchovies, and shrimp were also consumed more frequently with larger portions than the anemia group. Dark green leafy vegetables such as leunca, moringa, melinjo, and sauropus leaves were consumed more frequently by the non-anemic group, making an important contribution to iron intake. In addition, vitamin A-rich fruit and vegetables such as papaya, tomatoes, and carrots were consumed more by the non-anemic group, although their contribution to iron intake was relatively small. Some other vegetables such as chayote, melinjo fresh, and papaya flower are also part of the consumption pattern of women workers. Overall, the non-anemic group showed a more diverse and iron-rich food consumption pattern, especially from animal food sources, beans, peas, and dark green leafy vegetables.

CONCLUSION

Education level, income, consumption of diversified foods, and consumption of beans peas and lentils food groups had a significant association with anemia status. This shows the importance of education, economy and specific food consumption patterns in influencing anemia status in women workers. Women workers without anemia have more varied consumption patterns with larger portions, especially in iron-rich foods such as tempeh, chicken liver, fresh sardines and dark green leafy vegetables such as leunca, moringa and melinjo leaves. These food consumption patterns support iron sufficiency and play a role in preventing anemia.

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Blood glucose homeostasis, birth weight, and pancreas of rat pups during pregnancy the mother is intervened with food substitution beef bone marrow

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ABSTRACT

Background: The growth of the intrauterine pancreas in the fetus is very dependent on the mother's nutritional intake during pregnancy. Previous research on animal models found that mother rats during pregnancy who were given low-protein feed gave birth to offspring with lower pancreatic weight compared to rat offspring given normal diet. This study aims to evaluate the potential of feed nutrients substituted for bovine bone marrow in increasing intrauterine pancreatic growth with biomarkers of glucose homeostasis, birth weight and pancreatic weight in rat offspring.

Methods: This study employs an experimental study with in vivo design. During pregnancy, the Sprague Dawley rat animal model used in this study was intervened with Low Protein Feed (LPF), Normal Feed (NF) and Bovine Bone Marrow Substitution Feed (BBMSF). All formulated feeds are made isocaloric.

Results: there was a significant difference ($\alpha < 0.05$) in the blood glucose of rat offspring from mothers who were intervened with LPF, NF and BBMSF at the age of 60 days. Rat pups whose mothers were intervened with LPF, NF, and BBMSF during pregnancy had significant differences in body weight ($\alpha < 0.05$). There was no significant difference ($\alpha > 0.05$) in the weight of the pancreas of rat offspring from mothers who were intervened with LPF, NF and BBMSF at the ages of 30 and 60 days.

Conclusion: Rat pups from mothers who were intervened during pregnancy with bovine bone marrow substitute feed had a better ability to maintain blood glucose homeostasis, had a higher average birth weight and pancreatic weight compared to rat pups from NF and LPF mothers.

KEYWORDS

Dietary Supplementation, Fetal, Fetal Development.

INTRODUCTION

One of the organs most responsible for regulating blood sugar is the pancreas. The insulin hormone secreted by the organ's ß cells will be carried by the blood to the target cells where the insulin hormone then binds to the target cell receptor to open the glucose transporter (GLUT) gate so that glucose molecules can enter the cells[1]. Once in the cells, glucose will undergo further metabolism such as oxidation, glycolysis or glycogenesis[2]. An insufficient number of pancreatic beta cells will result in a decrease in the amount of insulin produced[3] causing disruption of blood glucose homeostasis resulting in hyperglycemia[4].

One of the factors that causes insulin production to be suboptimal is the insufficient number of pancreatic ß cells due to impaired cell proliferation that occurs during the intrauterine growth phase[3]. The factors causing disruption of cell proliferation are related to the mother's inadequate intake of nutrients needed to support this process (under nutrition) so that at birth the baby's ß-pancreatic cell number is also abnormal[5]. Change in people's dietary patterns will cause people with type 2 diabetes mellitus (T2DM) to continue to increase[6]. According to the International Diabetes Federation (IDF), the number of world people suffering from diabetes reached 537 million in

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2021 and is expected to increase to 783 million in 2045[7]. The number of diabetes sufferers in Indonesia reached 10.7 million people in 2019 and of this number, 219,083 people were found in Central Sulawesi spread across 13 districts (Profile-Dinkes-Sulteng-TA.-2019).

Overweight and obesity are the main risk factors in T2DM cases, apart from several other factors which are also known to act as risk factors, namely lifestyle and genetic factors[8]. Epidemiological studies show that malnutrition in the fetus during pregnancy plays a role in the incidence of T2DM[9]. Low birth weight is considered a form of malnutrition that occurs during pregnancy[10]. A meta-analysis study states that every 1 kg increase in birth weight will reduce the risk of T2DM by 20% [11] 2023).

The thrifty phenotype hypothesis states that there is a relationship between poor fetal and infant growth and an increased risk of developing T2DM and metabolic syndrome due to poor nutritional intake early in life[12]. This condition will result in permanent changes in glucose-insulin metabolism[13]. These changes can take the form of reduced insulin secretory capacity and which, combined with the effects of obesity, aging and physical inactivity, are the factors that most determine the incidence of T2DM[8].

Beef bone marrow is a food ingredient with a fairly high nutrient density. The results of analysis of the marrow indicated that it contains several essential fatty acids, vitamins and minerals which are needed to support cell proliferation during intrauterine growth[14]. Previous research also succeeded in showing that cow bone marrow substitute feed can increase intrauterine kidney growth[15].

METHOD

This research is a laboratory experimental study using the Sprague Dawley rat animal model with a completely randomized design (CRD). The factors involved in this research are intrauterine growth feed which consists of: NF (normal feed), LPF (low protein feed), BBMSF (bovine bone marrow substitute feed) which is isocalorically formulated[15].

Stage I Formulation and Manufacturing of isocaloric feed

At this stage, calculations were performed to determine the quantities of ingredients required for the production of NF (normal feed), LPF (low protein feed), BBMSF (bovine bone marrow substitute feed), using the formulas presented in Table 1.

Stage II. Acclimatization, mating and intervention

Rats to be used as animal models in this study will be acclimatized for 2 weeks and treated with anthelmintics.

Table 1. Intrauterine Growth Intervention Feed Formulation

Composition	Feed composition during pregnancy gr/kg		
	NF (normal feed)	LPF (low protein feed)	BBMSF (bovine bone marrow substitute feed)
Casein	180	90	176.10
Marrow protein	0	0	3.90
Folic acid	1	1	1
Corn starch	425	482	421.46*
Sucrose	213	243	213
Choline	2	2	2
DL-Methionine	5	5	5
Vitamins1	5	5	5
Minerals2	20	20	20
Cellulose	50	50	50
Corn oil	100	100	23.50
Marrow fat	0	0	76.50

Subsequently, once the female rats are in estrus, they will be mated by placing them in the same cage with male rats in a 2:1 ratio. During the mating process, vaginal checks will be conducted to confirm successful mating. If a vaginal plug is observed, the day of observation will be designated as day 0 of gestation. Pregnant dams will then be isolated in individual cages for intervention.

The gestation period of rats is approximately 21 days. After birth, the weight of each pup was recorded. Pups were weighed every 3 days to monitor their growth and development under different treatment conditions.

Phase III. Birth and rearing of stage IV rat pups, necropsy, pancreatic removal and blood sugar measurements.

Pups from each dam under the NF (normal feed), LPF (low protein feed), and BBMSF (bovine bone marrow substitute feed) treatments were monitored for growth and development by providing a standard commercial diet. At 1 and 2 months of age, blood samples were collected from the pups for glucose measurement using a glucometer. Prior to necropsy, the rats were anesthetized with ketamine-xylazine, and the pancreas was then excised and weighed.

Statistical analysis was performed using SPSS software, employing an Analysis of Variance (ANOVA) test. This research has received approval from the Ethics Commission No: 002503/KEPK POLTEKKES KEMENKES PALU/2024.

RESULTS

Blood glucose measurements of rat pups in this study were carried out after the rats were 60 days old. Blood glucose levels during 4-6 hours of fasting are one of the biomarkers to see the quality of the pancreas of rat offspring from mothers who were intervened during pregnancy with bovine bone marrow substitute feed. Data on the results of blood glucose measurements from each rat pup are presented in Table 2.

Table 2. Average blood glucose levels (mg/dL) of rat pups that were intervened with Normal Feed (NF) Low Protein Feed (LPF) Beef Bone Marrow Substitute Feed (BBMSF) at 60 days of age during pregnancy

Type of food	Blood glucose levels (mg/dL) (Mean ± SD)	p-value
Normal Feed (NF)	84.33 ± 16.64	0.027
Low Protein Feed (LPF)	120.90 ± 12.87	
Beef Bone Marrow Substitute Feed (BBMSF)	95.66 ± 17.60	

Table 2 presents the average blood glucose levels of 60-day-old rat pups whose mothers were fed different diets during pregnancy. The results indicate that there were significant differences in blood glucose levels among the three groups (p=0.027). Specifically, rat pups born to mothers fed a low-protein diet had significantly higher blood glucose levels compared to those born to mothers fed a normal diet. Interestingly, pups born to mothers fed a beef bone marrow substitute diet had intermediate blood glucose levels, suggesting a potential protective effect against hyperglycemia compared to the low-protein group.

Table 3 presents the average birth weight of rat offspring born to mothers fed different diets during pregnancy. The results indicate that there were significant differences in birth weight among the three groups (p=0.03). Specifically, rat pups born to mothers fed a normal diet had a significantly higher birth weight compared to those born to mothers fed a low-protein diet. Interestingly, pups born to mothers fed a beef bone marrow substitute diet also had a significantly higher birth weight compared to those fed a low-protein diet, although the difference was not as pronounced as compared to the normal diet group. The pancreas is a gland that is capable of secreting various types of hormones. One hormone that plays a very important role in regulating blood glucose is insulin which is secreted by the ß cell group of the gland. The ability of these glands to secrete the hormone in question decreases with increasing age[5]. In connection with the above, in this study evaluation of intrauterine pancreatic growth was carried out when rat pups were 30 and 60 days old.

Table 3. Average birth weight of rat offspring from mothers who were intervened with Normal Feed (NF) Low Protein Feed (LPF) Beef Bone Marrow Substitute Feed (BBMSF) during pregnancy

Type of food	Birth weight (gram) (Mean ± SD)	p-value
Normal Feed (NF)	6.46 ± 0.51	0.03
Low Protein Feed (LPF)	5.98 ± 0.45	
Beef Bone Marrow Substitute Feed (BBMSF)	6.82 ± 0.49	

After the mice were 30 days old, a necropsy was performed, the pancreas of each mouse was taken and weighed. The average weight of the pancreas of rat offspring from each mother who was intervened with NF, LPF and BBMSF during pregnancy is presented in Table 4.

Table 4. Pancreas weight of rat offspring from mothers who were intervened with NF, LPF and BBMSF feeds during pregnancy after 30 days of age

Type of food	Pancreas weight (gram), (Mean ± SD)	p-value
Normal Feed (NF)	0.16 ± 0.03	0.323
Low Protein Feed (LPF)	0.14 ± 0.05	
Beef Bone Marrow Substitute Feed (BBMSF)	0.17 ± 0.02	

Table 4 presents the average pancreas weight of rat offspring at 30 days of age whose mothers were fed different diets during pregnancy. The results indicate that there were no significant differences in pancreas weight among the three groups (p=0.323), suggesting that the type of maternal diet during pregnancy did not have a significant impact on the development of the offspring's pancreas.

After the other rat pups were 60 days old, stage 2 necropsy was carried out and data on the weight of the pancreatic of rat pups from each mother who was intervened with NF, LPF and BBMSF feeds is presented in Table 5.

Table 5. Average pancreatic weight of 60-day old rat pups from mothers who were intervened with NF, LPF and BBMSF during pregnancy

Type of food	Pancreatic weight (gram), (Mean ± SD)	p-value
Normal Feed (NF)	0.51 ± 0.06	0.341
Low Protein Feed (LPF)	0.44 ± 0.16	
Beef Bone Marrow Substitute Feed (BBMSF)	0.55 ± 0.13	

Table 5 presents the average pancreatic weight of 60-day-old rat pups whose mothers were fed different diets during pregnancy. The results indicate that there were no significant differences in pancreatic weight among the three groups (p=0.341), suggesting that the type of maternal diet during pregnancy did not have a significant impact on the development of the offspring's pancreas at 60 days of age.

DISCUSSION

The highest average blood glucose levels were found in rat offspring from mothers who were intervened with LPF during pregnancy, followed by rat offspring from mothers who were intervened with BBMSF, and NF (Table 1). Referring to Jensen T, et al (2013)[16] mice that are healthy and not diabetic will have fasting blood glucose (4-6 hours fasting) between 80-100 mg/dL, this means that rat offspring from mothers who were intervened with BBMSF have high levels of blood glucose of 95.66 mg/dL is still within the normal range or there is no hyperglycemia/diabetes (>135mg/dL). Even though the blood glucose levels of rat pups from mothers who were intervened with LPF have not yet entered the hyperglycemia range, they can be used as an indication of a disturbance in the regulation of blood sugar by insulin. According to Chen M, et al (1985)[17] as age increases, the ability of the pancreas will also experience a functional decline in producing insulin.

The results of the ANOVA analysis showed that the blood glucose levels were significantly different ($\alpha<0.05$), this is an indication that the cow bone marrow substitute feed intervention given to the mother during pregnancy had a significant effect on the ability of the offspring born to maintain blood glucose homeostasis. The ability to maintain glucose homeostasis is an illustration of the quality of the pancreas which can function optimally in secreting the hormone insulin. The increase in the quality of the pancreas is related to the effectiveness of cell proliferation that occurs during pregnancy due to the support of macro and micro nutrients contained in the intervention feed[13]. Macro and micro nutrients in beef bone marrow such as amino acids, fatty acids, fat soluble vitamins and macro and micro mineral content have an important role during the process of pancreatic organogenesis.

Beef bone marrow contains 16 types of amino acids, and 7 of them are essential amino acids (histidine, isoleucine, leucine, lysine, phenylalanine, threonine, phenylalanine) and 9 non-essential amino acids (arginine, tyrosine, serine, valine, aspartic acid, arginine, glycine and glutamic acid)[15]. The macronutrients integrated in beef bone marrow come from the essential fatty acid group such as α-linolenic acid, eicosapentaenoic acid (EPA) and docosahexaenoic acid[15]. Previous research stated that α-linoleic acid has the ability to maintain and support cell proliferation and differentiation processes[18]. α-linoleic acid is an important precursor in the formation of DHA and EPA fatty acids in the body. According to[19] fertile women have the ability to convert α-linoleic acid into DHA and EPA which are needed to support intrauterine growth. Apart from DHA and EPA which are the result of the lipogenesis process during intrauterine growth in mothers, DHA and EPA contained in cow bone marrow also contribute to increasing the growth of the pancreas in rat offspring (Tangkas et al., 2018).

The contribution of bovine bone marrow nutrients to intrauterine growth is also seen in the birth weight of rat offspring. The average birth weight of rat pups that came from mothers who were intervened with BBMSF food during pregnancy was significantly heavier than rat pups that came from mothers who were intervened with LPF feed.

The research results obtained in this study are in accordance with the results of research conducted by[20], which states that pregnant women in China have a higher risk of giving birth to babies with low birth weight compared to women who receive protein intake. the high one. In experiments using animal models, it was also found that rat mothers during pregnancy were intervened with low-protein feed which had an impact on the low birth weight of their offspring[21].

Even though it was not proven to be statistically significant, the average weight of the pancreas showed a different trend, in this case the rat offspring from mothers who were intervened with BBMSF had the heaviest pancreas compared to the offspring of LPF and NF rats. The unit used in measuring weight is grams, so if you compare and trace the number of cells, the difference will be very large.

The average weight of one mammalian cell is between 3 and 4 ng, therefore the difference between the weight of the pancreas of NF, LPF and BBMSF rat offspring can be calculated by the difference in the number of beta cells. The difference between the weight of the NF pancreas and the LPF when the rats were 60 days old was 0.0683 grams. After converting to nanograms, the difference became 68,300,000ng. If the weight of each cell is 3 ng, then NF rat pups have an excess number of pancreatic cells of 22,766,666 cells compared to the number

of pancreatic cells in LPF rat pups. Furthermore, the difference in pancreatic weight between BBMSF and LPF rat pups is 0.1133 grams. If converted into nanograms, the difference in pancreatic weight is 113,300,000 ng. If calculated, BBMSF rat pups have an excess number of pancreatic cells of 37,766,666 cells. As many as 75% of the excess number of cells are pancreatic beta cells which function to synthesize and secrete insulin to regulate blood glucose. Differences in the number of cells between the pancreas of rat offspring from BBSMF, NF and LPF parents have an impact on the ability of these glands to secrete pancreas and regulate blood glucose.

CONCLUSION AND RECOMMENDATIONS

Rat pups from mothers who were intervened during pregnancy with bovine bone marrow substitute feed had a better ability to maintain blood glucose homeostasis, had a higher average birth weight and pancreatic weight compared to rat pups from NF and LPF mothers.

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Concurrent validation and reliability of the silhouette scale to assess body image in adolescents living in a high altitude region of Peru

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ABSTRACT

Background: To verify the validity and reliability of the silhouette scale to assess self-perception of body image in adolescents living in a high altitude region.

Methods: A descriptive cross-sectional study was designed in 1149 adolescents (366 males and 783 females) with an age range of 12 to 17 years from an altitude region of Peru. The actual weight and height of the adolescents were evaluated. Body mass index (BMI) and Tri-ponderal Index (TPI) were calculated. Body image was evaluated through the silhouette method proposed by Stunkard (scale from 1 to 9 silhouettes). Concurrent validity was analyzed by Spearman correlations between the values of the body image scale and the anthropometric indicators.

Results: There was a moderate correlation between the silhouette scale and anthropometric indicators (BMI and TPI) in both sexes. In females it was (R= 0.52 to 0.56, p<0.001) and in males (R= 0.34 to 0.47, p<0.001). The limits of agreement of the Bland-Altman plot reflected a high degree of agreement between the measures (retest). The correlation coefficient of agreement in males was R=0.83. In females it was R= 0.90 and in both sexes it was R= 0.88. The mean differences in males were 0.18 points, in females 0.08 points and in both sexes 0.11 points.

Conclusion: The Stunkard silhouette scale is valid and reliable to assess body image in adolescents of both sexes in a high altitude region of Peru. The results suggest its use and application in contexts where anthropometric equipment is lacking.

KEY WORDS

Body perception, self-image, psychological factors, anthropometric assessment, mental health, adolescent development.

INTRODUCTION

Body image has been classically defined as the image of our own body that we form in our mind[1]. It is a complex psychological construct, which is composed of a body perceptual schema, emotions, thoughts and associated behaviors that influence the way a person relates to his or her own body and to his or her environment[2].

Body image is often influenced by various sociocultural factors, such as beauty ideals, social expectations and the media, which can shape the way people perceive and value their body[3-5].

In general, its assessment includes the subjective measurement of body size (how a person perceives his or her body), the estimation of body attractiveness (which body type a person considers most attractive), and perceptions related to one's own body shape and size[6]. On the other hand, in epidemiological studies quantitative measurement involves the use of objective tools, such as anthropometric tests (weight and height) and/or anthropometric indices[3]. These actual characteristics allow for a comprehensive assessment of body image at various stages of life.

In this context, the body image silhouette scale originally proposed by Stunkard et al.[7] represents one of the first tools developed that has been widely used to assess body image

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perception by silhouettes in diverse populations around the world[8,9]. In addition, several international studies have demonstrated its usefulness, validity and reliability when applied in adolescents from diverse sociocultural contexts[9-12].

These investigations highlight that, during the stage of growth and development, adolescence represents a period of intense and rapid physical changes, leading to an alteration in the perception of body characteristics. This can be a critical time for the development of body image[13]. Because dissatisfaction with one's own body can arise due to social pressures and beauty ideals. So, it becomes an important public health problem that can negatively influence various aspects of adolescent health. Such as self-esteem, eating, and emotional well-being, and may be related to eating disorders, depression, and anxiety[5,14].

In essence, given the diversity of body sizes by ethnicity and the social and cultural differences between populations, the Stunkard et al.[7] silhouette scale has not, to our knowledge, been validated for samples of adolescents living in a high-altitude region of Peru.

This suggests the need to adapt or develop instruments that consider the specific body characteristics of these populations. So that body perception can be accurately assessed in particular geographical and cultural contexts[3,12]. Moreover, we currently live in an increasingly multicultural and multilingual environment, in which scales are used as decision support in populations with diverse sociocultural characteristics[15]. Therefore, aspects such as climate, history, sociopolitical circumstances, health, economy and ethnicity could be relevant factors when measuring self-perception[16], especially for adolescents living in a high altitude region of Peru.

In general, physiological adaptation to high altitude conditions, may present differences in their physical growth and body adiposity compared to adolescents from other regions[17]. Which underlines the importance of having assessment tools that accurately reflect these particularities and promote a deeper understanding of their self-perception of body image in relation to their unique environment.

Therefore, the aim of the study was to verify the validity and reliability of the silhouette scale for assessing body image self-perception in adolescents living in a high-altitude region. The study seeks to determine if this tool is adequate to reflect the particularities of physical growth and body adiposity in this population, allowing an accurate assessment in relation to their unique geographic and sociocultural environment.

METHODOLOGY

Type of study and sample

A descriptive cross-sectional study was designed in 1149 adolescents (366 males and 783 females) with an age range of 12 to 17 years from an altitude region of Peru. The sample selection was non-probabilistic (convenience). Four secondary schools in the urban area of Puno (Peru) were evaluated. This region is located at 3820 meters above sea level.

The schoolchildren studied come from two main geographical areas and ethnic groups (Quechua and Aymara). For example, according to a previous study, Cossio-Bolaños et al.[17], consider indigenous schoolchildren as those whose parents have both surnames originating from the region (Quechua or Aymara) and mestizos, those who have at least one surname of Spanish origin, reflecting a mix between indigenous and European ancestry.

Schoolchildren who signed the informed consent form, those who completed the body image scale and the anthropometric measurements of weight and height were included. Those who were enrolled for the second time in the same grade and those who were not in the age range (12 to 17 years) were excluded. The study was conducted in accordance with the Helsinki declaration for human beings and the ethics committee of the Universidad Nacional del Altiplano, Puno, Peru (020/2023).

Techniques and procedures

A team of 4 physical education professionals was formed to collect data on body image and anthropometric measurements. All of them had ample experience in evaluations. Data collection was carried out in April and June 2024 at the schools' facilities.

The silhouette method proposed by Stunkard et al[7] was used to measure body image. The silhouettes or body sizes were organized in increasing order from left to right (these are on a scale of 1 to 9 for both sexes (1: thin and 9: obese). This procedure was carried out in the traditional way with pencil and paper and lasted approximately 10 to 15 minutes. The schoolchildren were first asked to choose their current body size. The silhouette categories were: silhouette 1 corresponded to thinness (BMI < 18.5), silhouettes 2 to 4 with normopesity (18.5 < BMI < 25), silhouette 5 with overweight (25≤ BMI< 30) and silhouettes 6 or higher with obesity (BMI ≥30). The silhouette scale was evaluated twice (test and retest). The interval was 7 days between both measurements.

Anthropometric measurements were evaluated using the protocol proposed by Ross-Marfell-Jones[18]. Weight and height were evaluated with as little clothing as possible (barefoot, shorts and T-shirt). For body weight, a Tanita digital scale (United Kingdom, Ltd.) with an accuracy of 0.1 kg and a range of 0.1 kg to 150 kg was used. For height, a portable stadiometer (Hamburg, Seca, Ltd.) with an accuracy of 0.1 mm and a measurement range of 0.0 cm to 220.0 cm was used.

Body mass index (BMI) was calculated using the formula: BMI = weight (kg)/height (m)2], the Tri-ponderal Index (TPI) was calculated using the formula: BMI = weight (kg)/height (m)3].

Statistics

The data set was subjected to the Kolmogorov-Smirnov K-S normality test. Descriptive statistics of arithmetic mean, standard deviation, range were analyzed. Significant differences between both sexes were verified by means of the t-test for independente samples. Concurrent validity was analyzed by Spearman correlations (nonparametric) between the values of the body image scale and the anthropometric indicators. For reliability, the intraclass correlation coefficient (ICC) and the Bland-Altman diagrams[19] were used to evaluate the concordance between test and retest of the body image silhouette scale. The significance of $p<0.05$ was adopted in all calculations. Calculations were performed in Excel spreadsheets, SPSS 18.0 and MedCalc 11.1.0.

RESULTS

Regarding the variables characterizing the adolescents studied, there were no differences in age between the sexes (p= 0.480). Males presented higher weight and height than females ($p<0.001$). On the contrary, females presented higher BMI, TPI and Current Image Perception than males ($p>0.001$). Table 1 shows the anthropometric characteristics and the mean and ± SD values of the Current Image Perception of the adolescents investigated.

The relationships between the body image silhouette scale and anthropometric indices such as BMI and PTI in both men and women reflect a moderate relationship. This means that as the value of the silhouette scale increases, the values of anthropometric indices such as BMI and ITP also increase. These relationships were stronger in women (R= 0.52 to 0.56, $p<0.001$) than in men (R= 0.34 to 0.47, $p<0.001$). Table 2 shows the correlations between the study variables.

The limits of agreement of the Bland-Altman plot are shown in Figure 1. For males in the retest of the silhouette scale ranged from -1.50 to 1.9 points. In females it ranged from -1.08 to 1.30 points and in both sexes it ranged from -1.2 to 1.5 points. The concordance correlation coefficient for males was R=0.83. In females it was R= 0.90 and in

Table 1. Characteristics of the sample studied

Variables	Males (n= 366)		Females (n= 783)		p
	X	SD	X	SD	
Age (years)	15.0	1.4	15.2	1.4	0.480
Anthropometry					
Weight (kg)	55.5	11.2	54.0	9,0	0.013
Height (cm)	163.2	8.6	154.7	5.2	0.001
Anthropometric indices					
BMI (Kg/m^2)	20.8	3.6	22.5	3.4	0.001
TPI (Kg/m^3)	12.8	2.7	14.6	2.3	0.001
Perception of current image (PCI)	3.4	1.5	3.9	1.3	0.001

X: Mean, SD: Standard deviation, BMI: Body mass index, TPI: Tri-ponderal index.

Table 2. Relationship between the values of the silhouette scale with anthropometric indicators in both sexes

Anthropometric Indexes	Males		Females		Both sexes	
	R	p	R	p	R	p
BMI (Kg/m^2)	0.47	0.001	0.56	0.001	0.54	0.001
TPI (Kg/m^3)	0.34	0.001	0.52	0.001	0.47	0.001

BMI: body mass index, TPI: Tri-ponderal index.

both sexes it was R= 0.88. The mean differences in men were 0.18 points, in females 0.08 points and in both sexes 0.11 points.

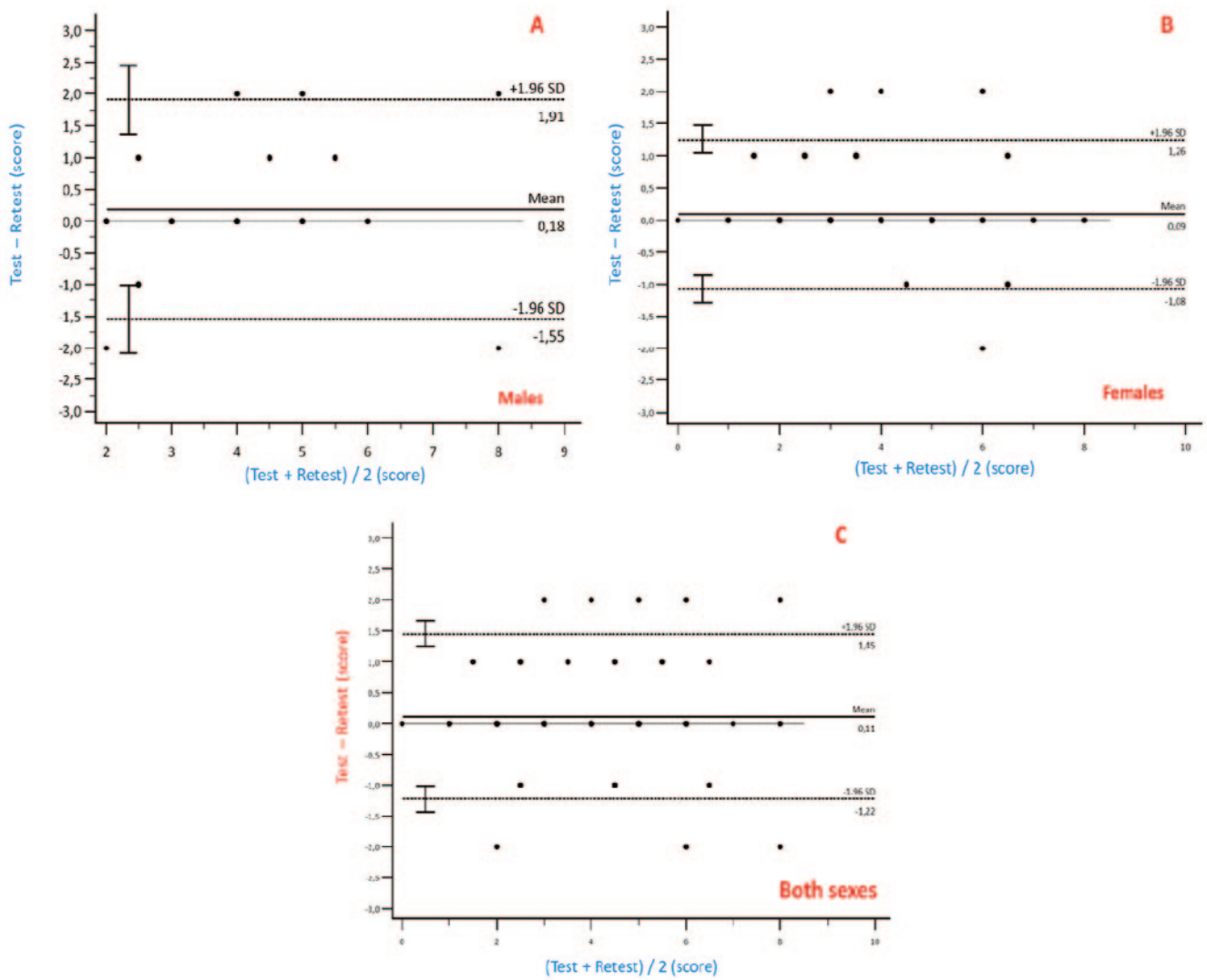
The comparisons of the anthropometric indicators (BMI and TPI) aligned according to silhouette scale (from 1: Thin, 2 to 4 normopeso, 5: Overweight and >6: Obesity) in both sexes are observed in Figure 2. For example, in BMI, females presented significantly higher values in relation to males from silhouette 3-4-5-6, whose values are higher from 1. 45 to 2.02kg/m2, and in the TPI, females presented higher values in silhouettes 2-3-4-5-6 compared to men, these values being higher from 1.02 to 2.03kg/m3, however, in silhouette 1 and 7 there were no significant differences.

DISCUSSION

The aim of the study was to verify the validity and reliability of the silhouette scale for assessing self-perception of body image in adolescents living in a high altitude region. The study sought to verify concurrent validity, using as a method the actual BMI values and reliability through retesting.

The results have shown that the silhouette scale of Stunkard et al[7] is a good indicator to assess body image in relation to anthropometric indicators (BMI and TPI), both in males and females, although slightly stronger in females.

The results obtained in this study indicate that the correlations between silhouettes and anthropometric indicators were



A: Males, B: Females, C: Both sexes.

Figure 1. Bland-Altman plot evaluating the concordance between test-retest of the silhouette scale to assess body image in adolescents

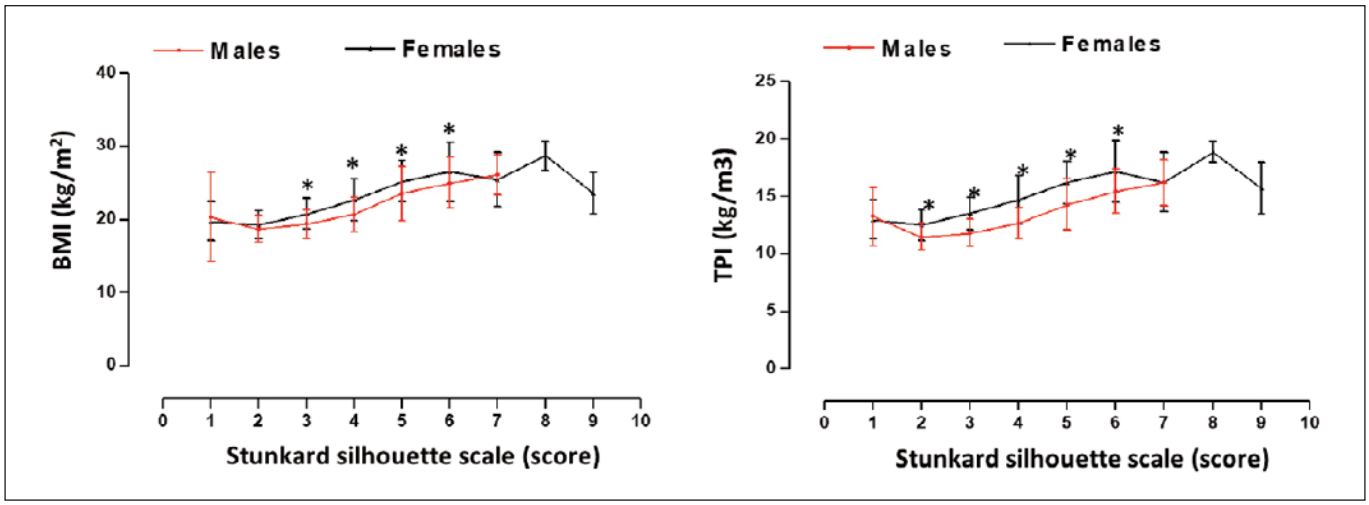


Figure 2. Comparison of anthropometric indicators (BMI and TPI) along the silhouette scale assessing body image in adolescents of both sexes

relatively low (r= 0.47 to 0.54) compared to the higher correlations reported in previous international studies (r= 0.70 to 0.80)[3,9]. This discrepancy could be attributed to the methodology used in those studies, where body mass index (BMI) was self-reported, which could have influenced the accuracy of the observed correlations. This suggests that the validity of self-assessments may affect the relationship between silhouettes and anthropometric indicators, highlighting the importance of employing objective measures to obtain more consistent results.

In general, the values of the correlations obtained to evidence concurrent validation were consistent with previous international studies conducted in other regions of the world. This indicates that the Stunkard et al[7] silhouette scaling is a good and valid indicator to assess body image in adolescents living in a high altitude region of Peru.

In relation to reliability, the results indicate that the silhouette scale evidenced minimal mean differences between test and retest in both sexes, in addition, the limits of agreement in the Bland-Altman analysis show a relatively small variability between test and retest measurements in both sexes, and even the degree of agreement is high, suggesting a good reliability of the body image scale for both sexes.

Another study that has used the retest to verify the reliability of the Stunkard et al[7] silhouette scale has reported reliability values similar to the findings of this study[10], although other studies, using the Figural Rating Scale developed by Collins[20], have also reported values similar to the present study[21,22].

These results highlight that the test and retest technique as a measure of stability is essential, since a high degree of agreement was obtained between the measures, suggesting that the scale used is reliable and consistent.

The study also verified that adolescents of both sexes showed a pronounced increase in BMI and TPI as silhouette levels increase from 1 to 9. This indicates that adolescents categorized at level 1 and 2 showed a slim BMI and silhouettes of 3 and 4 as normal and >5 as overweight. In addition, females, showed higher levels of BMI and TPI relative to males from silhouette 3 through six. This reflects not only differences in body composition between sexes, but also the need to consider specific intervention strategies that address these disparities and promote healthy habits among adolescents, especially in the case of females, who seem to be more predisposed to experience an increase in BMI and TPI.

In sum, the silhouette scale can be applied in sociocultural and demographic contexts where anthropometric equipment is lacking, offering an accessible tool for body image assessment when technical resources are limited. Indeed, health professionals need a valid and reliable tool to address this problem and its related factors in youth[14]. This type of subjective assessment is significant in promoting healthy lifestyles during this crucial stage of their lives[23].

The study has some limitations. For example, the type of sample selection was non-probabilistic, and the study focused on a specific population of adolescents in a high-altitude region of Peru, which may limit the generalizability of the results to other populations with different demographic and sociocultural characteristics. In addition, it is necessary to develop a longitudinal study in the future, with which it is possible to monitor changes in body image and weight status throughout the growth and development stage.

Also, the study presents some strengths, since it is the first study conducted at high altitude in Peru, which allows establishing a baseline for future research and achieving comparisons of changes over the years. This contribution is

significant because it provides a specific context that can be used in longitudinal studies to evaluate the evolution of body image.

On the other hand, this information obtained can serve as a reference for the implementation of health and wellness programs aimed at adolescents in similar contexts, offering data that can guide the design of specific interventions that address the health needs of young people.

CONCLUSION

The present study has demonstrated that the Stunkard et al.[7] silhouette scaling is a valid and reliable tool for assessing self-perception of body image in adolescents residing in a high-altitude region of Peru. Although the correlations between silhouettes and anthropometric indicators (BMI and TPI) were moderate in comparison with international studies, the results suggest that the scale can be useful in contexts where anthropometric equipment is lacking, highlighting its applicability in the promotion of healthy habits.

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From manual to digital: Transforming hospital nutrition with Nutrihas-Pro application

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ABSTRACT

Background: Hospital malnutrition is a serious issue, often caused by inadequate food intake and underlying diseases. In Makassar, malnutrition in hospitals is 28.1%, higher than provincial and national levels. This can lead to more extended hospital stays, higher costs, and increased risks of complications. To improve care, the Nutrihas-Pro app was developed to help plan patient meals more efficiently. Automatically calculating an individual's energy requirements saves time and reduces errors, leading to better patient outcomes.;

Methods: The study uses an **experimental design with repeated measures** to compare two methods (manual vs. app) in Accuracy in Calculating Total Energy Requirements and Efficiency in Time for Composing Patient Food Composition. The research was conducted over four weeks at Dr. Wahidin Sudirohusodo Hospital, Makassar. A sample of 30 participants (Residents from the Clinical Nutrition Specialist Program) were selected based on **purposive sampling**. In stage 1, each sample was given 2 cases of malnutrition patients to perform according to the manual calculation procedure; 2 weeks later, the same participants performed the same cases by application.

Results: The study revealed a significant difference in time efficiency between the Nutrihas-Pro app and the manual method (89.53 ± 17.52 seconds vs. 297.5 ± 39.08 seconds, **p<0.001**). However, both methods showed similar accuracy in calculating energy requirements, with no statistically significant difference in results (**p=0.096**), demonstrating that the Nutrihas-Pro app is both faster and equally accurate.

Conclusions: The Nutrihas-Pro App reduced the time required for meal planning by more than **60-70%**, making it a valuable tool for clinical nutritionists, especially in time-constrained environments.

KEYWORDS

Food composition, malnutrition, energy requirements, nutritional medical therapy, nutrition software.

INTRODUCTION

Malnutrition in hospitals is a serious health problem, especially in hospitalized patients. This condition is caused by several factors, such as inadequate food intake and increased catabolism due to underlying diseases, such as metabolic infections and malignancies[1]. Based on research in Makassar, the prevalence of malnutrition in hospitals is relatively high, reaching 28.1%, which exceeds the provincial and national averages. This malnutrition condition can affect patients' clinical outcomes, prolong hospitalization, increase treatment costs, and increase the risk of morbidity and mortality[2,3]. Therefore, proper meal planning is critical in ensuring patients' nutritional requirements are met during hospitalization to support recovery and improve health outcomes.

Manually compiling food composition poses significant challenges due to the complex process of relating foods described in compositional datasets to those reported in dietary assessment tools. This task is often time-consuming and relies heavily on individual judgment[4]. Manual extraction of Food Composition Knowledge from the scientific literature is a laborious process involving copying elements one by one to create a Food Composition Table[5]. The classification and description of foods required to link food composition data with consumption data is done manually. This leads to insufficient integration between these data sets and requires substantial time and expertise[6].

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Digitalization in the healthcare sector, including technology-based applications, can help plan and calculate patient meal composition[7]. The Nutrihas-Pro application, developed by the nutrition department of Hasanuddin University's Faculty of Medicine, aims to improve the efficiency of nutritional medical therapy planning for hospitalized patients. The app automatically calculates patients' energy and nutrient requirements based on anthropometric data and clinical conditions, reducing the potential for human error and speeding up the planning process. In addition, studies have shown that using apps saves time composing meal compositions compared to manual methods, which were often time-consuming and prone to errors[4,8]. Implementing this technology is expected to improve the quality of healthcare services and support more effective patient nutrition management[9].

The study concludes that the Nutrihas-Pro application significantly improves the efficiency of calculating patients' energy requirements and composing meal plans compared to the manual method. While both methods produce similar results in terms of accuracy, Nutrihas-Pro drastically reduces the time required for these tasks, making it a valuable tool for clinical nutritionists. This enhanced efficiency, especially in time-sensitive hospital settings, supports using digital solutions like Nutrihas-Pro to optimize medical nutrition therapy and improve patient care outcomes.

MATERIALS AND METHODS

Study design

The study design used in this research is an *Experimental* design with a *Repeated Measures* approach. This design involves testing the same group of participants under different conditions—in this case, comparing the manual method versus the Nutrihas-Pro application for calculating energy requirements and preparing meal plans for hospitalized patients. The repeated measures design allows for direct comparisons between the two methods by having the same respondents perform the task twice, reducing variability due to individual differences.

The study was conducted over four weeks in June 2023 at Dr. Wahidin Sudirohusodo Hospital in Makassar. In the first week (stage 1), each participant was given 2 cases of malnutrition patients and manually calculated the energy requirements and meal compositions of patients. After resting during the second week, they used the Nutrihas-Pro application to perform the same tasks in the third week (stage 2). By measuring performance under both conditions, the researchers could assess differences in accuracy and efficiency between the two methods. The fourth week was dedicated to analyzing the collected data.

Instruments and tools

Several instruments and tools were used to measure the effectiveness of the manual method versus the Nutrihas-Pro application for calculating energy requirements and preparing meal plans. The primary tools included inpatient data from Dr. Wahidin Sudirohusodo Hospital, which provided the clinical information needed for each participant to perform their calculations. This data was used for manual and application-based methods to ensure consistency in the evaluation process.

For the manual calculation phase, the researchers provided participants with calculators and food composition tables, which were essential for manually determining energy requirements and macronutrient breakdowns. Stopwatches tracked each participant's time to complete the tasks, ensuring precise efficiency measurement. The time requirements for each respondent to calculate energy requirements and prepare meal compositions was an important outcome variable in the study.

During the application phase, participants used laptops to access the Nutrihas-Pro web-based application. The app provided an automated platform for calculating energy requirements and planning meal compositions, allowing participants to input patient data and receive results instantly. This setup allowed for direct comparisons between the manual and app-based methods regarding time efficiency and accuracy. Office stationery was also used for note-taking and data logging during the process.Top of Form

Nutrihas-Pro

Nutrihas-Pro is a web-based application designed to assist clinical nutrition specialists in planning nutritional medical therapy for hospitalized patients. The software was developed using hundreds of algorithms to streamline the time-consuming process of calculating food intake, dietary requirements, and therapy planning.

The program is built on robust technical foundations, utilizing HTML, PHP, CSS, and JavaScript, with a client-server architecture based on a MySQL relational database. The software integrates formulas and algorithms to calculate daily energy and fluid requirements, macronutrient and micronutrient needs, and specific nutritional therapies based on the patient's condition. It also features a comprehensive food database, including information on foods available at hospitals, their macronutrient and micronutrient composition, and compatibility with clinical conditions.

In terms of functionality, Nutrihas-Pro offers several modules, including a user interface for easy interaction, a security module for data protection, and a business logic module for implementing nutritional therapy planning. A significant feature is its reporting module, which produces detailed reports on patient data, including anthropometric measurements, laboratory values, and therapy plans.

Participants

The participants in this study were clinical nutrition residents from the Specialist Medical Education Program at

Hasanuddin University, Makassar, Indonesia. A total of 30 respondents were selected through purposive sampling based on specific inclusion and exclusion criteria to ensure they met the study requirements. The study involved two phases, with the respondents testing 60 patient samples. In the first phase, each respondent manually tested two patient samples. After a two-week interval, the same respondents re-evaluated the same patient samples using an application-based method. This comparative approach assesses the application's effectiveness in improving the testing process's accuracy and efficiency.

The inclusion criteria required participants to be at their intermediate or expert level, and they also had to participate in the socialization and training sessions for the Nutrihas-Pro application. Exclusion criteria included residents assigned to the Intensive Care Unit (ICU) or those unable to attend the research activities.

This selection process ensured that the participants had sufficient knowledge of both the manual methods and the newly introduced Nutrihas-Pro application, enabling them to provide meaningful comparisons between the two approaches. The sample consisted of a balanced mix of participant's experience levels, with half categorized as intermediate and half as expert.

During the study, each respondent was required to calculate energy requirements and prepare meal compositions for patients using the manual method and the Nutrihas-Pro app. Their performance was measured in terms of accuracy and the time taken to complete the tasks, with their results providing insights into the effectiveness and efficiency of using the application in clinical settings.

Ethical and approval

Before the study began, we obtained ethical clearance from the Medical Ethics Commission at the Faculty of Medicine, Hasanuddin University, which ensured that research ethics standards conducted the study. With approval number No. 776/UN4-6.4-5.31/PP36/2023, this study was eligible to be carried out by maintaining the confidentiality of respondent data, safety, and comfort of participants.

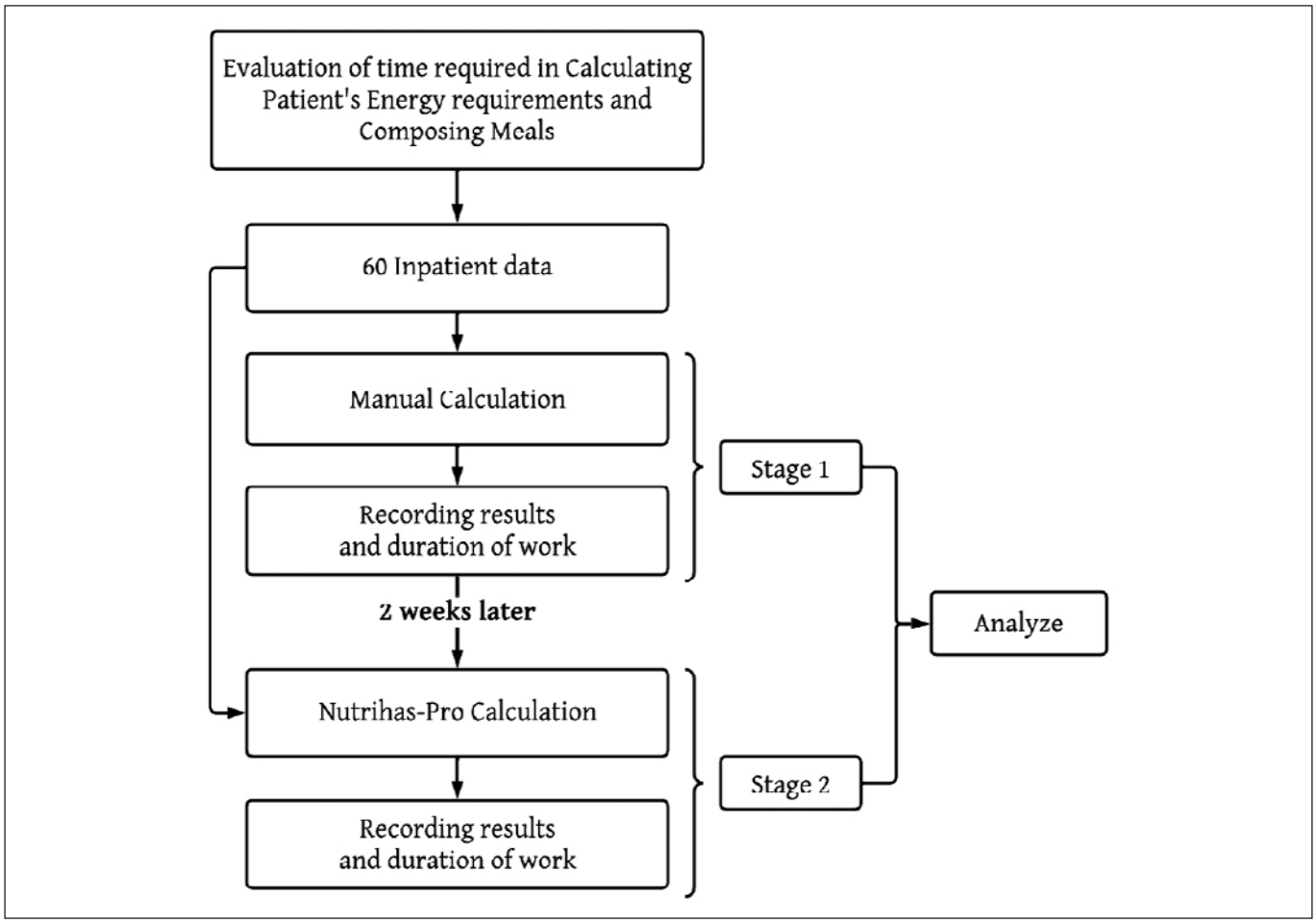

Figure 1. Flowchart of this study

Statistical Analysis

Data were analyzed using IBM SPSS Statistics for Macintosh (version 29.0.0.0 (241), IBM Corp, Armonk, NY, USA, 2022). Descriptive statistics are presented as a number, percentage, mean ± standard deviation (SD), or median with corresponding 95% confidence intervals (CI). Differences between groups were analyzed using the advanced *t-test* (parametric), Mann-Whitney U-test (nonparametric), Wilcoxon, and ANOVA tests. Tests with a calculated two-sided *p-value* ≤0.05 were considered significant.

RESULTS

Participant Characteristics

The characteristics of respondents were carefully documented to provide a clear understanding of the sample composition. The research involved 30 participants, primarily female (83%) and aged between 35 and 40 (63.3%). The distribution of respondents was balanced in terms of professional level, with 50% categorized as intermediate and 50% as advanced participants (table 1). These respondent characteristics are integral to this study as they ensure that the sample accurately reflects the intended population, thereby contributing to the reliability and validity of the research outcomes.

This study uses 60 case data of malnutrition patients hospitalized at Wahidin Sudirohusodo Hospital, then randomly selected 2 cases each per participant to test the calculation. The patient cases tested were dominated by men (60%), with SGA score C (severe malnutrition) at 70% and SGA score B (moderate malnutrition) at 30%. The patient's nutritional pathway dominated the oral path (61.7%), but there were also nutritional pathways via combination (16.7%), enteral (15%), and parenteral (6.7%) (table 2).

In the analysis of patients' energy and macronutrient requirements, no significant differences were found between the manual and app methods, with all p values showing results above the recognized threshold (table 3). In contrast,

Table 1. Characteristic of participants

characteristic		n	%
Age	35–40y	19	63.3
	> 40y	11	36.7
Gender	Male	5	16.7
	Female	25	83.3
Level	Intermediate	15	50.0
	advance	15	50.0

Table 2. Characteristics of patients tested

Characteristic		n	%
SGA	B	18	30.0
	C	42	70.0
Age	48 (17-60 y.o)		
Sex	Male	36	60.0
	Female	24	40.0
Nutrient Pathway	Oral	37	61.7
	Enteral	9	15.0
	Parental	4	6.7
	Combination	10	16.7

Table 3. Comparison of Calculation of Energy requirements, Protein requirement, carbohydrates, and fats in manual method calculations and application method calculations

	Manual			Nutrihas-Pro			p
	Mean	SD	Median	Mean	SD	Median	
Energy (kcal)	1764.17	239.90	1800.00	1753.33	227.34	1800.00	0.096
Protein (gram)	63.08	12.85	64.25	63.00	12.83	64.00	0.216
carbohydrate (gram)	219.41	27.28	218.75	218.75	27.95	218.75	0.477
Fat (gram)	69.48	13.2	68.00	69.44	13.20	68.00	0.148

Pair(t) test.

the difference in time taken to compose the patient's diet was significant, with the app drastically speeding up the process (table 4). These findings indicate that while the accuracy in nutrient requirement calculation did not differ between the two methods, the app offered a significant advantage in time efficiency of meal composition.

The results showed no statistically significant difference between the manual method and the app in calculating energy requirements at the Intermediate level, with p values showing consistency across both methods (table 5). However, in the analysis of food composition time, there was a significant difference between the two methods at the Intermediate and Advanced levels, with the app showing higher time efficiency (table 6). These findings indicate that apps can be helpful in simplifying the food composition process, increasing efficiency, and reducing the potential for human error in daily practice.

Table 7 compares meal composition time between manual and app-based methods for various patient nutrition pathways. The analysis showed that each path, including oral, enteral, parenteral, and combined, showed a statistically significant difference in time with a p-value of 0.001. This finding indicates that using apps in the food composition process consistently speeds up the time taken compared to the manual method, highlighting the efficiency of technology in improving patient nutrition services[10].

DISCUSSION

The use of manual calculations and applications each has advantages and disadvantages. Manual calculations offer a deeper understanding of basic concepts, enhance critical thinking skills, and do not require technology, making them flexible for various situations. However, this process is time-consuming, prone to human error, and less efficient for processing large amounts of data. Manual calculations are suitable for deep understanding and situations that do not require speed or automation[11].

Table 4. Comparison of food composition preparation time using the manual method compared to using the App method (in seconds)

	Manual			Nutrihas-Pro			p
	Mean	SD	Median	Mean	SD	Median	
Preparation time (seconds)	297.05	39.08	291.50	89.53	17.52	89.50	<0.001*

Wilcoxon test.

Table 5. Comparison of Energy Requirement Calculation in manual method calculation and application method calculation based on participant level (Kcal unit)

	Manual			Nutrihas-Pro			p
	Mean	SD	Median	Mean	SD	Median	
Intermediate level	1758.33	241.70	1700.00	1766.67	258.20	1700.00	0.262
Advanced level	1616.67	204.12	1650.00	1616.67	204.12	1650.00	0.623

Pair(t) test.

Table 6. Comparison of food composition preparation time using the manual method compared to using the Application method based on participant level (in seconds)

	Manual			Nutrihas-Pro			p
	Mean	SD	Median	Mean	SD	Median	
Intermediate level	327.50	22.31	329.50	97.67	6.41	97.50	<0.001*
Advanced level	270.17	18.24	277.00	93.50	23.70	100.50	<0.001*

Wilcoxon test.

Table 7. Comparison of meal composition time using the manual method compared to using the App method based on the patient's nutritional path (in seconds)

Nutrient Pathway	Manual			Nutrihas-Pro			p
	Mean	SD	Median	Mean	SD	Median	
Oral	291.8	36.1	283	87.1	18.6	87	0.001*
Enteral	311.8	38.6	341	87.7	14.1	89	0.001*
Parenteral	242	31.2	293	70	19.7	108	0.001*
Combination	236	49.8	323	72	15.3	94	0.001*

Pair(t) test.

On the other hand, apps offer high speed, accuracy, and efficiency in processing extensive data, with automation capabilities and visualization of results that make analysis easier. Apps make integration with other systems easier but are technology-dependent, cost money, and potentially face technical risks like bugs. App users may not understand the calculation process deeply because they focus on the result. Apps are more suitable for business and professional needs that require high efficiency and accuracy[12].

This study compares the accuracy and efficiency of manual and application methods in calculating Total Energy Requirements. Based on the study's results, manual calculations using the standard formula and automatic application calculation showed no significant difference in the result (p=0.096). This proves that both methods are valid for energy calculations so that users can choose either method depending on preference or need. However, although the results produced are almost the same, there is a notable difference in time efficiency. Manual calculations take an average of two minutes for a data set, while the app only takes about 10 seconds, providing a huge advantage, especially in scenarios with extensive data or limited time.

In terms of efficiency and practicality, the app is superior. Its fast, practical use and ability to reduce the potential for human error in the calculation process make it a more effective tool, especially for complex data analysis in the field. By speeding up the calculation process and ensuring accuracy on par with manual methods, the app provides a more efficient solution for professionals who need energy analysis in various scenarios. Therefore, it is recommended that this app be adopted as a more efficient and practical alternative to manual methods[13].

This is consistent with using mobile applications as food diaries. This can efficiently reduce the time required to report dietary patterns, with completion durations of no more than three minutes per meal[14]. This efficacy is crucial for users who may feel compelled to maintain a comprehensive food diary using pen and paper, frequently leading to inaccurate or incomplete records[15]. Furthermore, the systematic review conducted by Thornton et al. underscores that smartphone applications optimize the accuracy of dietary pattern assessment by automating the calculation of energy and nutrient intake[16].

This study evaluates the efficacy of manual calculations vs an application in assembling inpatient meal compositions, specifically to meet nutritional requirements, including calories, protein, carbs, and fat. The findings indicated that the application significantly enhanced efficiency, decreasing preparation time by 60-70% while maintaining the precision of nutritional calculations. The application provides seamless customization, enabling dietitians to concentrate more on clinical assessment and patient consultation. Although the manual method remains precise, the application demonstrated enhanced ease and adaptability in response to fluctuating patient health situations. The application is endorsed as an efficient support tool in clinical practice for the expedited and accurate formulation of diet plans, accessible to users with diverse degrees of specialist clinical nutrition[17].

The research demonstrated that the application of the app considerably expedited the preparation of food composition in comparison to the manual method, as shown by both Intermediate and Advanced study participants. The time required by Intermediate participants decreased from an average of 327.50 seconds with the manual method to 97.67 seconds with the app, while Advanced participants decreased from 270.17 seconds to 93.50 seconds. The app's effectiveness was evident in the extremely low p-value (<0.001), demonstrating that it enhanced time efficiency for all participants, irrespective of their proficiency level. These results indicate that app technology can be a highly efficient and beneficial instrument for all users, regardless of their level of independence or proficiency[18,19].

Nutrihas-Pro's ability to compose meals for patients based on nutritional pathways significantly improves efficiency compared to manual methods. With optimized algorithms, the app can calculate nutritional requirements more quickly and accurately, thereby reducing the workload of healthcare workers and enabling a faster response to patient needs. Statistical analysis showed improved efficiency in all nutrition pathways (oral, enteral, parenteral, and combined) with a p-value of 0.001. The integration of this application is expected to improve the quality of health care through accelerated time and accuracy in the preparation of patient nutrition[20].

This study has limitations, including variability of patient data, limitations of the application in handling complex medical conditions, and dependence on the quality of data input. In addition, the study did not include local food variations or special medical diets and faced non-technical challenges such as resistance to technology and limited infrastructure. Although the app is effective in the short term, further research is needed for long-term evaluation and wider applicability.

CONCLUSIONS AND RECOMMENDATIONS

The application's performance in determining patients' energy requirements and dietary composition was more precise and expeditious than the manual approach. While the manual method necessitates using tools such as calculators and food tables, which result in a lengthier processing time, the application utilizes algorithms with lower error rates to automatically process the data. The app's efficacy significantly enhances patient nutrition management, particularly in time-constrained clinical settings.

It is recommended that this application be used as the primary tool in calculating energy requirements and composing patient diets, especially in hospitals or clinics with many patients. However, adequate training for health workers on using the app is essential to avoid data input errors. In addition, although the app is more efficient, it is important to understand the manual method as a basic science foundation in certain cases requiring in-depth analysis or when the app is unavailable.

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Efecto del fruto de *Euterpe oleracea* (asaí) sobre el daño hepático inducido por fructosa y etanol en ratas

Effect of *Euterpe oleracea* (acai) on liver damage induced by fructose and ethanol in rats

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RESUMEN

Introducción: Las enfermedades hepáticas presentan una alta tasa de morbimortalidad a nivel mundial, siendo el consumo de fructosa y etanol los desencadenantes principales de alteración estructural y metabólica en la población adulta.

Objetivos: Determinar el efecto de *Euterpe oleracea* (asaí) sobre el daño hepático inducido por fructosa y etanol en ratas.

Materiales: Estudio de tipo experimental puro, con grupo control y postprueba. Se utilizó el pulverizado del fruto de *Euterpe oleracea* (asaí) y 30 ratas Holtzman machos distribuidos en 5 grupos aleatoriamente. Los grupos de investigación recibieron, durante 22 días el siguiente esquema de alimentación: grupo I: dieta balanceada pulverizada + agua *ad libitum,* grupo II: dieta balanceada + etanol al 5% con fructosa al 15%, grupo III, IV y V: dieta balanceada con asaí al 1%, 3% y 9%, respectivamente + etanol al 5% con fructosa al 15%. Finalizado el tratamiento los animales fueron anestesiados y sometidos a hepatectomía parcial, extirpando una porción del lóbulo lateral medial derecho (LLMD), para el procesamiento de los láminas histológicas y una porción del lóbulo lateral medial izquierdo (LLMI), para el procesamiento de los indicadores transcripcionales con los promedios obtenidos.

Resultados: La ingesta del *Euterpe oleracea* (asaí) incrementó los niveles de expresión PPAR-α, PPAR-α /SREBP 1-c y PPAR-γ /SREBP 1-c y disminuyó, PPAR-γ y SREBP-1c. En el perfil histológico se encontró menor inflamación periportal, sinusoidal y congestión de venas centrolobulillares a comparación de los controles.

Conclusiones: La ingesta del pulverizado del *Euterpe oleracea* (asaí) presentó efecto hepatoprotector frente al daño inducido por el consumo de etanol y fructosa en ratas.

PALABRAS CLAVE

Euterpe oleracea; metabolismo hepático, factor de transcripción, alimento funcional (Fuente: DeCS BIREME).

ABSTRACT

Introduction: Liver diseases have a high morbidity and mortality rate worldwide, with fructose and ethanol consumption being the main triggers of structural and metabolic alterations in the adult population.

Objectives: To determine the effect of Euterpe oleracea (acai) on fructose- and ethanol-induced liver damage in rats.

Materials: A purely experimental study with a control group and post-test. The pulverized fruit of Euterpe oleracea (acai) was used and 30 male Holtzman rats were randomly assigned to 5 groups. The research groups received the following feeding scheme for 22 days: group I: pulverized balanced diet + water ***ad libitum***, group II: balanced

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diet + 5% ethanol with 15% fructose, group III, IV and V: balanced diet with 1%, 3% and 9% acai, respectively + 5% ethanol with 15% fructose. After treatment, the animals were anesthetized and subjected to partial hepatectomy, removing a portion of the right medial lateral lobe (MLLL) for processing histological slides and a portion of the left medial lateral lobe (MLLL) for processing transcriptional indicators with the averages obtained.

Results: Euterpe oleracea (acai) ingestion increased the expression levels of PPAR-α, PPAR-α /SREBP 1-c and PPAR-γ /SREBP 1-c and decreased PPAR-γ and SREBP-1c. The histological profile showed less periportal and sinusoidal inflammation and congestion of centrilobular veins compared to controls.

Conclusions: Ingestion of Euterpe oleracea (acai) powder had a hepatoprotective effect against the damage induced by ethanol and fructose consumption in rats.

KEYWORDS

Euterpe oleracea (acai); hepatic metabolism; transcription factors; functional food (Source: DeCS BIREME).

INTRODUCCIÓN

Las enfermedades hepáticas presentan una alta tasa de morbimortalidad a nivel mundial, siendo la esteatosis hepática, la alteración estructural y metabólica, de mayor impacto y prevalencia en la población adulta[1]. En la actualidad, la esteatosis hepática no alcohólica (EHGNA) presenta una prevalencia global de 30% en adultos, siendo mayor en hombres (40%) respecto a mujeres (26%). Es por ello que se prevé, un incremento en la prevalencia en múltiples regiones del mundo para el 2030, según las diferentes tasas de obesidad, factores genéticos y socioeconómicos locales[2,3].

Dentro de los factores causales más frecuentes de esteatosis hepática se encuentra la enfermedad por hígado graso no alcohólico, el consumo de etanol y las hepatitis virales[3]. Se ha reportado, que una ingesta de fructosa mayor a 50 g/día en la dieta, se asocia con un mayor riesgo de lipogénesis y síndrome metabólico. Asimismo, el consumo de etanol de 60 g/día en los varones y en 40 g/día en las mujeres, se relaciona con el desarrollo de hígado graso[4,5].

La alta ingesta de fructosa induce la activación de factores de transcripción tales como la proteína de unión al elemento sensible a los carbohidratos (ChREBP) y la proteína de unión al elemento regulador de esteroles 1c (SREBP-1c). El SREBP-1c cumple un rol trascendental en el metabolismo de enzimas lipogénicas, como la ácido graso sintasa y la acetil CoA carboxilasa, encargadas de la biosíntesis de ácidos grasos. Asimismo, la escisión proteolítica de este factor, contribuye con la síntesis de ácidos grasos y posterior sobreproducción de triglicéridos al translocar la forma activa al núcleo[6,7].

Además, el consumo excesivo de fructosa induce la evasión del control endocrino ejercido por la insulina e inhibe la expresión de los receptores activados por proliferadores peroxisomales (PPAR). Los PPAR constituyen un tipo de receptores nucleares que desempeñan una función clave en la regulación del metabolismo de los nutrientes. En particular, el PPAR-α es el subtipo al que se le atribuye el papel más importante en la expresión génica de procesos adipogénicos, tales como la oxidación de ácidos grasos peroxisomales, mitocondriales y microsomales en el tejido hepático, contribuyendo de esta manera con la regulación de los niveles plasmáticos de triglicéridos[7,8].

Por otro lado, el consumo elevado de etanol favorece la disminución de la relación NAD+/NADH, incrementa la expresión de SREBP-1c y PPAR-γ, y promueve la inhibición de PPAR-α, incrementando la síntesis de triglicéridos, y por ende, el grado de esteatosis hepática[9,10]. Es así que, el consumo de etanol y fructosa, de forma individual o simultánea, actúan como agentes desencadenantes de disrupción metabólica y esteatosis, al provocar a nivel nuclear, la inactivación de factores de transcripción como el PPAR-α y la activación de SREBP-1c y PPAR-γ, proteínas involucradas en la regulación de la expresión génica y el metabolismo de ácidos grasos en el tejido hepático[11,12].

Actualmente, existe un interés creciente por el estudio de productos alimenticios con capacidad preventiva y correctiva del estado de salud. El asaí, fruto de Euterpe oleracea, ha demostrado tener múltiples propiedades biológicas en los procesos metabólicos debido a la interacción de los compuestos bioactivos presentes en la pulpa. La acción antiinflamatoria, antioxidante y moduladora del metabolismo de los lípidos, radica en su alto contenido de polifenoles totales, antocianinas y proantocianidinas, así como niveles significativos de calcio, magnesio, potasio manganeso, tiamina y piridoxina[13-17]; sin embargo, aún no se ha podido relacionar el papel del consumo de asaí sobre el nivel de expresión de los factores de transcripción como el SREBP-1c, PPAR-α y PPAR-γ.

Frente a este contexto, y debido a los altos costos en el tratamiento farmacológico y baja adherencia a la medicación de las enfermedades hepáticas, la alimentación basada en frutas y plantas, como el asaí, podría jugar un papel trascendental en la prevención y neutralización de los efectos perjudiciales del consumo de etanol y fructosa sobre el metabolismo hepático[18,19]. Teniendo en cuenta estos elementos, el objetivo de la presente investigación fue determinar el efecto del fruto de *Euterpe oleracea* (asaí) sobre el daño hepático inducido por fructosa y etanol en ratas.

MATERIALES Y MÉTODOS

El estudio es de tipo experimental puro con grupo control y posprueba.

Recolección y obtención del pulverizado de asaí: El pulverizado del fruto de *Euterpe oleracea* (asaí) fue adquirido del centro expendedor Kera superfoods (R.S. N1308320N). Para la preparación de las dietas experimentales se mezcló el pulverizado de asaí con la dieta estándar obtenida del bioterio de la Universidad Nacional Agraria La Molina. La dieta A contenía 1% de pulverizado de asaí; la dieta B, el 3% de pulveri-

zado de asaí y la dieta C, el 9% de pulverizado de asaí mezcladas por medio de un procesador de alimentos (Biobase).

Evaluación del efecto hepatoprotector: Se utilizaron 30 ratas Holtzman "*Ratus novergicus*" machos, de 334 ± 17 g, adquiridas del Centro Nacional de Productos Biológicos del Instituto Nacional de Salud (CNPB/INS), mantenidos en un periodo de aclimatación de siete días, en jaulas provistas de rejillas metálicas, en un ambiente controlado de temperatura a 20°C, con ciclos alternados de 12 horas de luz y 12 horas de oscuridad, con disponibilidad de alimento balanceado y agua *ad libitum* (Cielo®), en el bioterio de la Facultad de Medicina de la Universidad Nacional Mayor de San Marcos (UNMSM).

Para la **inducción al daño hepático** se suministró una solución de etanol al 5% con fructosa al 15% en los bebederos para consumo *ad libitum*, durante 22 días.

Tras el periodo de aclimatación, los animales fueron distribuidos, en cinco grupos (n=6), aleatoriamente, según el siguiente esquema de alimentación:

Grupo I: Dieta balanceada estándar y agua *ad libitum.*

Grupo II: Dieta balanceada estándar y etanol al 5% con fructosa al 15%.

Grupo III: Dieta balanceada estándar con asaí 1% y etanol al 5% con fructosa al 15%.

Grupo IV: Dieta balanceada estándar con asaí 3% y etanol al 5% con fructosa al 15%.

Grupo V: Dieta balanceada estándar con asaí 9% y etanol al 5% con fructosa al 15%.

Culminado el esquema de alimentación, los animales se mantuvieron en ayuno de 12 horas, para luego ser anestesiados con pentobarbital sódico (0,3 mg/kg), y sacrificados con posterior hepatectomía total, por cirugía abdominal incisional abierta. El órgano extirpado fue lavado en solución salina isotónica, secado y pesado en balanza analítica (Radwag WTB 200). El lóbulo lateral medial derecho (LLMD) fue seccionado y conservado en formol al 10% en buffer fosfato (pH 7,4 y 0,05 mol/L) para el procesamiento histológico. El lóbulo lateral medial izquierdo (LLMI) fue seccionado y perfundido, a través de la vasculatura hepática con buffer fosfato helado (pH 7,4 y 0,02 mol/L), para la eliminación de restos sanguíneos. Este proceso se realizó sobre placas de gel helado, luego fue seccionado en dos porciones de 0,5 g y 0,8 g y homogeneizado para el dosaje de los indicadores transcripcionales

Preparación del homogeneizado para PPAR-alpha y SREBP: Para la obtención del homogeneizado, se utilizó buffer fosfato con pH 7,2 a 0,02 mol/L en la proporción tejido/buffer 1/1, sobre placas de gel helado; después de dos ciclos de congelación y descongelación, el homogeneizado obtenido fue centrifugado durante 15 minutos a 5000 rpm

Preparación del homogeneizado PPAR-gamma: Se utilizó buffer fosfato con pH 7,4 a 0,02 mol/L en la proporción tejido/buffer 1/40 sobre placas de gel helado; después de dos ciclos de congelación y descongelación, el homogeneizado obtenido fue centrifugado durante 5 minutos a 5000 rpm.

Los sobrenadantes obtenidos se conservaron a -20° C hasta el momento del dosaje de los indicadores transcripcionales PPAR alpha, PPAR gamma y SREBP1-c mediante el test de ELISA (Biosource), y lectura de los resultados (Biocaremedical).

Evaluación morfológica e histológica: Una sección del lóbulo lateral medial derecho fue fijado en formaldehído al 10% con buffer fosfato 0,05 mol/L a pH 7,4, embebido en parafina y procesado para obtener una lámina teñida con hematoxilina-eosina. Las láminas obtenidas fueron analizadas de manera ciega por un médico patólogo especialista en el campo[20].

Análisis estadísticos: Para evaluar la normalidad de los datos se aplicó la prueba de Shapiro-Wilk utilizando los promedios encontrados en cada grupo. Los indicadores que presentaron distribución normal fueron procesados mediante la prueba de ANOVA, luego el estadístico de Levene para evaluar la homogeneidad de varianzas y por último el estadístico de Tukey. Los indicadores que presentaron distribución asimétrica fueron procesados mediante el test de Kruskall-Wallis, luego el estadístico pos hoc U de Mann- Whitney.

Aspectos éticos: El presente estudio consideró las normas éticas de experimentación animal según Russell y Burch y lo dispuesto por la Ley peruana de Protección y Bienestar Animal N°30407, además de la aprobación por el Comité de de Bioética, de la Facultad de Ciencias Biológicas de la UNMSM (036-2022-CBE-FCB-UNMSM).

RESULTADOS

Niveles de expresión de PPAR-α, PPAR-γ y SREBP-1c en tejido hepático

Los niveles de expresión de PPAR-α en tejido hepático fueron menores en el grupo II con respecto al grupo III y IV ($p < 0.05$). Los grupos I y V presentaron similares valores de expresión de PPAR-α en relación al grupo II (Tabla 1).

Los niveles de expresión de PPAR-γ en tejido hepático fueron menores en el grupo I, III y IV en comparación con el grupo II ($p < 0.05$). El grupo V presentó similares valores de expresión de PPAR-γ respecto al grupo II.

Los niveles de expresión de SREBP-1c en tejido hepático fueron menores en el grupo IV en comparación a los niveles de expresión del grupo II ($p < 0.05$). Los grupos I, III, V presentaron similares valores de expresión de SREBP-1c respecto al grupo II.

Relación de PPAR-α /SREBP 1-c y PPAR-γ /SREBP 1-c en el tejido hepático

En la relación PPAR-α /SREBP 1-c se encontró que el grupo IV tuvo una mayor relación respecto a los valores encontra-

Tabla 1. Niveles de expresión de PPAR-α, PPAR-ɣ y SREBP-1c según grupo de tratamiento frente al consumo de etanol y fructosa en ratas

	PPAR-α * (pg/mg prot)	**PPAR-ɣ * (pg/mg prot)**	**SREBP-1c * (pg/mg prot)**
Grupo I: Dieta balanceada + agua *ad libitum*	0,051 ± 0,007	0,428 ± 0,052 [(a)]	3,121 ± 0,531
Grupo II: Dieta balanceada + etanol-fructosa	0,047 ± 0,006	0,688 ± 0,049	4,699 ± 0,825
Grupo III: Dieta A + etanol-fructosa	0,058 ± 0,008 [(a)]	0, 418 ± 0,041 [(a)]	3,270 ± 0,915
Grupo IV: Dieta B + etanol-fructosa	0,056 ± 0,008 [(a)]	0,445 ± 0,045 [(a)]	2,288 ± 1,004 [(a)]
Grupo V: Dieta C + etanol-fructosa	0,049 ± 0,012	0, 456 ± 0,043	4,292 ± 1,144

* Shapiro Wilk - ANOVA (Media + DE).
(a) p<0.05 comparado con el grupo II.
PPAR-α: Receptor activado por proliferadores peroxisomales tipo alfa. PPAR-ɣ: receptores activados por proliferadores peroxisomales gamma. SREBP-1c: proteína de unión a los elementos reguladores de esteroles - 1c. Dieta A: Asaí al 1%. Dieta B: Asaí al 3%. Dieta C: Asaí al 9%

dos en grupo II (p < 0.05). Los grupos I, III y V presentaron similares valores de expresión de PPAR-α en relación al grupo II (Tabla 2).

El índice PPAR-ɣ /SREBP 1-c presentó un incremento en los grupos III y IV respecto a los valores encontrados en grupo II (p < 0.05). El grupo V presentó menor relación PPAR-ɣ /SREBP 1-c comparado con el grupo II (p < 0.05). El grupo I presentó similares valores de expresión PPAR-ɣ /SREBP 1-c respecto al grupo II.

Descripción histológica del tejido hepático

Grupo I: Biopsia hepática sin alteraciones de la arquitectura a bajo aumento. Inflamación leve periportal y sinusoidal. Congestión leve en algunas venas centrolobulillares. Esteatosis microvesicular en 5% de la biopsia. No se observa esteatosis macrovesicular ni fibrosis. Ausencia de esteatohepatitis.

Grupo II: Biopsia hepática sin alteraciones de la arquitectura a bajo aumento. Inflamación leve periportal y sinusoidal. Esteatosis microvesicular en menos del 33% de la biopsia.

Grupo III: Biopsia hepática sin alteraciones de la arquitectura a bajo aumento. Inflamación leve periportal y sinusoidal. Congestión leve en algunas venas centrolobulillares. Esteatosis microvesicular en menos del 33% de la biopsia.

Grupo IV: Biopsia hepática sin alteraciones de la arquitectura a bajo aumento. Inflamación leve periportal y sinusoidal. Congestión leve en algunas venas centrolobulillares. Esteatosis microvesicular en menos del 66% de la biopsia. No se observa esteatosis macrovesicular ni fibrosis. Ausencia de esteatohepatitis.

Grupo V: Biopsia hepática sin alteraciones de la arquitectura a bajo aumento. Inflamación leve periportal y sinusoidal. Esteatosis microvesicular en menos del 33% de la biopsia.

Tabla 2. Relación PPAR-α/ SREBP1-c y PPAR-ɣ/ SREBP-1c según grupo de tratamiento frente al consumo de etanol y fructosa en ratas

	PPAR-α / SREBP1-c		**PPAR-ɣ / SREBP1-c**	
	Mediana (RIQ)	**% Incremento**	**Mediana (RIQ)**	**% Incremento**
Grupo I: dieta balanceada + agua ad libitum	2, 07 (1, 12)	—	2, 04 (1, 01)	—
Grupo II: dieta balanceada + etanol-fructosa	1, 05 (1, 03)	—	1, 21 (1, 1)	—
Grupo III: Dieta A + etanol-fructosa	2, 11 (1, 23)	101, 44	2, 36 (1, 33) [(a)]	96,2
Grupo IV: Dieta B + etanol-fructosa	2, 47 (1, 28) [(a)]	102, 1 7	3, 15 (1, 22) [(a)]	185, 1
Grupo V: Dieta C + etanol-fructosa	1, 39 (1, 45)	18, 03	1, 18 (1, 41) [(a)]	76, 3

* Prueba Shapiro wilk (p<0,05). Kruskal-Wallis. U de Mann Whitney. ** MEDIANA (RIQ).
(a) p<0.05 comparado con el grupo II.
PPAR-α: Receptor activado por proliferadores peroxisomales tipo alfa. PPAR-ɣ: receptores activados por proliferadores peroxisomales gamma. SREBP-1c: proteína de unión a los elementos reguladores de esteroles - 1c. Dieta A: Asaí al 1%. Dieta B: Asaí al 3%. Dieta C: Asaí al 9%

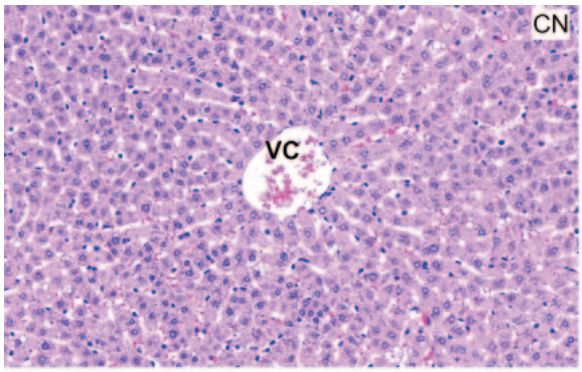

Figura 1. Grupo I; hígado: se observa leve congestión de la vena centrolobulillar (VC), escasos linfocitos y escasos hepatocitos con esteatosis microvesicular (menos del 5% de la biopsia)

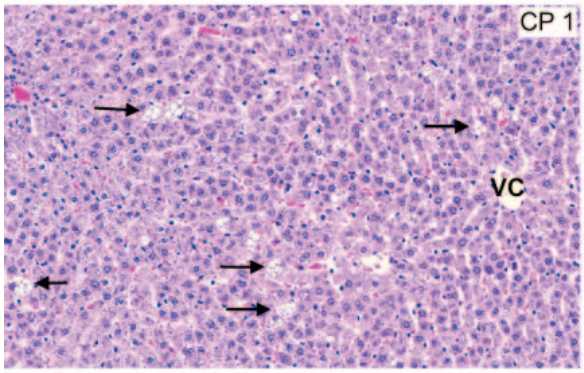

Figura 2. Grupo II; hígado: se observan escasos linfocitos y hepatocitos con esteatosis microvesicular (flechas) en menos del 33% de la biopsia

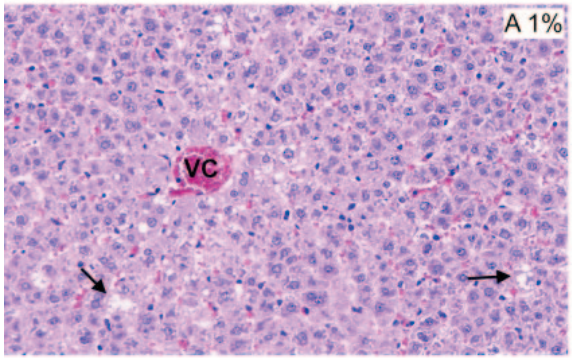

Figura 3. Grupo III; hígado: se observa leve congestión de la vena centrolobulillar (VC), escasos linfocitos y hepatocitos con esteatosis microvesicular (flechas) en menos del 33% de la biopsia

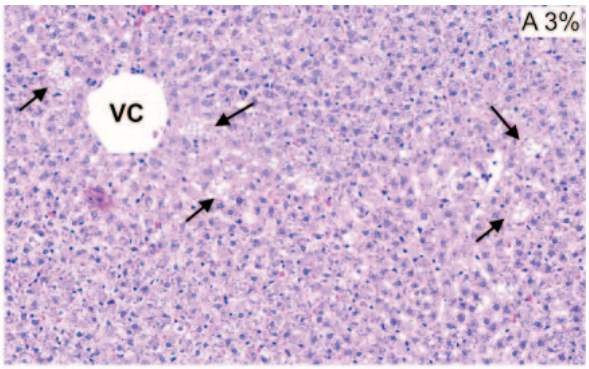

Figura 4. Grupo IV; hígado: se observa leve congestión de la vena centrolobulillar (VC), escasos linfocitos y hepatocitos con esteatosis microvesicular (flechas) en menos del 66% de la biopsia

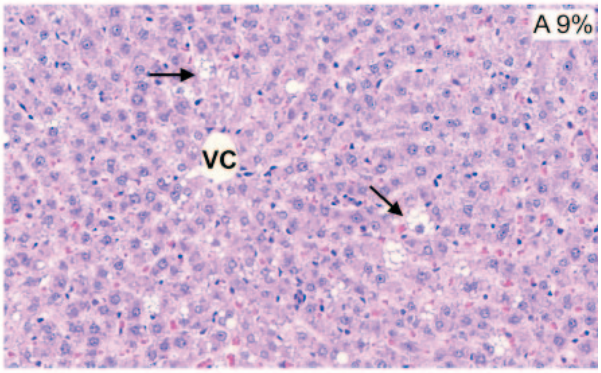

Figura 5. Grupo V; hígado: se observan escasos linfocitos y hepatocitos con esteatosis microvesicular (flechas) en menos del 33% de la biopsia

DISCUSIÓN

La adición del alimento funcional asai, en diferentes concentraciones (grupos III, IV y V) presentó un incremento de los niveles de PPAR-α y disminución de los niveles de PPAR-γ y SREBP-1c; además de un incremento en las relaciones PPAR-α /SREBP 1-c y PPAR-γ /SREBP 1-c en tejido hepático. A nivel histológico, se encontró inflamación periportal leve y sinusoidal, congestión leve en algunas venas centrolobulillares, esteatosis microvesicular en menos del 33% de la biopsia sin alteraciones en la arquitectura a bajo aumento y una mayor conservación del tejido hepático, en comparación al grupo II. En el grupo IV, se encontró esteatosis microvesicular en menos del 66% de la biopsia.

La regulación positiva del factor de transcripción PPAR-α encontrada en los grupos que recibieron asai al 1% y 3% más etanol y fructosa, podría estar relacionada a la presencia de compuestos fenólicos en el fruto. Una de ellas, las cianidinas, promueven la transactivación mediada por PPAR-α, regulan positivamente la expresión de carnitina palmitoil transferasa I (CPT-1α), estimulan la β-oxidación de ácidos grasos, reducen la biosíntesis de lípidos, previenen la acumulación excesiva de triglicéridos, y por lo tanto, el fruto del asaí sería tendría un rol agonista en la expresión de PPAR-α a través de los mecanismos mediados por la adiponectina, coincidiendo con los resultados reportados por Jia y col[21,22].

El heterodímero formado por la unión de los receptores PPAR-γ y RXR (ácido 9cis-retinoico), a nivel nuclear, potencia la transcripción al unirse a una región específica del gen promotor del ADN, facilitando la síntesis de ARNm involucrado en la diferenciación de adipocitos, síntesis de ácidos grasos e incremento del factor SREBP-1c. La regulación negativa de la proteína PPAR-γ encontrada en nuestro estudio podría estar relacionada con el rol de las antocianinas en la expresión de factores correpresores de la transcripción[23].

En un estudio previo, Martino y col (2016) observaron que el jugo de asaí rico en antocianinas y flavonoides, disminuyó la acumulación intracelular de lípidos en el adipocito, regulando negativamente el nivel de expresión de PPARγ2, SREBP-1c y genes adipogénicos como aP2, LPL, FATP1 y FAS[24]. Oliveira y otros (2012), reportaron que el consumo de pulpa de asaí redujo la expresión de los genes SREBP-2 respecto a los controles, disminuyendo los niveles de colesterol en sangre[25]. En otro estudio, se demostró que el consumo del extracto acuoso de la pulpa de asaí (3 g/kg), durante seis semanas, inhibe la lipogénesis hepática y los niveles de SREBP-1c y FAS, sosteniendo el efecto beneficioso de las antocianinas en la regulación génica y la disminución del grado de esteatosis hepática[21]. Estos resultados coinciden con nuestros resultados experimentales y podrían tener una relación dosis dependiente.

La homeostasis de ácidos grasos hepáticos está regulada principalmente por SREBP-1c y PPAR-α, factores de transcripción responsables del control de la síntesis y oxidación de ácidos grasos respectivamente. Ambas proteínas coexisten con el propósito de conservar un metabolismo óptimo, no obstante, presentan una relación inversamente proporcional. Es por ello, que el incremento de PPAR-α desencadena una menor expresión proteica de SREBP-1c, siendo esta relación inversamente proporcional, semejante a la reportada en nuestra investigación. Lucero y col (2015) reportaron que la resistencia a la insulina promueve la secreción de VLDL y se asocia con una mayor expresión proteica de SREBP-1c y una menor expresión de PPAR-α, ambos reguladores de la disponibilidad de ácidos grasos hepáticos[26,27].

La proteína SREBP-1c, subtipo predominante en el tejido adiposo y hepático, se encarga de regular enzimas lipogénicas en respuesta a la insulina. Esta hormona modula el proceso transcripcional y contribuye en la autorregulación, junto al receptor X hepático (LXR), caracterizado por su participación en el metabolismo del colesterol y la lipogénesis de novo. La expresión de LXR se promueve por regulación positiva mediada por PPARγ, que estimula vías glucolíticas, síntesis de ácidos grasos, triglicéridos y genes adipogénicos (adipsina y adiponectina) desencadenando esteatosis. Es por ello, que el aumento de PPARγ genera el aumento proporcional de SREBP-1c siendo estos resultados congruentes con los encontrados en nuestro estudio[28,29].

El incremento de la expresión de factores de transcripción adipogénicos puede ser evidenciado mediante el depósito de triglicéridos y vesículas de grasa en el hepatocito. A nivel histológico, se reportó esteatosis hepática leve (<33%) sin alteraciones significativas de la arquitectura, inflamación periportal y sinusoidal leve y congestión en algunas venas centrolobulillares coincidiendo con la disminución del daño histopatológico reportado en la literatura[13,17,30]. Según los hallazgos histológicos de nuestro estudio, el grupo que recibió asaí al 9% no evidenció congestión de venas centrolobulillares ni dilatación sinusoidal; por lo que, el efecto hepatoprotector del asaí presenta una relación dosis-dependiente

La presente investigación tuvo como limitantes el uso de animales de experimentación y el tiempo. Los resultados obtenidos en animales no pueden ser inferidos directamente a la población, sin embargo, permite sentar las evidencias de los efectos beneficiosos del consumo del asaí. Si bien el método de inducción a daño con etanol al 5% y fructosa al 15% está muy difundido en publicaciones, el tiempo de exposición de 22 días no permitió producir cambios histológicos más severos.

CONCLUSIÓN

La ingesta del fruto de *Euterpe oleracea* (asaí), a diferentes dosis, produjo un aumento proporcional y significativo de los niveles de expresión de PPAR-α y las relaciones entre PPAR-α /SREBP 1-c y PPAR-ɣ /SREBP 1-c. Por otro lado, se observó una disminución en los niveles de expresión de PPAR-ɣ y SREBP-1c, en las dosis de experimentación baja y media. A nivel histológico se observó una disminución en el grado de esteatosis hepática en las tres dosis experimentales, evidenciándose una mayor protección en el grupo que recibió la dosis media En conclusión, la ingesta del fruto de *Euterpe oleracea* (asaí) tuvo un efecto protector sobre el daño hepático inducido por fructosa y etanol en ratas.

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Factores asociados a la diabetes mellitus tipo 2 de la población adulta peruana

Factors associated with diabetes mellitus type 2 in the peruvian adult population

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RESUMEN

Introducción: Las personas diagnosticadas con diabetes mellitus tipo 2 tienen más riesgo de mortalidad, a comparación de las personas que no la padecen, el principal motivo son las enfermedades cardiovasculares entre otros factores.

Objetivo: Determinar los factores asociados a la diabetes mellitus tipo 2 de los adultos peruanos de 18 a 59 años.

Material y métodos: Se trata de una investigación transversal, descriptiva y relacional. La muestra fue de 1921 personas de 18 a 59 años. El estudio fue un análisis secundario de la base de datos de la Encuesta Nacional Demográfica y Salud Familiar del Perú del año 2022. Para el análisis estadístico se utilizó las pruebas de chi cuadrado y la prueba exacta de fisher para determinar la asociación entre la diabetes mellitus tipo 2 con los factores de riesgo. Además, se realizó regresión logística binaria en el cual la variable dependiente diabetes mellitus tipo 2 y las variables independientes fueron edad, sexo, IMC, perímetro abdominal, consumo de frutas y verduras, hipertensión y estilos de vida, los datos para estos análisis fueron presentados como odds ratio (OR) y su respectivo intervalo de confianza del 95% (95% IC). Se aplicó un nivel de significancia p<0,05.

Resultados: El 45,2% presentaron sobrepeso y el 29,4% obesidad, el 48% evidenciaron un perímetro abdominal con un riesgo muy alto de presentar alguna enfermedad cardiovascular. El 47,2% consume una vez a la semana ensalada de frutas y el 21,1% consume 7 días a la semana ensalada de verduras. Las edades comprendidas de 18 a 29 años tienen menor riesgo de diabetes mellitus, que si se encuentran en edades de 30 a 59 años (p=0,002; OR=0,186). Asimismo, a más hipertensión existe más probabilidad de padecer diabetes mellitus 2 (p=0,001; OR=4,913).

Conclusiones: Los factores asociados a la diabetes mellitus tipo 2 fueron la edad y la hipertensión arterial.

PALABRAS CLAVE

Enfermedades crónicas; Exceso de peso; Estilo de vida; Salud pública.

ABSTRACT

Introduction: People diagnosed with type 2 diabetes mellitus have a higher risk of mortality compared to people who do not have it, the main reason being cardiovascular diseases among other factors.

Objective: To determine the factors associated with type 2 diabetes mellitus in Peruvian adults aged 18 to 59 years.

Material and methods: This was a cross-sectional, descriptive and relational study. The sample consisted of 1921 persons aged 18 to 59 years. The study was a secondary analysis of the

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2022 Peruvian National Demographic and Family Health Survey database. For the statistical analysis, chi-square tests and fisher's exact test were used to determine the association between type 2 diabetes mellitus and risk factors. In addition, binary logistic regression was performed in which the dependent variable type 2 diabetes mellitus and the independent variables were age, sex, BMI, abdominal perimeter, fruit and vegetable consumption, hypertension and lifestyles; the data for these analyses were presented as odds ratio (OR) and their respective 95% confidence interval (95% CI). A significance level of $p<0.05$ was applied.

Results: 45.2% were overweight and 29.4% obese, 48% showed an abdominal perimeter with a very high risk of presenting some cardiovascular disease. A total of 47.2% consumed fruit salad once a week and 21.1% consumed vegetable salad 7 days a week. Those aged 18 to 29 years had a lower risk of diabetes mellitus than those aged 30 to 59 years (p=0.002; OR=0.186). Likewise, the more hypertension the higher the probability of diabetes mellitus 2 (p=0.001; OR=4.913).

Conclusions: The factors associated with type 2 diabetes mellitus were age and hypertension.

KEYWORDS

Chronic diseases; Excess weight; Lifestyle; Public health.

LISTA DE ABREVIATURAS

OMS: Organización Mundial de la Salud.

DM2: Diabetes Mellitus tipo 2.

ENDES: Encuesta Nacional Demográfica y Salud Familiar.

IMC: Índice de masa corporal.

PAB: Perímetro abdominal.

HTA: Hipertensión arterial.

FINDRISC: Finnish Diabetes Risk Score.

INTRODUCCIÓN

La Organización Mundial de la Salud (OMS) menciona que la diabetes mellitus tipo 2 (DM2), la cual se da por resistencia a la insulina o la producción insuficiente de la misma, esta enfermedad crónica ha aumentado en los últimos tiempos, actualmente tenemos a nivel mundial 62 millones de pacientes, y se estima que, para el año 2040, la cifra de pacientes con DM2 sería hasta de 190 millones[1].

En el Perú, se ha evidenciado que el 7,7% de la población mayor de 18 años presenta DM2 en el año 2019[2]. A nivel sociodemográfico, el sexo femenino tiene la mayor prevalencia, en comparación con el masculino (5,5%)[3]. Asimismo, la población de adultos mayores (mayores de 60 años) tenían un 13,7% de prevalencia, seguido del grupo de adultos de 50 a 59 años (10%), cifras mayores comparadas con el 1,8% de adultos de 30 a 39 años y el 0,8 de adultos de 20 a 29 años[4].

Las personas diagnosticadas con DM2 tienen un 15% más de riesgo de mortalidad, a comparación de las personas que no la padecen, donde el principal motivo de morbilidad y mortalidad de dichos pacientes es por las enfermedades cardiovasculares[5]. Esto lo evidencian los estudios realizados por la Oficina General de Epidemiología - MINSA del año 2017, en el cual se muestra que, las principales causas de muerte en el país eran las complicaciones de enfermedades crónicas como la DM2 y la hipertensión arterial (HTA)[6].

Como factores de riesgo identificados en la encuesta Finnish Diabetes Risk Score (FINDRISC) para poder determinar el riesgo de padecer de DM2 en los próximos 10 años[7] se tiene al sobrepeso y obesidad, obtenido por el índice de masa corporal (IMC), el perímetro abdominal (PAB) así como los antecedentes de hiperglucemias y de hipertensión arterial también predisponen a la persona a padecer de DM2[8], así como otros factores de riesgo como el consumo de alcohol y tabaco[9].

Por lo expuesto, no existe evidencia publicada sobre los factores relacionados a la DM2 en la población peruana es relevante para un mejor manejo de dichos factores de riesgo relacionados a las características sociodemográficas (edad, sexo), los hábitos alimentarios (consumo de frutas y verduras, consumo de alcohol/tabaco) y estado nutricional de la persona (IMC, PAB, HTA) de pacientes con mayor predisposición de dicha enfermedad crónica en adultos peruanos de 18 a 59 años, y así establecer mayor planificación del ámbito preventivo a nivel nutricional para así reducir el impacto que dicha enfermedad crónica genera en la población peruana a corto y largo plazo[10].

MÉTODOS

El diseño de la investigación fue no experimental, enfoque cuantitativo, se trata de una investigación de tipo transversal, descriptivo, relacional. Este estudio es un análisis secundario de la base de datos de la Encuesta Nacional Demográfica y Salud Familiar (ENDES) del año 2022[9].

Población y muestra

La población de este estudio fue la población adulta peruana, los varones y mujeres de 18 a 59 años de edad, empleando la base de datos de la ENDES del año 2022, desarrollado en los meses de enero a diciembre[9].

La muestra se caracteriza por ser bietápica, probabilística de tipo equilibrado, estratificada e independiente, a nivel departamental, por área urbana y rural. El tamaño de la muestra anual de la ENDES es de 36.650 viviendas del Perú y se entrevistó a 34.301 mujeres y hombres de 15 y más años de edad[9].

Para el estudio se eliminaron 32.380 casos entre ellos datos perdidos, respuestas no sabe/no recuerda, gestantes, menores de 18 años, mayores de 59 años, y población con incapacidad para moverse/caminar/usar brazos o piernas, por lo que se obtuvo una muestra de 1921 adultos peruanos de 18 a 59 años.

Variable e instrumentos

Se seleccionaron las preguntas de la encuesta ENDES 2022, donde se encuentran las variables sociodemográficas (edad, sexo), las medidas antropométricas (peso, talla, IMC y perímetro abdominal), el consumo de frutas y verduras, hipertensión arterial y estilos de vida (alcohol/tabaco).

Recopilación de los datos

La ENDES es una encuesta nacional anual, realizada por el Instituto Nacional de Estadística e Informática (INEI). La base de datos se obtuvo en la sección «consulta por encuestas» encuesta ENDES del año 2022, microdatos, código módulo 1640 encuesta de salud, del portal web del Instituto Nacional de Estadística e Informática (INEI), disponible en el siguiente enlace: https://proyectos.inei.gob.pe/microdatos/index.htm [9], siendo esta de acceso libre para el uso de la información. Luego se exportó la data al programa SPSS. Finalmente se seleccionó las variables de indicadores antropométricos como peso (kg), talla (m) y perímetro abdominal (cm) para posteriormente calcular el índice de masa corporal, así como otras variables relevantes para el estudio como el consumo de frutas y verduras, si consumió dentro de los 12 meses alcohol/tabaco, si fue diagnosticado(a) con DM2 y si fue diagnosticado(a) con hipertensión arterial.

El IMC se calculó a través de la división del peso corporal por la estatura al cuadrado (kg/m^2), fue categorizado en bajo peso (<18,5 kg/m^2), normal (18,5-24,9 kg/m^2), sobrepeso (25-29,9 kg/m^2) y obesidad (30 o más)[11], asimismo para el perímetro abdominal se utilizó los puntos de corte para identificar personas en riesgo, estableciendo tres categorías, "bajo riesgo" (≤ 79 cm en mujeres y ≤ 93 cm en hombres); "riesgo incrementado" (80 a 87 cm en mujeres y de 94 a 101 cm en hombres), y "alto riesgo" (≥ 88 cm en mujeres y ≥ 102 cm en hombres), de acuerdo a la OMS[12].

Análisis estadístico

Se utilizó el Software SPSS 27 para el desarrollo del análisis de datos. Se realizó un análisis descriptivo de los datos. Se realizó la prueba de Chi-cuadrado y la prueba exacta de Fisher para determinar la asociación entre los factores de riesgo con la DM2. También, se utilizó la prueba estadística de regresión binaria para identificar los factores de riesgo con la DM2, en el cual la variable dependiente fue la diabetes mellitus 2 (1=Si presenta, 2=No presenta) y las variables independientes o predictoras fueron la edad, el sexo (1=masculino, 2= femenino), IMC, perímetro abdominal, consumo de frutas y verduras, hipertensión y estilo de vida. Se aplicó un nivel de significancia p<0,05.

RESULTADOS

Los participantes fueron 1921 adultos peruanos, el 36,5% (n=701) fueron mujeres y el 63,5% (n=1220) varones. Asimismo, el 2,6% presentó diabetes mellitus 2. El 63,8% estuvieron conformados de 30 a 59 años y el 36,2% de 18 a 29 años.

Tabla 1. Características demográficas, antropométricas y de estilo de vida de los adultos peruanos

Variables	n	%
Edad		
18 a 29 años	695	36,2
30 a 59 años	1226	63,8
Sexo		
Femenino	701	36,5
Masculino	1220	63,5
IMC (kg/m^2)		
Bajo peso	14	0,7
Normal	474	24,7
Sobrepeso	868	45,2
Obesidad	565	29,4
Perímetro abdominal (cm)		
Bajo riesgo	524	27,3
Alto riesgo	475	24,7
Muy alto riesgo	922	48,0
Diabetes mellitus 2		
Si	49	2,6
No	1872	97,4
Hipertensión Arterial		
Si	92	4,8
No	1829	95,2
Los últimos 12 meses ha fumado cigarrillos		
Si	304	15,8
No	1617	84,2
Los últimos 12 meses consumió alguna bebida alcohólica		
Si	1568	81,6
No	353	18,4
Total	**1921**	**100,0**

El 45,2% de los participantes presentaron sobrepeso y el 29,4% obesidad, además el 48% evidenciaron un perímetro abdominal con un riesgo muy alto de presentar alguna enfermedad cardiovascular y el 24,7% con alto riesgo. Las mujeres presentaron mayor prevalencia de riesgo muy alto (62%) comparado con los varones, quienes presentaron riesgo muy bajo del 50,2%. Por otro lado, el 95,2% no presentaron hipertensión arterial.

El 81,6% consumieron alcohol durante los últimos 12 meses, el 84,2% no fumó cigarrillos durante ese tiempo. El 86,6% (n=607) de los varones consumen bebidas alcohólicas mientras que el 78,8% (n=961) de las mujeres consumen bebidas alcohólicas en comparación a los que no consumen.

El promedio de consumo de frutas por semana fue 5 días (DE=1,98), las ensaladas de frutas 2 días a la semana (DE=1,47. En cuanto a los jugos de frutas el promedio fue 3 días por semana (DE=1,97) y el consumo de ensalada de verduras fue 3 días a la semana (DE=2,14). El 30,3% de los adultos consumen dos días a la semana jugo de fruta, el 47,2% consume una vez a la semana ensalada de frutas y el 21,1% consumen 7 días a la semana ensalada de verduras (Tabla 2).

En la tabla 3, se muestra que la hipertensión arterial se relaciona con la diabetes mellitus tipo 2 (p=0,001), con las demás variables no hubo relación significativa.

Finalmente, en la tabla 4, se muestra que las edades comprendidas de 18 a 29 años tienen menor riesgo de diabetes mellitus, que si se encuentran en edades de 30 a 59 años (p=0,002; OR=0,186). Asimismo, a más hipertensión existe más probabilidad de padecer diabetes mellitus 2 (p=0,001; OR= 4,913).

Tabla 3. Asociación entre los factores sociodemográficos, antropométricos, consumo de alimentos, estilo de vida e hipertensión con la diabetes mellitus tipo 2

Variables		Diabetes mellitus tipo 2		Valor p*
		SI	NO	
		n (%)	n (%)	
Edad				
18 a 29 años		4 (0,6%)	691 (99,4%)	0,139*
30 a 59 años		45 (3,7%)	1181 (96,3%)	
Sexo				
Hombres		22 (3,1%)	679 (96,9%)	0,139*
Mujeres		27 (2,2%)	1193 (97,8%)	
Antropometría				
IMC (kg/m^2)	Bajo peso	0 (0%)	17 (0,7%)	0,350**
	Normal	8 (1,7%)	466 (98,3%)	
	Sobrepeso	22 (2,5%)	846 (97,5%)	
	Obesidad	19 (3,4%)	546 (96,6%)	
Perímetro abdominal (cm)	Bajo riesgo	9 (1,7%)	515 (98,3%)	0,237**
	Alto riesgo	11 (2,3%)	464 (97,7%)	
	Muy alto riesgo	29 (3,1%)	893 (96,9%)	

* Prueba exacta de Fisher p<0,05. **Chi cuadrado p<0,05.

Tabla 2. Consumo de frutas y verduras de los adultos peruanos

		Cantidad de días que consumió							n (%)
		1 día	2 día	3 día	4 día	5 día	6 día	7 día	
Frutas	n	60	141	284	204	147	49	1036	1921 (100)
	%	3,1	7,3	14,8	10,6	7,7	2,6	53,9	
Jugo de frutas	n	359	582	419	153	81	28	299	
	%	18,7	30,3	21,8	7,9	4,2	1,5	15,6	
Ensalada frutas	n	907	539	263	83	31	10	88	
	%	47,2	28,1	13,7	4,3	1,6	0,5	4,6	
Ensalada de verduras	n	337	429	385	193	123	48	406	
	%	17,6	22,3	20,0	10,1	6,4	2,5	21,1	

Tabla 3 continuación. Asociación entre los factores sociodemográficos, antropométricos, consumo de alimentos, estilo de vida e hipertensión con la diabetes mellitus tipo 2

Variables		Diabetes mellitus tipo 2		Valor p*
		SI	NO	
		n (%)	n (%)	
Consumo frutas y verduras				
Frutas enteras (Cantidad de días)	1	3 (5%)	57 (95%)	0,068**
	2	6 (4,3%)	135 (95,7%)	
	3	10 (3,5%)	274 (96,5%)	
	4	0 (0%)	204 (100%)	
	5	2 (1,4%)	145 (98,6%)	
	6	0 (0%)	49 (100%)	
	7	28 (2,7%)	1008 (97,3%)	
Jugo de frutas (Cantidad de días)	1	6 (1,7%)	353 (98,3%)	0,780**
	2	15 (2,6%)	567 (97,4%)	
	3	14 (3,3%)	405 (96,7%)	
	4	5 (3,3%)	148 (96,7%)	
	5	1 (1,2%)	80 (98,8%)	
	6	1 (3,6%)	27 (96,4%)	
	7	7 (2,3%)	292 (97,7%)	
Ensalada de frutas (Cantidad de días)	1	20 (2,2%)	887 (97,8%)	0,281**
	2	15 (2,8%)	524 (97,2%)	
	3	8 (3%)	255 (97%)	
	4	5 (6%)	78 (94%)	
	5	1 (3,2%)	30 (96,8%)	
	6	0 (0%)	10 (100%)	
	7	0 (0%)	88 (100%)	
Ensalada de verduras (Cantidad de días)	1	9 (2,7%)	328 (97,3%)	0,798**
	2	10 (2,3%)	419 (97,7%)	
	3	8 (2,1%)	377 (97,9%)	
	4	3 (1,6%)	190 (98,4%)	
	5	5 (4,1%)	118 (95,9%)	
	6	1 (2,1%)	47 (97,9%)	
	7	13 (3,2%)	393 (96,8%)	
Estilo de vida				
Alcohol	Si	41 (2,6%)	1527 (97,4%)	0,440*
	No	8 (2,3%)	345 (97,7%)	
Tabaco	Si	10 (3,3%)	394 (96,7%)	0,237*
	No	39 (2,4%)	1578 (97,6%)	
Hipertensión				
	Si	11 (12%)	81 (88%)	**0,001***
	No	38 (2,1%)	1791 (97,9%)	

* Prueba exacta de Fisher p<0,05. **Chi cuadrado p<0,05.

DISCUSIÓN

La DM2 es una patología que se encuentra relacionada de forma directa con los hábitos alimentarios y un estado nutricional inapropiado. Asimismo, es necesario precisar que en nuestro país la prevalencia de dicha patología es mayor en la población femenina que en la masculina[13]. Por tanto, es imprescindible la adopción de medidas preventivas de los factores de riesgo y así poder reducir las complicaciones que conlleva la DM2.

En nuestra investigación, se evidenció que el 45,2% de los adultos obtuvieron sobrepeso, mientras que el 29,4% presentaron obesidad, cifras que se asemejan al estudio realizado por Bohórquez et al.[10], quien mencionó que el 36,7% de la población colombiana encuestada presenta sobrepeso y el 15,7% resultó con obesidad, lo cual sugiere que una considerable parte de la población tiende a padecer de sobrepeso, a diferencia de la obesidad. Por su parte Peralta et al.[14], determinaron que los trabajadores argentinos municipales mayores de 18 años presentaron sobrepeso con una cifra del 52%, mientras que el 25,7% padece de obesidad, valores similares al estudio. Por otro lado, la ENDES del año 2021, evidenció que el 62,7 % de personas de 15 años de edad a más padece de exceso de peso. Al respecto, los países latinoamericanos, así como el Perú tienen una mayor tendencia al exceso de peso[15]. Es necesario implementar estrategias de salud pública para reducir la prevalencia de sobrepeso y obesidad.

El estudio evidenció que las mujeres presentaron mayor prevalencia de riesgo muy alto de enfermedades cardiovasculares (62%) comparado con los varones, quienes presentaron riesgo muy bajo del 50,2%. Por su parte Peralta, et al.[14], sus resultados muestran que el 54,4% de las mujeres presentaron un riesgo muy alto a presentar enfermedades cardiovasculares, en tanto los varones representaron el 51% de riesgo muy alto. Estas diferencias según sexo pueden ser explicado en las mujeres ya que suelen subir de peso entre los 40 y 50 años, lo cual corresponde a la etapa perimenopáusica, donde se hacen presentes los cambios hormonales y producto de ello retienen más agua, acumulan más grasa y adicionalmente se vuelven más sedentarias[16].

Respecto al estilo de vida, el consumo de bebidas alcohólicas en el lapso de los últimos 12 meses, se registra que el 81,6% de adultos afirman haber ingerido alcohol. Los hallazgos se contraponen al estudio de Rodríguez y Mendoza[16], demostraron que el 42,06% de los adultos barranquilleros con edad entre 18 y 64 años consumen bebidas alcohólicas, así mismo en el año 2020,la OMS[17], manifestó que el consumo total de alcohol per cápita en adultos peruanos es de 6,2 litros y en los adultos colombianos es de 5,8 litros. Cabe resaltar que, Rodríguez y Mendoza demostraron que el consumo de alcohol no presentó relación estadísticamente significativa (p=0,1847) para desarrollar DM2[16], la investigación tampoco encontró relación significativa (p=0,440).

Tabla 4. Factores sociodemográficos, antropométricos, consumo de frutas y verduras, estilo de vida e hipertensión y su relación con la DM2 en adultos peruanos

Factores		OR*	p-valor	95% C.I.	
				Inferior	Superior
Edad		0,186	0,002	0,065	0,534
Sexo		1,302	0,483	0,623	2,724
IMC (kg/m^2)		1,028	0,926	0,578	1,827
Perímetro abdominal (cm)		0,830	0,528	0,464	1,482
Consumo de frutas y verduras (Cantidad de días)	Frutas	1,060	0,455	0,910	1,233
	Jugo de frutas	0,979	0,774	0,846	1,133
	Ensalada de frutas	1,025	0,819	0,831	1,264
	Ensalada de verduras	0,946	0,430	0,825	1,086
Estilo de vida	Alcohol	0,957	0,913	0,433	2,116
	Tabaco	1,216	0,624	0,556	2,660
Hipertensión		4,913	0,001	2,352	10,262

*OR <1, menor riesgo; >1, mayor riesgo.

Respecto a la variable sobre el hábito de fumar cigarrillos durante los últimos 12 meses, se evidenció que el 84,2% de la población adulta peruana refieren no haber fumado cigarrillos durante ese tiempo. Situación similar reflejada en los resultados de Rodríguez y Mendoza[16], quienes manifiestan en su estudio que sólo el 5,59% de adultos colombianos fuma cigarrillos. Estudios sobre tabaquismo mencionan que aumenta significativamente el riesgo de diabetes de tipo 2: entre un 30 y un 40% en comparación con las personas que no son fumadoras[18], la investigación no encontró evidencia significativa entre las variables (p=0,237).

Con respecto al consumo de frutas por semana el promedio fue 5 días, las ensaladas de frutas 2 días a la semana. En cuanto a los jugos de frutas el promedio fue 3 días por semana y el consumo de ensalada de verduras fue 3 días a la semana, al respecto el estudio de Pinillos et al.[19], quienes manifestaron que el 30% no incluye frutas ni vegetales en su dieta, además el consumo de frutas y verduras es de manera frecuente o rutinaria. Asimismo, la ingesta de verduras fue de 3 a 5 porciones diarias. En cuanto al consumo de frutas y verduras el estudio de Tumax y Leon[20] hallaron que el 73,7% de los adultos de 18 a 60 años no consumieron todos los días las hierbas, vegetales y frutas, resultados similares a la investigación.

Por otro lado, en el presente estudio sobre la relación de los factores propuestos (edad, sexo, IMC, perímetro abdominal, consumo frutas y verduras, consumo de alcohol/tabaco, HTA) con el diagnóstico de diabetes mellitus tipo 2 y sus valores estadísticamente significativos mostrados, se obtuvo como factores relacionados el de la hipertensión arterial (p =0,001). En el presente estudio no se encontró relación con respecto al consumo de frutas y verduras (p>0,05).

Con respecto al estilo de vida, no hubo una relación significativa con el consumo de alcohol (p =0,440). Una perspectiva distinta es expuesta por Palomino[21], quien a través de una encuesta dirigida a 412 residentes del departamento de Ayacucho de entre 18 y 64 años, confirmó que el consumo de alcohol (p <0,00001) si presenta asociación significativa frente a la condición clínica en la que se centra el presente estudio.

Asimismo, los resultados de nuestros análisis de asociación de factores con la DM2 se tuvieron que variables como la edad y la hipertensión fueron estadísticamente significativas (p=0,002, OR =0,186 y p= 0,001, OR = 4,913 respectivamente). Dichos resultados concuerdan con lo señalado por Uyuguari et al.[8],, quienes a través de la aplicación de la escala de FINDRISC en 379 adultos no diabéticos que comprenden entre 18 y 65 años, identificaron a la edad como una variable que presentó una correlación significativa con el riesgo de desarrollar DM2; sin embargo, no se logró evidenciar la relación inversamente proporcional que se halló en el presente estudio. Por lo contrario, Varela et al.[22], luego de aplicar la misma escala mencionada anteriormente en adultos de 20 a 60 años en la ciudad de México, aseveran que una edad menor a 55 años es un factor asociado a la DM2, lo cual no ocurre con la HTA, ya que no resultó como un factor asociado.

Las limitaciones del estudio fue la cantidad de adultos con diabetes, a pesar de ser una muestra a nivel nacional, hubo poca muestra, asimismo, la encuesta nacional no considera la actividad física y la cantidad en gramos del consumo de frutas y verduras.

CONCLUSIÓN

Los factores asociados a la diabetes mellitus tipo 2 fueron la edad y la hipertensión arterial. Es necesario mejorar los hábitos alimentarios saludables para una mejor elección de los componentes de su dieta en los adultos peruanos.

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Development of nutrient-Rich purple Sweet potato and moringa-based biscuits as an alternative snack for toddlers at risk of stunting

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ABSTRACT

Background: This study aims to address the nutritional needs of young children while utilizing local food resources in Central Sulawesi, Indonesia.

Methods: This study employs a descriptive method based on laboratory tests for nutrient content analysis and acceptability. The research design utilizes a Completely Randomized Design (CRD) with 5 treatments of varying substitutions of purple sweet potato flour and moringa flour. The analysis of carbohydrate, fat, protein, ash, moisture, and fiber content is conducted by descriptively comparing each formula.

Results: Carbohydrates, namely formula F5 has the highest carbohydrate content of 52.2%, Fat, namely formula F1 has the highest fat content of 35.7%, Protein, namely formula F1 also has the highest protein content of 15.38%. Water Content, namely formula F1 has the highest water content of 2.55%, Ash Content, namely formula F1 also has the highest ash content of 4.84%, Fiber Content, namely formula F3 has the highest fiber content of 5.12%. F1 formula biscuits have relatively strong antioxidant power with an IC50 of 94.655 ppm compared to other formulas. Sensory analysis revealed significant differences in the perception of quality and preference for color, aroma, and taste among the five formulas. The highly significant differences in color and taste preferences indicate that the composition of each formula has a substantial influence on the product's sensory characteristics.

Conclusion: Purple sweet potato and Moringa leaf-based biscuits demonstrate potential as a snack for children experiencing stunting and wasting due to their favorable nutritional content and relatively high acceptance rate. However, further research is necessary to determine the optimal formulation that maximizes nutritional value while maintaining sensory qualities acceptable to children.

KEYWORDS

Food formulation, Food technology, Malnutrition.

INTRODUCTION

Biscuits are indeed widely accepted snacks across various age groups in Indonesia, as evidenced by their prevalence in consumer diets and market offerings. Research indicates that sweet biscuits are among the most commonly consumed snack foods, particularly among children and adolescents[1]. Palatability and diverse forms play a significant role in biscuit consumption. A study on Indonesian adolescent girls revealed that cookies and chips were among the most salient processed convenience foods, with respondents typically snacking multiple times daily (Blum et al., 2019). The widespread availability of affordable and "tasty" snacks makes them appealing meal substitutes, providing a distraction from boredom and enhancing social gatherings.

The accessibility and palatability of biscuits contribute significantly to their widespread acceptance across age groups in Indonesia. However, this trend raises concerns about nutritional quality, as many commercial snack products are high in sugar and salt[1]. Future research and product development should focus on creating healthier biscuit options that maintain palatability while addressing nutritional needs.

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Purple sweet potato flour and Moringa leaf powder can be used to create functional foods with positive health effects when added to cookie recipes[2]. These ingredients are locally available in Indonesia, making them cost-effective alternatives to imported wheat flour. Purple sweet potato flour has higher levels of ash and fiber compared to wheat flour, while maintaining similar carbohydrate and calorie content[3]. The addition of Moringa leaf powder further enhances the nutritional profile of the biscuits.

Purple sweet potato and Moringa leaves have shown great potential in developing nutrient-rich biscuits as an alternative snack for toddlers at risk of stunting in Indonesia. Studies have demonstrated that these ingredients can significantly enhance the nutritional profile of biscuits, making them suitable for addressing malnutrition issues. Research has shown that biscuits made with purple sweet potato flour and jack bean flour can meet 9% of protein needs, 26% of fat needs, and 15% of daily carbohydrate needs for toddlers aged 1-3 years, providing 238 kcal/100 g when consuming 46 g of biscuits[4]. Purple sweet potatoes are rich in nutrients, including carbohydrates, fats, proteins, anthocyanins, fiber, vitamins, and minerals, making them an excellent choice for improving nutritional intake[5].

Developing nutrient-rich biscuits based on purple sweet potato and Moringa leaves presents a promising alternative snack for toddlers at risk of stunting. This study aims to address the nutritional needs of young children while utilizing local food resources in Central Sulawesi, Indonesia.

METHOD

Desain

This study employs a descriptive method based on laboratory tests for nutrient content analysis and acceptability. The research design utilizes a Completely Randomized Design (CRD) with 5 treatments of varying substitutions of purple sweet potato flour and moringa flour (Table 1).

Table 1. The varying substitutions of purple sweet potato flour and moringa flour for each of the 5 treatments (F1 to F5)

Treatment	Purple Sweet Potato Flour (g)	Moringa Flour (g)	Total (g)
F1	15	85	100
F2	30	70	100
F3	55	45	100
F4	65	35	100
F5	80	20	100

The research will be conducted from April 2024 to August 2024 at the Food Chemistry Laboratory, Faculty of Mathematics and Natural Sciences, Tadulako University.

Equipment and Materials

Equipment: scales, oven, baking tray, cookie cutter, stove, mixer, mixing bowl, spatula, tablespoon, small bowl. Materials: purple sweet potato flour, moringa flour, butter, cornstarch, baking powder, milk powder, egg yolk, vanilla, and powdered sugar.

Biscuit Making Process

Fresh purple sweet potatoes (Ipomoea batatas) were procured and subjected to a series of preparatory steps. Initially, the tubers were peeled to remove the outer skin and then rinsed under running tap water to eliminate any adhering soil or contaminants. Following this, the potatoes were manually sliced into uniform pieces using a knife. To remove the latex content, the sliced potatoes were immersed in a 2% saline solution for a duration of 1 hour. After the soaking process, the potatoes were drained to remove excess solution. Subsequently, the sliced potatoes were spread out on a drying tray and exposed to direct sunlight for a period sufficient to achieve complete dehydration. Once dried, the dehydrated potato pieces were ground to a fine powder using a blender. The resultant powder was then passed through an 80-mesh sieve to ensure a consistent particle size distribution. The sieved powder, which was purple sweet potato flour, was then stored for further experimental use.

Fresh moringa oleifera leaves were harvested and visually inspected for any signs of damage or disease. The leaves were then subjected to a cleaning process involving thorough washing under running tap water to remove any adhering soil or contaminants. Following this, the leaves were allowed to air dry for a period of 24 hours to reduce moisture content. The dried leaves were manually separated from the stems and veins. The cleaned and dried leaves were then placed in a dryer and subjected to a controlled drying process to achieve complete dehydration. Once dried, the leaves were milled using a high-speed grinder to reduce them to a fine powder. The resultant powder was sieved using an 80-mesh sieve to ensure a uniform particle size distribution. The sieved powder, which was moringa leaf powder, was then stored in airtight containers for further analysis.

The initial stage of biscuit production involves the creation of a dough cream. This cream is formulated by combining powdered sugar, margarine, whole eggs, skim milk powder, moringa leaf powder, and purple sweet potato flour. The ingredients are thoroughly mixed to ensure a homogenous blend. The prepared dough is then portioned and placed into molds. A pressing technique is employed to shape the biscuits and transfer them onto baking sheets. The baking sheets are subsequently introduced into a preheated oven where the bis-

cuits are baked for approximately 20 minutes. The specific baking temperature and duration may vary based on the desired texture and color of the final product.

Proximate Analysis of Biscuits

Carbohydrate Content Analysis: Determined by difference, subtracting the sum of moisture, protein, fat, ash, and fiber from the total sample weight. Protein Content, quantified by measuring the absorbance of protein-dye complexes using UV/Vis spectrophotometry[6]. Fat Content Analysis, extracted with a solvent in a Soxhlet apparatus and quantified gravimetrically[7]. Fiber Content, Determined by gravimetrically measuring the insoluble residue after acid and alkali hydrolysis[8]. Total Moisture Content, measured by weight loss upon heating in an oven (thermogravimetric method). Total Ash Content, determined by burning the sample to remove organic matter and weighing the remaining inorganic residue (dry ashing).

Antioxidant Activity Analysis

Evaluated by measuring the ability of the sample to scavenge the stable free radical DPPH (2,2-diphenyl-1-picrylhydrazyl) using spectrophotometry[9].

Acceptability Analysis (Organoleptic).

Assessed through sensory evaluation by a panel of 25 semi-trained individuals using a standardized scoring system.

Data Analysis

The analysis of carbohydrate, fat, protein, ash, moisture, and fiber content is conducted by descriptively comparing each formula (mean ± SD). The obtained data is presented in both textual and tabular formats. The statistical analysis involved the use of SPSS software and an ANOVA test to determine significant differences between groups

RESULTS

Figure 1 shows the average value and standard deviation of carbohydrate (%), fat (%), and protein (%) based on 5 Formula Groups (F1, F2, F3, F4, and F5). Carbohydrates, namely formula F5 has the highest carbohydrate content of 52.2%, followed by F4 (51.52%), F3 (50.07%), F2 (45.24%), and F1 the lowest at 41.53%. Fat, namely formula F1 has the highest fat content of 35.7%, followed by F2 (34.6%), F3 (33.4%), F4 (33.02%), and F5 the lowest at 32.64%. Protein, namely formula F1 also has the highest protein content of 15.38%, followed by F2 (13.6%), F3 (11%), F4 (10.03%), and F5 the lowest at 9.26%. Formula F5 has the highest carbohydrate content but the lowest fat and protein content compared to other formulas. In contrast, Formula F1 has the highest fat and protein content but the lowest carbohydrate content among the five formulas.

Figure 2 shows the water content, ash content, and fiber content in the five formula groups (F1, F2, F3, F4, and F5). Water Content, namely formula F1 has the highest water content of 2.55%, followed by F5 (2.67%), F4 (1.96%), F2 (2.16%), and the lowest is F3 with 1.59%. Ash Content, namely formula F1 also has the highest ash content of 4.84%, followed by F2 (4.4%), F3 (3.93%), F4 (3.47%), and F5 which is the lowest at 3.23%. Fiber Content, namely formula F3 has the highest fiber content of 5.12%, followed by F1 (4.78%), F2 (4.33%), F4 (3.52%), and F5 which is the lowest at 2.59%. Formula F1 stands out in water content and ash content. Formula F3 has the highest fiber content among all formulas, while F5 consistently has the lowest water, ash, and fiber content among the other formulas.

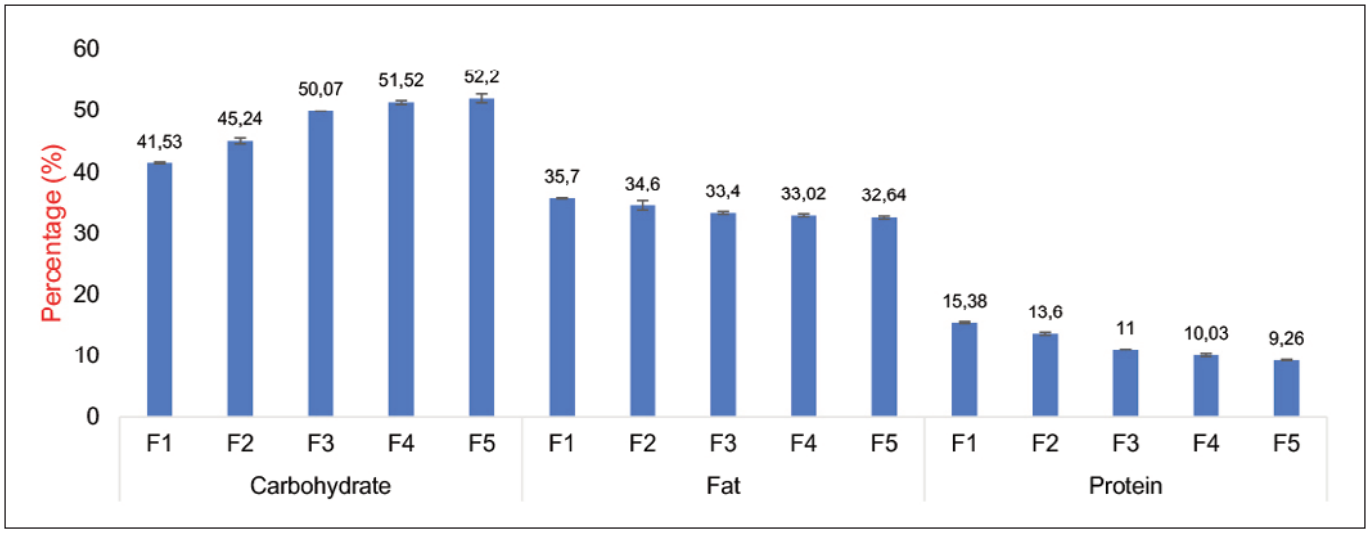

Figure 1. Average Value and Standard Deviation of Carbohydrate (%), Fat (%), and Protein (%) Based on 5 Formula Groups

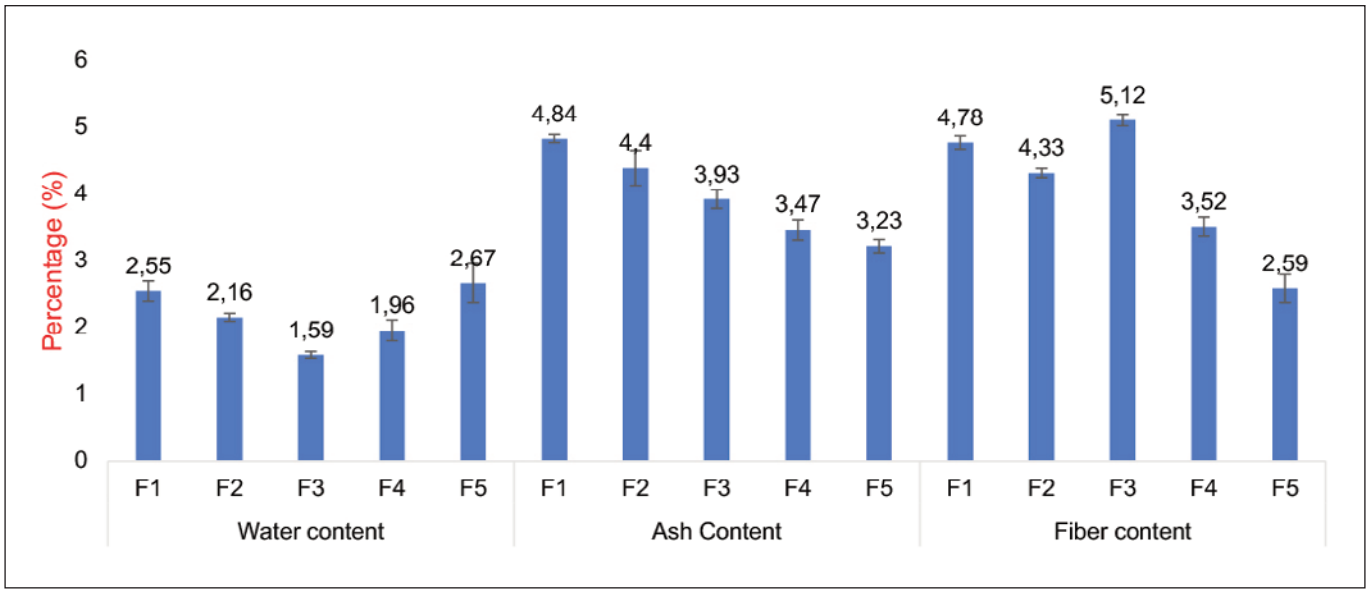

Figure 2. Average Value and Standard Deviation of Water content (%), ash content (%), and fiber content (%) based on 5 formula groups

Figure 3 shows that the F1 formula biscuits have relatively strong antioxidant power with an IC50 of 94.655 ppm compared to other formulas. Based on these results, it shows that biscuits with a higher composition of moringa leaf flour compared to purple sweet potatoes have stronger antioxidant power.

Figure 4 shows significant differences in the perception of quality and color preference levels in five formula groups (F1 to F5). This result is indicated by a very small p-value (p = 0.000) in the "Color (Hedonic)" category, which indicates that the difference in color preference between formula groups is very statistically significant. This means that the composition of each formula produces colors with different characteristics, thus causing different responses in observers**.**

Figure 5 shows the results of the product texture assessment based on five different formula groups (F1 to F5). The results of the statistical analysis showed that there was no statistically significant difference in the two texture assessment categories, namely texture quality (p = 0.272) and texture preference level (p = 0.679). This indicates that the five formulas produce products with relatively similar textures and there is no striking difference in consumer perception of product texture.

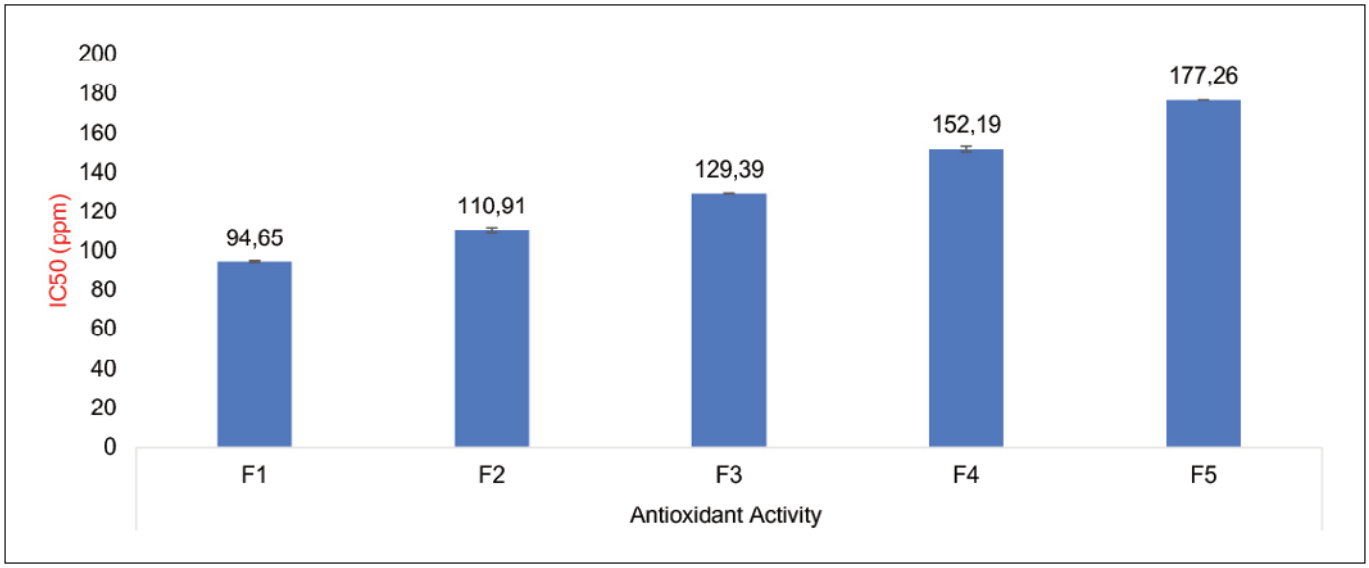

Figure 3. Antioxidant Activity based on 5 formula groups

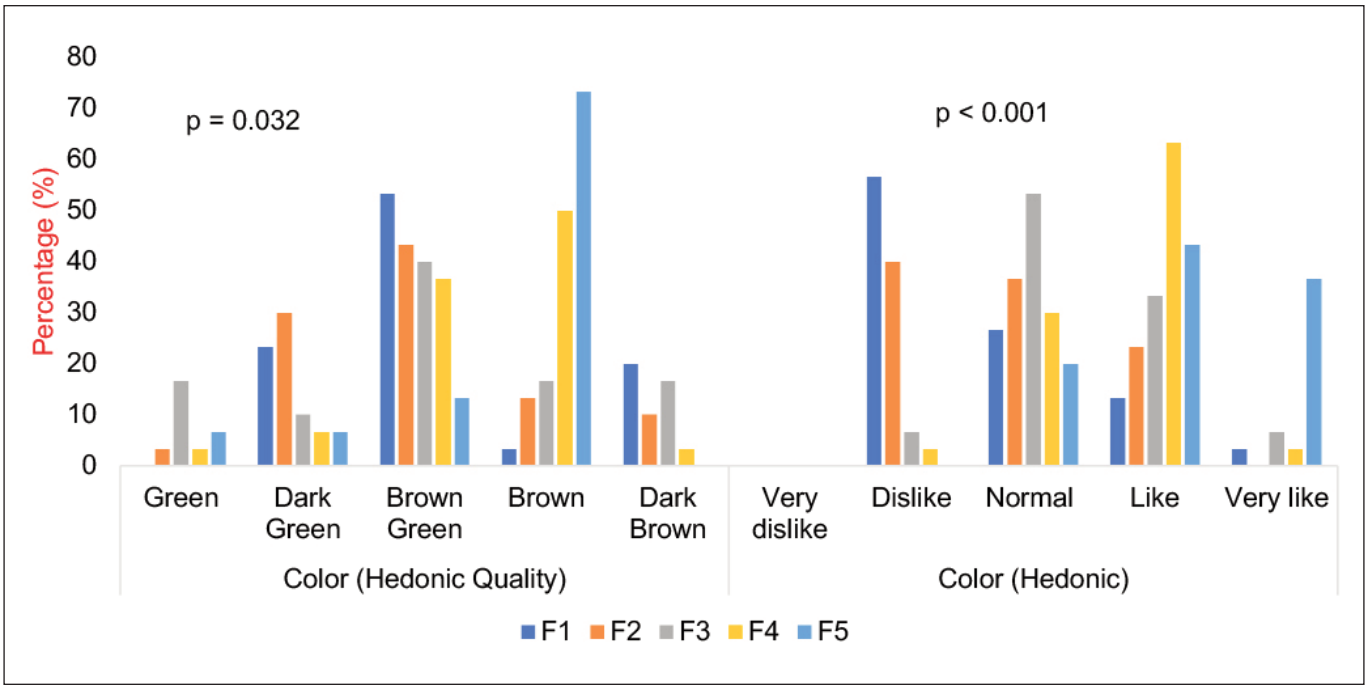

Figure 4. Color (Quality and Hedonic) based on 5 formula groups

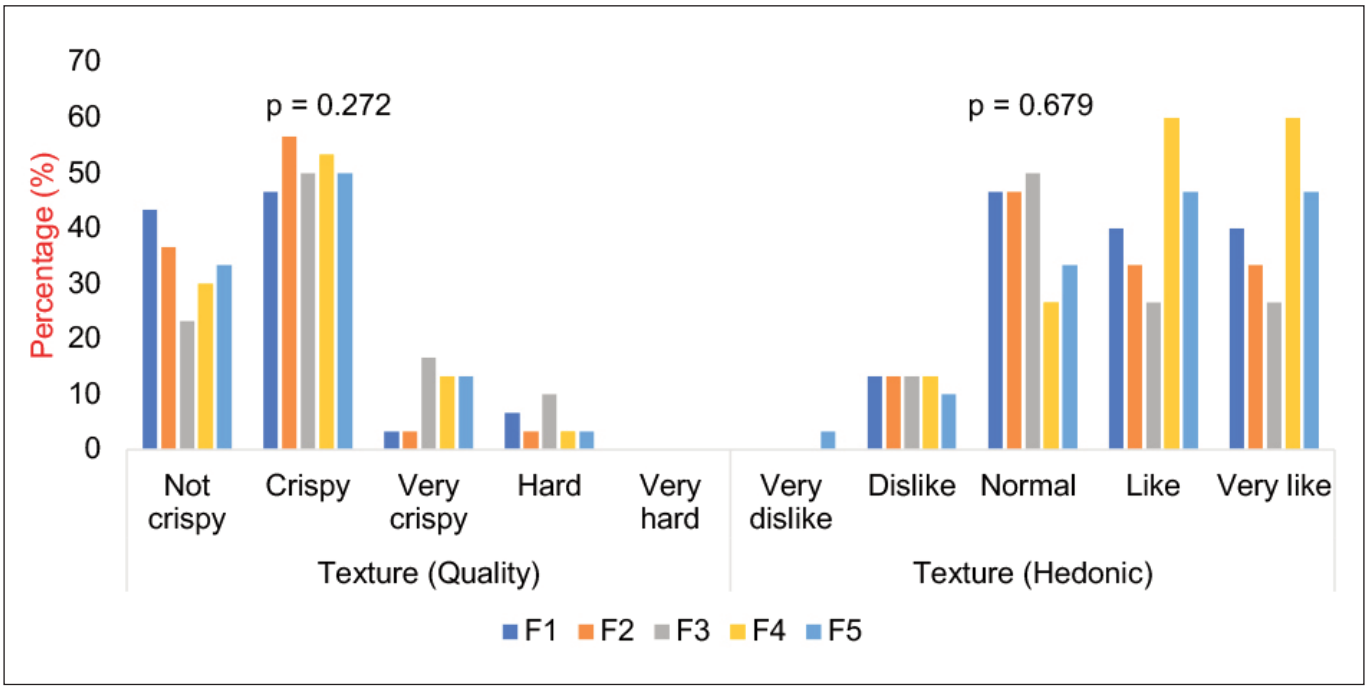

Figure 5. Texture (Quality and Hedonic) based on 5 formula groups

Figure 6 shows the results of the product aroma assessment based on five different formula groups (F1 to F5). The results of the statistical analysis showed that there was a statistically significant difference in the aroma preference category ($p = 0.000$), but there was no significant difference in the aroma quality category ($p = 0.087$). This indicates that the five formulas produce different aromas and cause different preferences in the panelists.

Figure 7 shows the results of the product taste assessment based on five different formula groups (F1 to F5). The results of

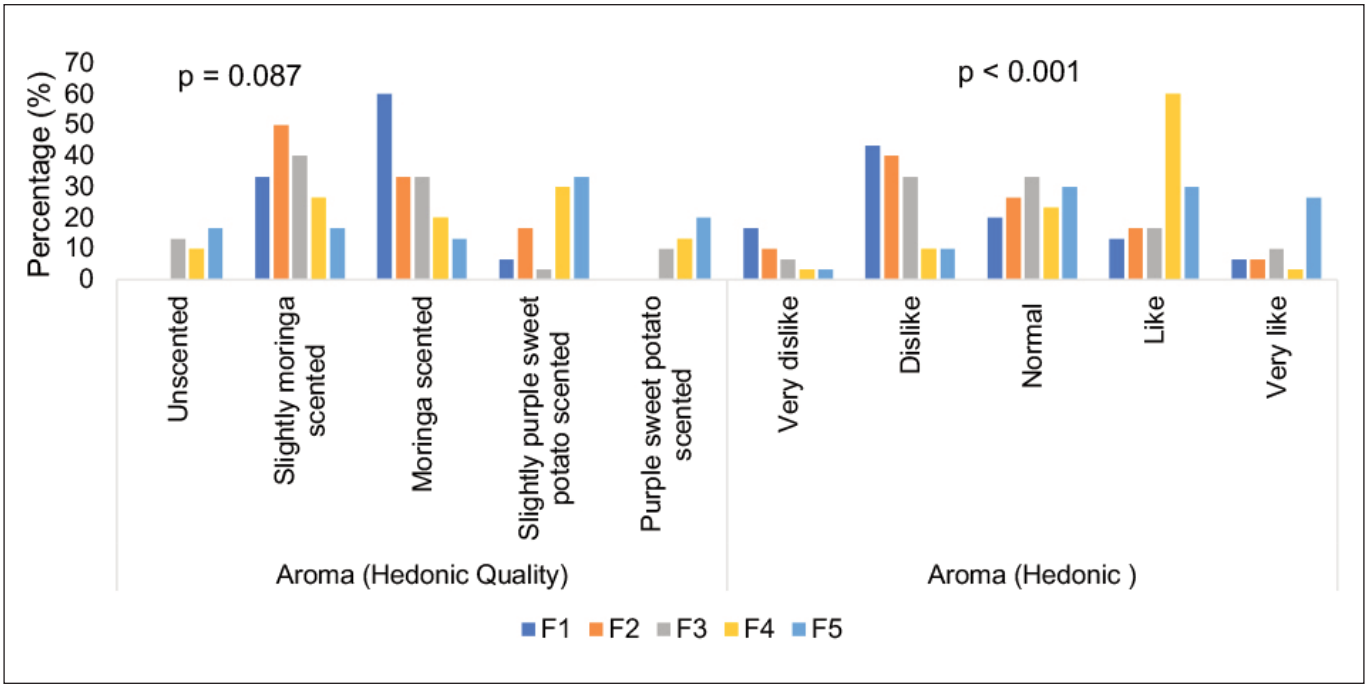

Figure 6. Aroma (Quality and Hedonic) based on 5 formula groups

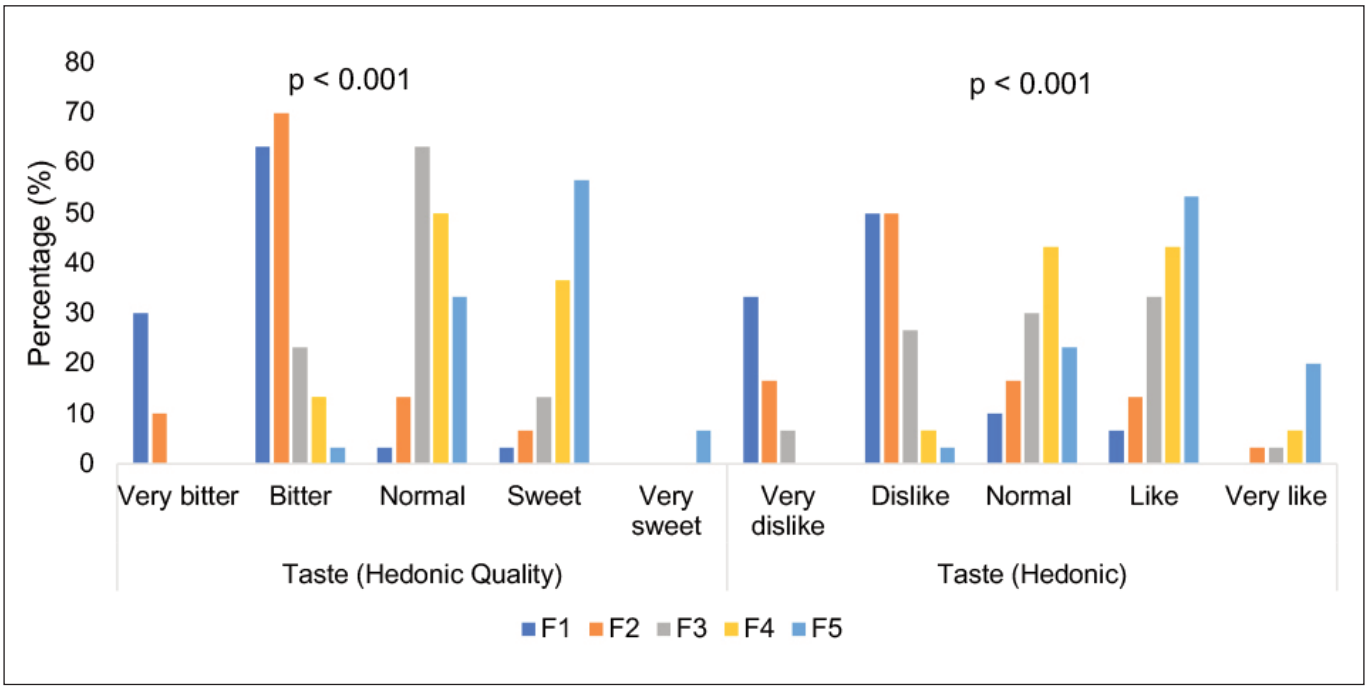

Figure 7. Taste (Quality and Hedonic) based on 5 formula groups

the statistical analysis showed that there were very significant differences both in the taste quality category (p = 0.000) and the level of taste preference (p = 0.000). This indicates that the five formulas produced very different taste profiles and also caused very different responses from the panelists. This very significant difference indicates that the composition of each formula has a very large influence on the perception of the product's taste. These formulas produce varying tastes, ranging from very bitter to very sweet, and this greatly influences consumer preferences.

DISCUSSION

Research findings indicate that the development of biscuits based on purple sweet potato and Moringa leaves holds significant potential as a nutritious snack alternative for infants at risk of stunting. Nutritional analysis revealed substantial variations in nutritional composition among the five biscuit formulations (F1-F5). Formula F5 exhibited the highest carbohydrate content (52.2%), while F1 excelled in fat (35.7%) and protein (15.38%) content. This demonstrates that each formula possesses a distinct nutritional profile, allowing for adjustments to meet specific nutritional requirements.

In addition to macronutrient content, this study also elucidated other crucial aspects such as moisture content, ash content, fiber content, and antioxidant activity. Formula F1 stood out with the highest moisture and ash content, while F3 contained the highest fiber content. Interestingly, formula F1 also demonstrated the strongest antioxidant activity with an IC50 value of 94.655 ppm, indicating that a higher composition of Moringa leaf flour contributes to enhanced antioxidant potency.

Purple sweet potatoes are known for their high anthocyanin content and antioxidant activity. Research has shown that biscuit formulations containing 75% purple sweet potato flour exhibited the highest anthocyanin content (95.05 ppm) and antioxidant activity (61.57%) [10]. Meanwhile, Moringa leaves are nutrient-dense and can be utilized to promote weight gain in undernourished infants. The administration of dry snacks supplemented with 100 mg of Moringa leaf powder daily for 3 weeks significantly increased the body weight of infants[11].

The combination of purple sweet potato and Moringa leaves in a single snack product has not been extensively researched. However, the development of similar products, such as purple sweet potato-based snack bars for vegans[12] and food bars with purple sweet potato paste, demonstrates the potential for developing comparable products for toddlers[13]. Research indicates that snacks with the addition of 1% Moringa leaf powder exhibit higher concentrations of calcium, magnesium, potassium, phosphorus, zinc, manganese, iron, and crude protein compared to control samples[14]. Considering the nutritional benefits of both ingredients, the development of biscuits based on purple sweet potato and Moringa leaves has the potential to become an alternative nutritious snack that may help prevent stunting and wasting in toddlers.

Sensory analysis revealed significant differences in the perception of quality and preference for color, aroma, and taste among the five formulas. The highly significant differences in color and taste preferences indicate that the composition of each formula has a substantial influence on the product's sensory characteristics. Although there were no significant differences in texture, variations in aroma and taste suggest that different formulations can affect consumer acceptance. From an organoleptic perspective, biscuits with purple sweet potato substitution were generally well-accepted. In a study with four different formulas, biscuits with a 50:50 ratio of wheat flour and purple sweet potato were most preferred by panelists[15]. The addition of purple sweet potato significantly affected the color of the biscuits but did not significantly influence taste, aroma, and texture[16]. The incorporation of Moringa oleifera leaves in biscuits can increase the content of minerals such as calcium, magnesium, potassium, phosphorus, zinc, manganese, and iron, as well as crude protein. Biscuits with 1% Moringa leaf powder had an acceptance level similar to the control for all sensory attributes[14].

In summary, purple sweet potato and Moringa leaf-based biscuits demonstrate potential as a nutritious snack for children experiencing stunting and wasting due to their favorable nutritional content and relatively high acceptance rate. However, further research is necessary to determine the optimal formulation that maximizes nutritional value while maintaining sensory qualities acceptable to children.

CONCLUSION AND RECOMMENDATIONS

The development of biscuits based on purple sweet potato and Moringa leaves demonstrates promising potential as a nutritious snack alternative for toddlers at risk of stunting. Several key points from this research include: 1) Nutritional: Five biscuit formulations (F1-F5) exhibited diverse nutritional compositions. F5 excelled in carbohydrate content, while F1 contained the highest levels of fat and protein. 2) Sensory characteristics: Significant differences were observed in the perception of quality and preference for color, aroma, and taste among the five formulations. Texture remained relatively consistent across all formulations.

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Efecto de la suplementación de una mezcla instantánea a base de cañihua, cacao y sangre bovina para la recuperación de la anemia en ratas wistar

Effect of supplementation of an instant mixture based on cañihua, cocoa and bovine blood on the recovery of anemia in wistar rats

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RESUMEN

Objetivo: Verificar el efecto de la suplementación de una mezcla instantánea a base de cañihua, cacao y sangre bovina para la recuperación de la anemia en ratas wistar.

Material y métodos: Se efectuó un estudio experimental (aleatorizado) en ratas Wistar con un rango de edad de 21-22 días de edad. Los 24 animales fueron alojados en jaulas (dos por jaula). Todos los animales vivían en ciclos de claro/oscuro (12 h/12 h) en un ambiente con temperatura constante (24º C ± 2º C). Se conformó cuatro grupos experimentales: Grupo experimental 1 (GE1): [Formulación 1: Cañihua 54%, cacao 16%, harina de sangre bovina 30%], Grupo experimental 2: (GE2): [Formulación 2: Cañihua 47%, cacao 13%, harina de sangre bovina 40%], Grupo experimental 3 (GE3): [Formulación 3: Hierro, Quinua Shake] y Grupo control (GC): Sin suplementación de hierro. Las diferencias entre grupos se determinaron por medio de Anova de dos vías y tamaño del efecto (*d* de Cohen).

Resultados: Hubo diferencias significativas en tres grupos experimentales. En el GE1 la Hb se incrementó en un 40% (tamaño del efecto -0.87), en el GE2 aumentó 22% (tamaño del efecto-0.79) y en el GE3 aumentó 23% (tamaño del efecto -0.79). El GC permaneció con los valores de Hb relativamente estables. No hubo diferencias significativas en los tres grupos experimentales en los niveles de Hb ($p>0.05$).

Conclusión: La suplementación con la mezcla instantánea a base de cañihua (54%), cacao (16%) y harina de sangre bovina demostró ser efectiva para la recuperación de la anemia en ratas Wistar. Estos resultados sugieren que este producto tiene un alto potencial como estrategia nutricional para combatir la deficiencia de hierro.

PALABRAS CLAVE

Hemoglobina, micronutrientes, hierro hemo, modelos animales, fortificación alimentaria.

ABSTRACT

Objective: To verify the effect of supplementation of an instant mixture based on cañihua, cocoa and bovine blood for the recovery of anemia in wistar rats.

Material and methods: An experimental study (randomized) was carried out in Wistar rats with an age range of 21-22 days of age. The 24 animals were housed in cages (two per cage). All animals lived in light/dark cycles (12 h/12 h) in

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a constant temperature environment (24o C ± 2o C). Four experimental groups were formed: Experimental Group 1 (EG1): [Formulation 1: Cañihua 54%, cocoa 16%, bovine blood meal 30%], Experimental Group 2 (EG2): [Formulation 2: Cañihua 47%, cocoa 13%, bovine blood meal 40%], Experimental Group 3 (EG3): [Formulation 3: Iron, Quinoa Shake] and Control Group (CG): No iron supplementation. Differences between groups were determined by two-way Anova and effect size (Cohen's d).

Results: The average age of the animals was 20-21 days old. There were significant differences in three experimental groups. In GE1 Hb increased by 40% (effect size -0.87), in GE2 it increased 22% (effect size-0.79) and in GE3 it increased 23% (effect size -0.79). The CG remained with relatively stable Hb values. There were no significant differences in the three experimental groups in Hb levels (p>0.05).

Conclusion: Supplementation with the instant mixture based on cañihua (54%), cocoa (16%) and bovine blood meal proved to be effective for the recovery of anemia in Wistar rats. These results suggest that this product has a high potential as a nutritional strategy to combat iron deficiency..

KEY WORDS

Hemoglobin, micronutrients, heme iron, animal models, food fortification.

INTRODUCCIÓN

La anemia afecta a una cuarta parte de la población mundial y se concentra en niños en edad preescolar y mujeres, lo que la convierte en un problema de salud pública a nivel mundial, tanto en países industrializados, como en los no industrializados[1]. Está determinado por dos factores principales, siendo el primero relacionado a la nutrición insuficiente (incluidas deficiencias de hierro, vitamina B12, folato y otros) y en segundo lugar, que tiene que ver con condiciones de salud comprometidas (como enfermedad renal crónica (ERC) o trastornos de la médula ósea)[2].

La anemia es un problema crítico de salud pública global debido a su impacto significativo en la mortalidad materna e infantil, la disminución del rendimiento físico y cognitivo, y la carga adicional sobre los sistemas de salud debido al aumento en la necesidad de atención médica especializada[3].

Ante esta problemática, en los últimos años varios estudios efectuados en modelos animales han sugerido la implementación de estrategias de suplementación nutricional, como la administración de hierro con alta biodisponibilidad, vitamina B12 y ácido fólico, junto con intervenciones de salud pública dirigidas a abordar las causas subyacentes, de recuperación y prevención de la anemia[4,5,6]. Sin embargo, aunque estos estudios ofrecen valiosas perspectivas sobre los mecanismos fisiológicos y los efectos de las intervenciones, su extrapolación a poblaciones humanas requiere cautela y una evaluación más profunda mediante ensayos.

De hecho, el hierro desempeña papeles importantes en el transporte de oxígeno, la síntesis del ácido desoxirribonucleico (ADN), el transporte de electrones mitocondriales y en el metabolismo energético, funciones que son esenciales para el adecuado desarrollo celular y el mantenimiento de la homeostasis corporal[7].

En ese contexto, estudiar la anemia en modelo animal y específicamente en la sepa Wistar es importante porque este modelo animal ofrece varias ventajas significativas para investigar las causas, mecanismos y posibles tratamientos de esta condición lo que las hace útiles para extrapolar resultados preliminares en humanos.

Por lo tanto, la suplementación nutricional con hierro de alta biodisponibilidad en estudios previos en modelos animales[8,9,10], podrían mejorar significativamente los niveles de hemoglobina, y podría ser una estrategia eficaz para prevenir y tratar la anemia en humanos, siempre que se validen sus efectos mediante estudios clínicos.

Por lo tanto, el objetivo del estudio fue verificar el efecto de la suplementación de una mezcla instantánea a base de cañihua, cacao y sangre bovina para la recuperación de la anemia en ratas wistar.

METODOLOGÍA

Tipo de estudio y muestra

Se efectuó un estudio experimental (aleatorizado) en ratas Wistar en un laboratorio de la Universidad Nacional del Altiplano de Puno (Perú). La muestra fue conformada por 24 ratas machos. El rango de edad fue de 21 a 22 dias. Los 24 animales fueron alojados en jaulas (dos por jaula). Todos los animales vivían en ciclos de claro/oscuro (12 h/12 h) en un ambiente con temperatura constante (24º C ± 2º C). La alimentación estándar para todos los animales consistió en Labina y Purina (sin hierro) y agua *ad libitum.* La tabla 1 muestra la dieta hipoférrica. Esta dieta se administró durante 4 semanas, hasta conseguir los valores inferiores a 10,5g/dl. Cada jaula tenía aserrín y se renovaba tres veces por semana durante todo el estudio.

La distribución de los cuatro grupos se efectuó aleatoriamente, llegándose a conformar 4 grupos, la suplementación que se administró después de las 4 semana de inducción se organizó de la siguiente forma.

- Grupo experimental 1 (GE1): Suplementación a base de cañihua, cacao polvo y harina de sangre bovina. [Formulación 1: Cañihua 54%, cacao 16%, harina de sangre bovina 30%].
- Grupo experimental 2: (GE2): Suplementación a base de mezcla instantánea (cañihua, cacao polvo, harina de san-

Tabla 1. Valores de la dieta hipoférrica que se administró en las 4 semanas de inducción

Alimentos	Cantidad (g)	Energía (KCal)	Carbohidratos (g)	Proteína (g)	Grasa (g)	Hierro hem (mg)	Hierro no hem (mg)
Arroz con cáscara	10	33.2	7.57	0.59	0.2	0	0
Clara de huevo	8	4.4	0	0.9	0.02	0	0
Maicena	7	25.5	6.3	0.02	0.007	0	0
Aceite vegetal	5	44.2	0	0	5	0	0
Total	30	107.35	13.96	1.56	5.23	0	0

gre bovina). [Formulación 2: Cañihua 47%, cacao 13%, harina de sangre bovina 40%].

- Grupo experimental 3 (GE3): Suplementación a base mezcla instantánea (cañihua, cacao polvo, harina de sangre bovina). [Formulación 3: Iron Quinua Shake].
- Grupo control (GC): Sin suplementación de hierro.

El valor nutricional de cada grupo se describe en la tabla 2. La suplementación consistió en juntar el polvo de cañihua, cacao, y sangre bovina y se dio los alimentos tres veces al día en horarios de 8.00 am. 13.00 horas y 19:00h.

Técnicas e instrumentos

La evaluación del peso y la hemoglobina se efectuaron en el pre test y post test. Se evaluó el peso de las ratas utilizando una balanza digital de marca Scaltec modelo SAC-62, con una precisión de (10-4gramos), siguiendo las recomendaciones de Cossio-Bolaños et al[11]. Es necesario un frasco de plástico donde se debe ubicar al animal. Previamente se pesa el frasco para restar el peso excedente. El procedimiento se repite dos veces.

La superficie corporal (SC) se evaluó utilizando la edad y el peso. Se utilizó la ecuación propuesta por Cano-Rabano

Tabla 2. Valor nutricional para la suplementación de los 3 grupos experimentales

Alimentos	Cantidad (g)	Energía (KCal)	Carbohidratos (g)	Proteína (g)	Grasa (g)	Hierro (mg)
GE1						
Cañihua	25	88.75	16.55	3.45	0.88	3.75
Cacao en polvo	7.1	27.05	4.76	0.69	0.58	0.31
Hierro de sangre bovina	15	11.7	0.0	25.66	0.03	9.21
Total		127.5	21.31	29.8	1.49	13.27
GE2						
Cañihua	21.1	74.9	13.97	2.91	0.74	3.17
Cacao en polvo	6	22.86	4.03	0.59	0.49	0.26
Hierro de sangre bovina	20	15.6	0.0	5.8	0.04	12.28
Total		113.36	18.0	9.3	1.27	15.71
GE3						
Hierro Quinua Shake	100	398.95	51.27	32.74	6.99	70
Total						

et al[12], donde SC = 0,1*PV*0,685 (SC = superficie corporal; PV = peso vivo).

Los valores de hemoglobina se midieron al final del experimento. Se extrajo sangre de la cola de cada animal por gota en ayunas (10 µL de sangre capilar). La medición de los niveles de hemoglobina se realizó utilizando un equipo portátil (Analizador Hemocue HB-201). La lectura demoró alrededor de 15 a 60 segundos.

Intervención para suplementar

El programa de intervención tuvo dos etapas: a) Una etapa inicial de adaptación y de inducción a anemia que duró 4 semanas. La etapa final de suplementación tuvo una duración de 5 semanas. Ambos procedimientos se pueden observar en la figura 1.

En general, todo el procedimiento efectuado en este estudio se llevó a cabo de acuerdo al comité de ética de la Universidad Nacional del Altiplano de Puno (protocolo N° 026 – 2023) y de acuerdo a la guía de ética de experimentación para animales de los Estados Unidos[13].

Estadística

El test de Shapiro-Wilk se utilizó para verificar la normalidad de los datos. Se efectuó el cálculo de la estadística descriptiva (media aritmética, desviación estándar y rango. Para determinar las diferencias significativas se utilizó el análisis de varianza (ANOVA) de dos vías, seguida de la prueba de especificidad de Tukey. Se calculó también el tamaño del efecto y la *d* de Cohen. En todos los casos se adoptó $p<0.05$. Los cálculos se efectuaron en SPSS 18.0 y en planillas de Excel.

RESULTADOS

En la tabla 3 se muestran los valores de edad, peso, Sc y Hb de los 4 grupos estudiados antes de la inducción a la anemia. No hubo diferencias significativas entre los 4 grupos en ninguna de las variables antes descritas. Los 4 grupos son relativamente homogéneos en sus medidas somáticas.

El proceso de inducción a anemia (Hb) se muestra en la tabla 4. Después de las 4 semanas de inducción, los resultados muestran que, en la última semana, los cuatro grupos experimentales alcanzaron el punto de corte de anemia (<10.5 g/dl).

Las comparaciones entre el pre test y post test de los 4 grupos estudiados se observan en la tabla 5. Hubo diferencias significativas en tres grupos experimentales. Por ejemplo, en el GE1 la Hb se incrementó en un 40% (tamaño del efecto -0.87), en el GE2 aumentó 22% (tamaño del efecto-0.79) y en el GE3 aumentó 23% (tamaño del efecto -0.79). El GC permaneció durante las 4 semanas de suplementación. En la figura 2 se puede observar las diferencias y cambios significativos.

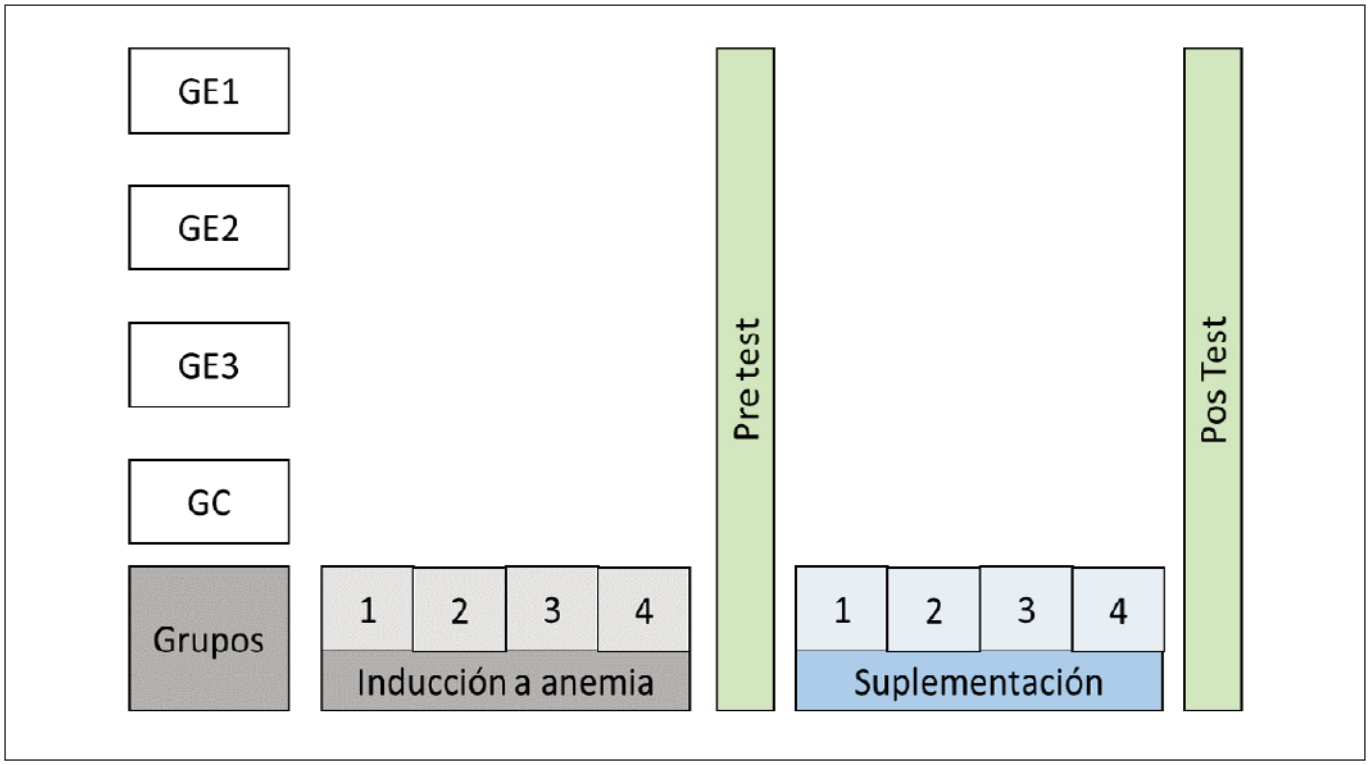


Figura 1. Diseño utilizado para el desarrollo del estudio en ratas machos wistar

Tabla 3. Características murinométricas de la muestra estudiada

Variables	GE1		GE2		GE3		GC	
	X	DE	X	DE	X	DE	X	DE
Edad (días)	21,60	1,90	22,60	1,70	21,60	1,90	22,60	1,70
Peso /g)	90,05	14,74	89,45	9,55	95,62	11,99	83,12	5,74
SC (m2)	5,85	1,01	5,23	0,65	6,11	0,82	5,32	0,39
Hb (g/dl)	13,82	3,04	14,17	1,92	14,75	0,87	14,24	0,89

GE: Grupo experimental, SC: Superficie corporal.

Tabla 4. Valores descriptivos de los niveles de hemoglobina durante las 4 semanas de inducción a anemia

Grupos	Semana 1		Semana 2		Semana 3		Semana 4		Valor-p (semana 1 vs semana 4)
	X	DE	X	DE	X	DE	X	DE	
GE1	13,82	3,04	12,9	3,09	10,78	2,09	9,25	2,11	0.051
GE2	14,17	1,92	13,08	2,39	11,5	2,37	10,38	0,96	0.039
GE3	14,75	0,87	14,78	1,65	10,77	5,48	10,50	1,11	0.048
GC	14,24	0,89	13,2	0,52	11,43	2,08	10,17	1,59	0.001

GE: Grupo experimental, SC: Superficie corporal.

Tabla 5. Comparación de los niveles de hemoglobina de los 4 grupos durante el pre y post test

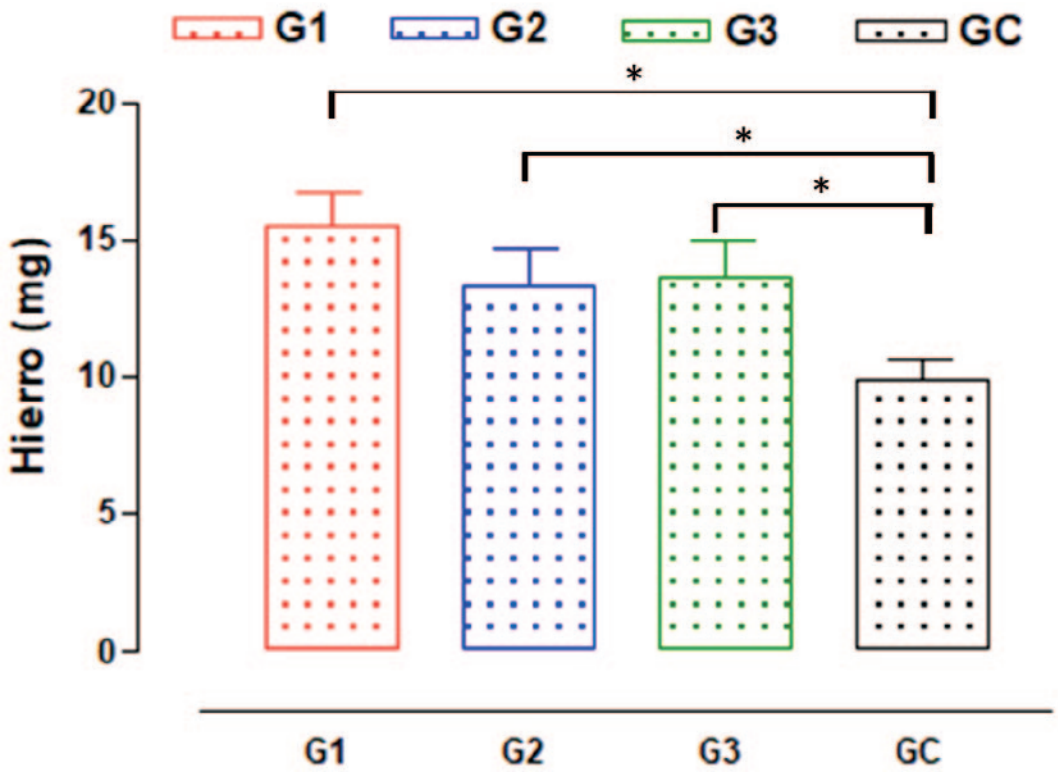
Grupos	Pre test		Post Test		ð (%)	r (tamaño efecto)	Comparaciones Post Test					
	X	DE	X	DE			GE1-GE2	GE1-GE3	GE1-GC	GE2-GE3	GE2-GC	GE3-GC
GE1	9,25	2,14	15,53*	1,25	40	-0,87	N	N	✓	N	✓	✓
GE2	10,38	0,96	13,35*	1,33	22	-0,79						
GE3	10,5	1,11	13,65*	1,29	23	-0,79						
GC	10,17	1,59	9,87	0,74	-3	0,12						

GE: Grupo experimental, SC: Superficie corporal, ð: delta, *: diferencia significativa en relación al pre test.

DISCUSIÓN

Los resultados del estudio demostraron que la suplementación con la mezcla instantánea a base de cañihua, cacao y harina de sangre bovina generó cambios significativos en los niveles de hemoglobina (Hb) en los tres grupos experimentales en comparación con el grupo control (GC). Aunque el GE1 mostró un incremento ligeramente superior en los niveles de Hb respecto a los demás grupos (pero no significativo), los hallazgos respaldan que esta mezcla constituye una estrategia prometedora para abordar problemas relacionados con la deficiencia de hierro.

Estudios previos han demostrado que las deficiencias de hierro se pueden suplir con péptido enriquecido con hierro hemo[14], suplementación de hierro del cacao[8] y harina de quinua y cañihua en ratas wistar[9]. En este contexto, los hallazgos de nuestro estudio refuerzan estas evidencias al demos-



*: diferencia significativa.

Figura 2. Diferencias significativas de los posts test en los cuatro grupos de estudio

trar que una mezcla instantánea a base de cañihua, cacao y harina de sangre bovina es efectiva para incrementar los niveles de hemoglobina en humanos.

Este enfoque innovador de combinar Múltiples fuentes de hierro, integrando el hierro hemo de la sangre bovina y el hierro no hemo presente en la cañihua y el cacao, podría potenciar su biodisponibilidad y eficacia en la alimentación de poblaciones vulnerables, como niños, adolescentes, mujeres. en edad fértil y personas mayores, quienes suelen presentar un mayor riesgo de desarrollar anemia por deficiencia de hierro[15,16].

De hecho, fortificar los alimentos con hierro puede ser una estrategia eficaz para prevenir la deficiencia de hierro, aunque la fortificación exitosa con hierro sigue siendo un desafío[17]. Esto se debe a varios factores, como la baja biodisponibilidad del hierro en muchas formas utilizadas para la fortificación, las interacciones negativas con otros componentes de los alimentos (como fitatos, polifenoles o calcio), y los cambios organolépticos que pueden alterar el sabor, olor o apariencia del producto final, afectado su aceptación por parte de los consumidores.

Por ello, combinar diferentes fuentes de hierro y optimizar su biodisponibilidad a través de formulaciones innovadoras, como la mezcla evaluada en este estudio, podría ser clave para superar estas limitaciones y maximizar los beneficios de los programas de fortificación.

Un estudio reciente considera que, para introducir los programas de alimentación o fortificación, es necesario tener en cuenta factores culturales, sociales y económicos para garantizar la implementación efectiva de estas estrategias, adaptándolas a las necesidades y preferencias de las poblaciones objetivo[18].

En este sentido, es fundamental desarrollar productos que sean accesibles, aceptados y sostenibles, especialmente en comunidades con alta prevalencia de anemia por deficiencia de hierro. Por ejemplo, en las zonas rurales andinas del Perú, la incorporación de alimentos tradicionales como la cañihua y la quinua en formulaciones fortificadas puede incrementar la aceptación debido a su profundo arraigo cultural y consumo habitual en estas comunidades[19]. Cabe destacar que la región andina del Perú es reconocida como uno de los ocho centros de domesticación de plantas cultivadas a nivel mundial, donde se producen diversos granos de alto valor nutricional, lo que refuerza su potencial para ser integrados en estrategias de fortificación alimentaria[20].

El estudio presenta algunas fortalezas que deben ser descritas, por ejemplo, la inclusión de ingredientes tradicionales como cañihua y cacao puede aumentar la aceptación del producto en comunidades andinas, donde estos alimentos son parte integral de la dieta cotidiana, además, se destaca que la inducción a anemia duró 4 semanas y el proceso de recuperación el mismo tiempo. También se describe algunas limitaciones, que los estudios futuros deben considerar. Es necesario evaluar más variables relacionadas con el crecimiento de las ratas, ya que es posible que la inducción a anemia ha producido cambios en el proceso de crecimiento y desarrollo ósea, además, es necesario que otros estudios verifiquen las cantidades específicas de cacao, cañihua y hierro bovino que contribuyen al mejoramiento de los niveles de hemoglobina.

CONCLUSIÓN

La suplementación con la mezcla instantánea a base de cañihua (54%), cacao (16%) y harina de sangre bovina demostró ser efectiva para la recuperación de la anemia en ratas Wistar. Estos resultados sugieren que este producto tiene un alto potencial como estrategia nutricional para combatir la deficiencia de hierro.

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Amino acid and fatty acid profile of instant kanji rumbi porridge as supplementary feeding for undernutrition children

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ABSTRACT

Background: Specific undernutrition interventions focused on children aged 6-24 months include exclusive breastfeeding and providing complementary food rich in animal protein and available locally for toddlers. Instant kanji rumbi porridge is a local food from Aceh.

Methods: The development of instant kanji rumbi porridge used an experimental design. Protein (Kjeldahl), amino acids (Ultra Performance Liquid Chromatography/UPLC), and fatty acids (Gas Chromatography/GC-FID) were analyzed. Amino acid and fatty acid profile data were tabulated and analyzed descriptively.

Results: Kanji rumbi porridge had a protein content of 20.22 g/100 grams and met the established complementary food standards. It contained essential, non-essential, and conditionally essential amino acids with an Amino Acid Score of 61% and valine as the limiting amino acid. The product also has complete fatty acid content, especially omega 3, 6, and 9.

Conclusion: Instant Kanji Rumbi porridge can be a supplementary feeding for undernutrition children with protein, essential amino acids, and essential fatty acids.

KEYWORDS

Child nutrition, micronutrients, complementary food, preventive nutrition, pediatric health.

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INTRODUCTION

The toodlers period is part of the critical period for child growth and development. It is characterized by identifiable phases such as exclusive breastfeeding (0-6 months of age) and complementary feeding (6-24 months), both of which are determinants of child growth and development[1]. Good nutrition and healthy growth during the 1000 HPK period will provide permanent benefits throughout the child's life, so this period is referred to as the best period for nutrition improvement interventions because it is more likely to prevent irreversible impacts[2].

Undernutrition in children before the age of two can cause short-term impairments in physical health such as growth and long-term impairments in psychosocial health such as cognitive, mental and motor development[3]. Undernutrition at this age will have a permanent impact on growth, leading to stunting, and development, characterized by reduced capacity for brain development.

Undernutrition children have high nutrient requirements, while the quantity and quality of food consumed is very limited (less diverse and not nutrient dense), making them vulnerable to weight loss and undernutrition[4]. Undernutrition children have inadequate levels of Essential Amino Acids and suffer from various other metabolic disorders[5]. This is partly due to the poor protein quality of complementary foods, especially low animal foods. Animal-sourced complementary foods are rich in essential amino acids, in addition to being a source of other essential macronutrients (such as energy, high-quality protein, and fatty acids), they are also rich in micronutrients (such as zinc, iron, iodine, magnesium, potassium, vitamin B, vitamin A, and vitamin D) that are building blocks and regulate processes involved in child growth and development[1].

Government policy on eleven specific undernutrition intervention programs focuses on children aged 6-24 months, one of which is through exclusive breastfeeding and complementary feeding rich in animal protein for toddlers. According to the guidelines for local food-based supplementary feeding for undernutrition children, increasing nutrient intake from diverse foods and adding animal protein sources of at least two types[6]. The WHO has also previously classified the problem of undernutrition as underweight with the BB/U indicator (Z-3.0 SD to <-2.0 SD), so it is necessary to provide nutrient-dense and locally available supplementary foods to increase weight, height and recovery functions and prevent undernutrition[7].

Instant kanji rumbi porridge is a local food from Aceh that has been formulated according to the needs of toddlers and served in instant form. Bubur kanji rumbi is processed from various types of food sources of nutrients, rice as the main ingredient of bubur kanji rumbi, while the additional ingredients come from potatoes, carrots, chicken/beef/shrimp/eggs/fish, tomatoes, coconut milk, and other typical herbs and spices[8,9]. Rice and potatoes contain carbohydrates and protein, carrots and tomatoes contain vitamins and minerals, while coconut milk and oil are sources of fat[10].

The most important additive in the processing of instant flour porridge is using two types of animal protein sources, namely chicken meat and quail egg flour. Animal protein from chicken meat and eggs is a good source of protein and micronutrients for the growth and development of toddlers and children, so it is important to add in complementary food[10–12]. Quail eggs are high in nutrients such as amino acids, fatty acids, vitamin E, and the minerals nitrogen, iron and zinc[13].Quail egg meal is one type of processed quail egg that has a high content of protein, minerals, and essential amino acids[14]. Essential amino acids are required for protein synthesis which is necessary for child growth and development[15]. Based on the ingredients used to make it, kanji rumbi porridge has the potential to be used as an alternative complementary food that is nutrient-dense, especially protein and is thought to also contain a number of amino acid and fatty acid profiles that can support the growth and development of undernutrition children. Therefore, this study aimed to analyze the amino acid and fatty acid content of instant kanji rumbi porridge.

METHODS

Design, Place and Time

The development of instant kanji rumbi porridge used an experimental design. This research was conducted in October-December 2023. The processing of instant kanji rumbi porridge was carried out at the Seafast Laboratory of IPB. Analysis of the amino acid profile and fatty acid content of instant rumbi porridge was conducted at Saraswanti Indo Genetech (SIG) Laboratory, Bogor.

Ingredients and Equipment

The ingredients used in the preparation of instant kanji rumbi porridge are white/ground rice, purebred chicken meat, quail egg flour, carrots, potatoes, tomatoes, coconut milk, palm oil; spices or herbs (shallots, garlic, cumin, fennel, pepper, coriander, cardamom, star anise, cinnamon, curry leaves, pandanus leaves, serei, salt, water) which are mostly available in traditional markets. The quail egg flour used was 5 grams obtained from CV Slamet Quail Farm, Sukabumi, West Java. The equipment used in the research of instant bubur kanji rumbi product development consisted of fresh bubur kanji rumbi cooking equipment (digital scales, steam jacket kettle, double drum dryer, knives, blender, stirrer, cutting board, stainless container, mixer).

The Development of Instant Kanji Rumbi Porridge

Modification of the standard instant kanji rumbi porridge recipe from three sources, namely the book "Guidelines for the Development of Local Food-Based Recipes for Healthy Breakfast Menus for School Children", the book "Local Food-Based Complementary Food Processing as an Effort to Prevent Stunting and Anemia in toddlers in Aceh" and traditional recipes commonly used by the people of Aceh to produce the right formula to meet the snack food standards for children aged 12-23 months, especially the content of energy, protein and amino acids applied in Microsoft excel 2010[8–10].

The process of making instant kanji rumbi porridge begins with making kanji rumbi porridge in fresh form, then making it in instant form. The process of making instant kanji rumbi porridge is shown in Figure 1. It can be seen that the process of making instant fresh kanji rumbi porridge includes several stages; (1) boiling rice until the water shrinks (almost forming porridge) using a steam jacket (2) sautéing chicken meat together with fine spices and coarse herbs until it produces tender meat texture using Teflon frying pan (3) steaming potatoes and carrots until tender texture using a steamer (4) re-boiling all ingredients to form porridge (5) drying fresh kanji porridge using a Drum Dryer to form a smooth slab of instant kanji rumbi porridge (T outlet: 90°C, T inlet: 130°C, speed: 10 rpm), (6) mixing instant kanji rumbi porridge with quail egg flour.

Analysis of Chemical Characteristics of Instant Kanji Rumbi Porridge

Analysis of the chemical characteristics of instant Kanji rumbi porridge consisted of analysis of protein content, amino acids, and fatty acids. Protein content was analyzed using the Kjeldahl method[16]. Amino acid profile analysis uses the Ultra Performance Liquid Chromatography (UPLC) method, while fatty acid profile uses the Gas Chromatography (GC-FID) method[17].

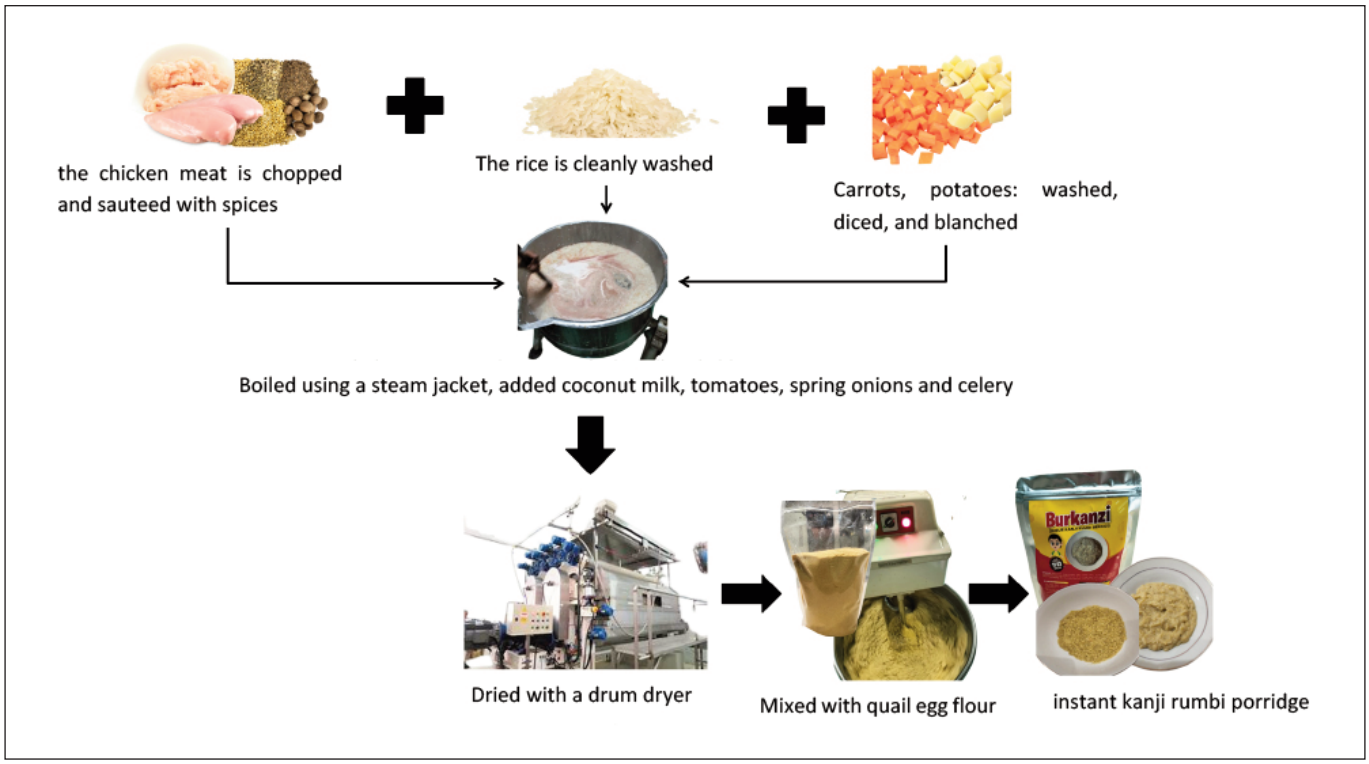

Figure 1. Procedure for making instant kanji rumbi porridge

Data Analysis

The values of each parameter were analyzed using the Microsoft Excell 2016 computer program and the Social Science Statistics Program (SPSS) version 16.0 for Windows. Data were presented as mean ± standard deviation (SD). Amino acid and fatty acid profile data were tabulated and analyzed descriptively and presented in tables.

RESULTS AND DISCUSSION

Amino Acid Profile of Instant Kanji Rumbi Porridge Complementary Food

Complementary feeding is nutritious food and drink given to toddlers aged 6-24 months in addition to breastfeeding according to medical indications, to achieve nutritional adequacy[18]. The Indonesian government has set the standard rules for complementary food snacks in Food and Drug Administration Regulation No. 24/2019 and SNI for complementary food through SNI 01-7111.1-2005. Table 1 shows a comparison of the protein analysis results of instant kanji rumbi porridge with these standards. It can be seen in Table 1 that kanji rumbi porridge has met the established complementary food standards.

The results of amino acid analysis of instant kanji rumbi porridge are shown in Table 2. Instant kanji rumbi porridge contains essential and non-essential amino acids. The dominant types of essential amino acids found in instant kanji rumbi porridge products are leucine, lysine, phenylalanine, threonine, valine, histidine, isoleucine, while tryptophan is the lowest type of amino acid. The most abundant non-essential amino acid profiles in instant kanji rumbi porridge

Table 1. Protein Content Comparison of Instant Kanji Rumbi Porridge with Standard MP-ASI

Standardized complementary snack* (g/100 kkal)			**SNI MP-ASI** (g/100 g)**		
analysis result	Standard	Interpretation	analysis result	Standard	Interpretation
0.8	0.8-5.5	Fulfill	20.22	8- 22	Fulfill

* Food and Drug Administration Regulation No. 24/2019.
** SNI 01-7111.1-2005.

Table 2. Amino Acid Profile of Instant Kanji Rumbi Porridge per 100 g Sample

Amino Acid Profile Content	mg/100 g
Asam amino essensial	
Histidine	373.39 ± 0.20
L-Lysine	804,64 ± 2.67
L-Leucine	1033.36 ± 2.22
L-Isoleucine	347.36 ± 0.00
L-Threonine	600.16 ± 2.41
L-Valine	524.22 ± 0.78
L-Phenilalanine	685.54 ± 2.09
L-Methionine	303.61 ± 0.14
L-Tryptophane	194.01 ± 0.15
Non essensial	
Aspartic acid	1257.58 ± 2.96
L-Serine	894.20 ± 1.92
L-sistin	1001.72 ± 0.00
L-Prolin	808.22 ± 2.41
L-Alanine	850.10 ± 2.39
L-tirosin	589.64 ± 1.25
Conditional essensial	
L-Arginine	1251.71 ± 3.02
Glutamic acid	2138.52 ± 7.00
L-glisin	1214.38 ±2.98

were glutamine, aspartic acid, arginine and glysine. The contribution of essential and non-essential amino acids in this instant kanji rumbi porridge comes from the combination of food ingredients used in the processing process, especially supplemented with animal protein sources from chicken meat and quail egg flour.

Table 3 shows that the amino acid scores (AAS) that are in accordance with the recommendations of FAO and WHO that have met 100% are methionine + cystine, phenylalanine + tyrosine, threonine, and tryptophan. AAS with a score of 70-87 are isoleucine, leucine, and lysine, while the AAS score of >60 is valine.

Table 3. Amino Acid Score (AAS) of Instant Kanji Rumbi Porridge

Essential amino acids	Grade in sample	FAO/WHO Standard[19]	AAS (%)
	(mg/g protein)		
Isoleucine	17.37	20	87
Leucine	51.67	66	79
Lysine	40.23	57	71
Methionine + Sistine	65.26	27	100
Phenilalanine + Tyrosine	63.76	52	100
Treonin	31.01	31	100
Triptofan	9.70	8.5	100
Valine	26.21	43	61

Fatty Acid Content of Instant Kanji Rumbi Porridge

Table 4 shows the results of fatty acid profile analysis in instant kanji rumbi porridge consisting of 15 types of fatty acids classified into saturated fatty acids, monounsaturated fatty acids, polyunsaturated fatty acids. The highest saturated fatty acid is Palmitic Acid (C16:0) which is 3688.05 mg/100 grams. Oleic is the dominant monounsaturated fatty acid. Oleic is also known as omega 9.

DISCUSSION

The quality and quantity of protein will determine the adequacy of intake in meeting the required amino acids. Amino acid composition describes the quality of protein in food[15]. Essential amino acids are used as a reference to assess the quality of a protein because these amino acids cannot be synthesized by the body. A steady intake of amino acids is essential to ensure all the body's proteins can be assembled and perform their vital functions for optimal growth, development and health[20].

Instant kanji rumbi porridge is a complementary food product (MP-ASI) snack formulated according to the nutritional needs and acceptability of toddlers aged 12-23 months[21]. In this study, in addition to protein analysis, amino acid analysis was also carried out, both essential and non-essential. Non-essential amino acids are types of amino acids that can be produced by the body and essential amino acids are amino acids that cannot be produced by the human body, so they must be obtained from food[22,23]. There are nine types of essential amino acids detected in instant kanji rumbi porridge including; histidine, lysine, leucine, isoleucine, threonine, va-

Table 4. Fatty acid profile of instant kanji rumbi porridge per 100 g sample

Contents	mg
Saturated fatty acid (SFA):	
Caproic Acid (C6:0)	39.65±0.21
Caprylic Acid (C8:0)	366.00±0.98
Capric Acid (C10:))	305.15±2.19
Lauric Acid (C12:0)	2692.45±5.30
Myristic Acid (C14:0)	1268.10±3.68
Palmitic Acid (C16:0)	3688.05±7.00
Heptadecanoic Acid (C17:0)	13.75±0.21
Stearic Acid (C18:0)	1012.00±1.13
Arachidic Acid (C20:0)	21.10±0.00
Total Saturated Fat	**9430.10±3.67**
Monounsaturated Fatty Acids (MUFA):	
Palmitoleic Acid (C16:1)	318.85±3.46
Oleic Acid (C18:1) (omega 9)	4941.40±0,14
Eicosenoic Acid (C20:1)	18.80±0.14
Heptadecanoic Acid (C17:1)	8.55±0.07
Mirisoleic Acid (C14:1)	11.55±0.21
Total Monounsaturated Fats	**5328.70**±3.67
Polyunsaturated Fatty Acids (PUFA):	
Linoleic Acid (C18:2) (omega 6)	1801.50±1.27
Alpha-linolenic Acid (C18:3) (omega 3)	50.30±0.35
Arachidonic Acid (C20:4)	182.65±0.63
Total Polyunsaturated Fat	**1851.15±0.07**
Total Unsaturated fat	**7179.90±3.67**

line, phenylalanine, methionine and tryptophan[19]. The non-essential amino acids detected in the product were aspartame, glutamic acid, arginine, serine, glycine, sisitin, proline, alanine, tyrosine.

The amino acids in this porridge were influenced by the addition of quail egg flour. Quail egg meal is one of the processed quail eggs that has a protein content of 94.17 g with a high content of essential amino acids (such as leucine, phenylalanine, lysine, valine, isoleucine, threonine, methionine) and high non-essential amino acids (such as aspartic acid, alanine, glutamic acid, proline, glycine[14]. Another study, quail egg flour has a higher amino acid content of glutamic acid than other amino acids, followed by aspartic acid and leucine[24]. Glutamic acid and aspartic acid contribute to the umami flavor of the product[25].

Instant kanji rumbi porridge is high in the conditional amino acids arginine, glycine and glutamine. Some non-essential amino acids are classified as conditional amino acids which means they are only considered essential at a certain age of growth or condition, e.g. undernutrition[22]. There are three types of conditional amino acids associated with growth and stunting in toddlers, namely arginine, glycine and glutamine[5]. Glutamic acid is a type of conditional amino acid that is needed especially in undernutrition children[22]. undernutrition children require large amounts of protein, so for protein synthesis, glutamine can be added in complementary foods. Arginine is a non-essential amino acid for adults, but essential for children because it is needed for growth, so it is called a conditional amino acid[22]. Conditional amino acids are useful for increasing growth hormone production. Therefore, all complementary foods produced should contain these amino acids.

The age of toddlers is a period of rapid growth and development[26]. During this period, children need adequate quality and quantity of nutrient intake, especially protein. Protein intake is important because it provides essential amino acids needed for protein synthesis, which is necessary for growth[27]. Essential amino acids are very important for the human body because they are precursors in various metabolic processes of the body[22]. Leucine is an essential amino acid that is indispensable for the growth of children and maintaining nitrogen balance. Leucine is also useful for the breakdown and formation of muscle proteins. Lysine is needed for tissue growth and repair, so it is very important and needed in the growth and development of children.

Various studies support the relationship between growth and amino acid levels in undernourished children. A study from South Mawawi Rural in children aged 12-59 months who were stunted had 15-20% lower blood levels of amino acids and other protein markers than normal toddlers[5]. Types of amino acids that are positively correlated with growth and stunting in toddlers include; tryptophan, isoleucine, leucine, valine, methionine, threonine, histidine, lysine, arginine, glycine, glutamine, tyrosine, asparagine, glutamate, serine and serotonin[5]. Among all these amino acids, arginine is the lowest type of amino acid found in stunted children compared to normal children[5]. A study from rural Ethiopia in children aged 6-35 months further supports the association between stunted growth and low concentrations of the mino acids tryptophan and lysine[28]. Not only can low concentrations of essential amino acids

potentially have adverse consequences for growth, they are also likely to impede children's neurocognitive development[1]. The association of low amino acid concentrations with growth and neurocognitive development is explained as suppressing protein and lipid synthesis through mTORC1 (mammalian rapamycin complex 1) and GCN2 (general control nonderepressible) and inhibiting growth[5].

The amino acid score (SAA) of instant kanji rumbi porridge is presented in Table 3. SAA is obtained by dividing the amount of amino acids (mg/g protein) by the reference pattern amino acids for children aged 6-36 months, then multiplying by 100%[20]. If the value is 100 or > 100, the amino acid score is written as 100, and if it is <100 and has the lowest value, it indicates that it is the limiting amino acid score. Table 3 shows that the chemical score of the instant kanji rumbi porridge protein sample is 61% with the main limiting amino acid being valine. The kanji rumbi porridge from this study has a score greater than beef with a score of 56%[29]. This can be caused by the use of quail egg flour as an ingredient used. Eggs are the food with the highest amino acid score with a score of 100%[30]. During growth and development, toddlers experience an increase in body mass, height, maturity of body functions, and cognitive development where this occurs due to the role of protein. Protein will be called quality if it contains a complete amino acid profile and according to individual needs. In addition, protein is declared to have good quality if it has high digestibility and high PDCAAS value, which has a value ≥ 90[30]. In this study, the PDCAAS value was not observed, so the PDCAAS score of kanji rumbi porridge cannot be known.

Fatty acids are part of fat molecules that function as substances that make up body fat or can also be used as energy producers. Fatty acids can be divided into saturated fatty acids or Saturated Fatty Acid (SFA) and unsaturated fatty acids or Unsaturated Fatty Acid which is then grouped into Monounsaturated Fatty Acid (MUFA) and Polyunsaturated Fatty Acid (PUFA). Fatty acids are the main content of foods that can influence brain development, endurance, and sensory development in toddlers. Fatty acids that have these functions include omega-3, omega-6, and omega-9 fatty acids.

The human body can make omega-9 fatty acids, so they are called non-essential fatty acids. However, the human body cannot make its own omega-3 and omega-6 fatty acids (essential fatty acids) so they must be obtained from sources outside the body. There are two types of fat from the Polyunsaturated Fatty Acid (PUFA) group that must be provided in the intake of toddlers and toddlers for brain growth and development, namely LA (linoleic acid) (C18:2 n-6) and ALA (α- Linolenic Acid) (C18:3 n-3). Essential fat intake is particularly important in the first two years of childhood to support brain growth and development.

CONCLUSION

Kanji rumbi porridge contains essential, non-essential, and conditionally essential amino acids with SAA of 61% and valine as the limiting amino acid. This product also contains complete fatty acids, especially omega 3, 6, and 9 which are needed to improve the nutritional status of undernutrition children and achieve optimal growth and development. SAA determination is one of the methods to evaluate the quality of food protein. In future research, the Digestible Indispensable Amino Acid Score (DIAAS) method can be applied to evaluate the quality of protein in kanji rumbi porridge.

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Percepción corporal y trastorno del comportamiento alimentario en universitarios españoles

Body perception and eating disorder in Spanish university students

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RESUMEN

Introducción: El vínculo entre la alimentación y la percepción corporal está influenciado por factores biológicos, psicológicos y socioculturales, pudiendo desembocar en hábitos peligrosos para la salud. Esto se potencia por la presión social, especialmente dirigida a las mujeres, para mantener un cuerpo delgado. Además, la etapa de la universidad es una etapa crítica que puede propiciar un mayor riesgo para el desarrollo de los trastornos del comportamiento alimentario (TCA).

Objetivos: Evaluar la asociación entre condición nutricional, percepción de la imagen corporal y satisfacción con la misma, con el riesgo de desarrollar un TCA en una muestra de jóvenes universitarios de ambos sexos.

Material y métodos: Se ha realizado una encuesta a 468 estudiantes universitarios a través de *Google Forms* compuesta por un test de siluetas y un cuestionario para diagnosticar riesgo de TCA (EAT-26).

Resultados: Un 61,5 % de los hombres y un 66,8 % de las mujeres se encuentra en la categoría nutricional de normopeso. Un 11,4 % de las mujeres y un 5,6 % de los hombres presentan un alto riesgo de TCA.

Discusión: El estudio muestra diferencias en la percepción y satisfacción corporal entre sexos, así como en la probabilidad de desarrollar un TCA, estando estos resultados alienados con la mayor parte de las investigaciones y revisiones precedentes.

Conclusiones: El riesgo de TCA es más frecuente en las mujeres con sobrepeso y obesidad y en los varones con insuficiencia ponderal. La percepción de la figura no se asocia de manera significativa con el riesgo de TCA, mientras que la satisfacción resulta determinante, ya que la proporción de individuos con bajo y alto riesgo de TCA es superior entre los que desearían ser más delgados, respecto a los que quisieran ser más corpulentos.

PALABRAS CLAVE

Imagen corporal, jóvenes adultos, IMC, EAT-26, siluetas corporales.

ABSTRACT

Introduction: The link between food and body perception is influenced by biological, psychological and socio-cultural factors and can lead to habits that are hazardous to health. This is reinforced by social pressure, especially directed at women, to maintain a slim body. In addition, the university stage is a critical stage that can lead to an increased risk for the development of eating disorders (ED).

Objective: To assess the association between nutritional status, body image perception and body image satisfaction

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with the risk of developing an ED in a sample of young university students.

Methods: A survey was carried out on 468 university students using Google Forms, consisting of a silhouette test and a questionnaire to diagnose the risk of ED (EAT-26).

Results: 61.5 % of the men and 66.8 % of the women were in the normopese nutritional category. 11.4 % of the women and 5.6 % of the men were at high risk of ED.

Discussion: The study shows differences in body perception and satisfaction between sexes, as well as in the likelihood of developing an ED, and these results are in line with most previous research and reviews.

Conclusion: The risk of ED is more frequent in overweight and obese women and underweight men. Figure perception is not significantly associated with the risk of ED, while satisfaction is a determinant, as the proportion of individuals at low and high risk of ED is higher among those who would like to be thinner than among those who would like to be heavier.

KEY WORDS

Body image, young adults, BMI, EAT-26, body silhouettes.

ABREVIATURAS

EAT-26: Test de actitudes alimentarias (*Eating Attitudes Test*).

IMC: índice de masa corporal.

TCA: trastorno del comportamiento alimentario.

INTRODUCCIÓN

La relación que mantiene una persona con la comida y sus hábitos de alimentación se ve condicionada por factores biológicos, psicológicos y socioculturales. La confluencia de dichos elementos puede llevar a conductas que potencialmente representan un riesgo para la salud e incluso conducir a un trastorno del comportamiento alimentario (TCA)[1]. En la sociedad actual existe una presión, especialmente dirigida hacia las mujeres y exacerbada por los medios de comunicación y las redes sociales, para mantener un cuerpo delgado como estándar de belleza, aceptación y éxito[2,3]. No responder a esta norma de delgadez puede provocar insatisfacción con el propio cuerpo y desencadenar actuaciones encaminadas a modificar el peso, como ejercicio físico excesivo, dietas restrictivas, atracones, abuso de laxantes o diuréticos, vómito autoinducido o ayuno[4,5].

Los TCA representan condiciones mentales complejas que pueden tener graves consecuencias y se caracterizan por alteraciones en los pensamientos y las actitudes hacia la comida, la alimentación y la percepción del peso o la forma corporal. Los TCA pueden tener repercusiones adversas que se manifiestan en forma de complicaciones médicas, psiquiátricas y psicosociales como obesidad, diabetes, síndrome metabólico amenorrea, problemas de fertilidad y disminución de la densidad mineral ósea[6-9]. Según la *Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition, Text Revisión* (DSM-5-TR), los TCA incluyen la anorexia y la bulimia nerviosa, trastornos de la conducta alimentaria no especificados, pica, rumiación, trastorno por atracón y trastorno evitativo/restrictivo de la ingesta[10,11].

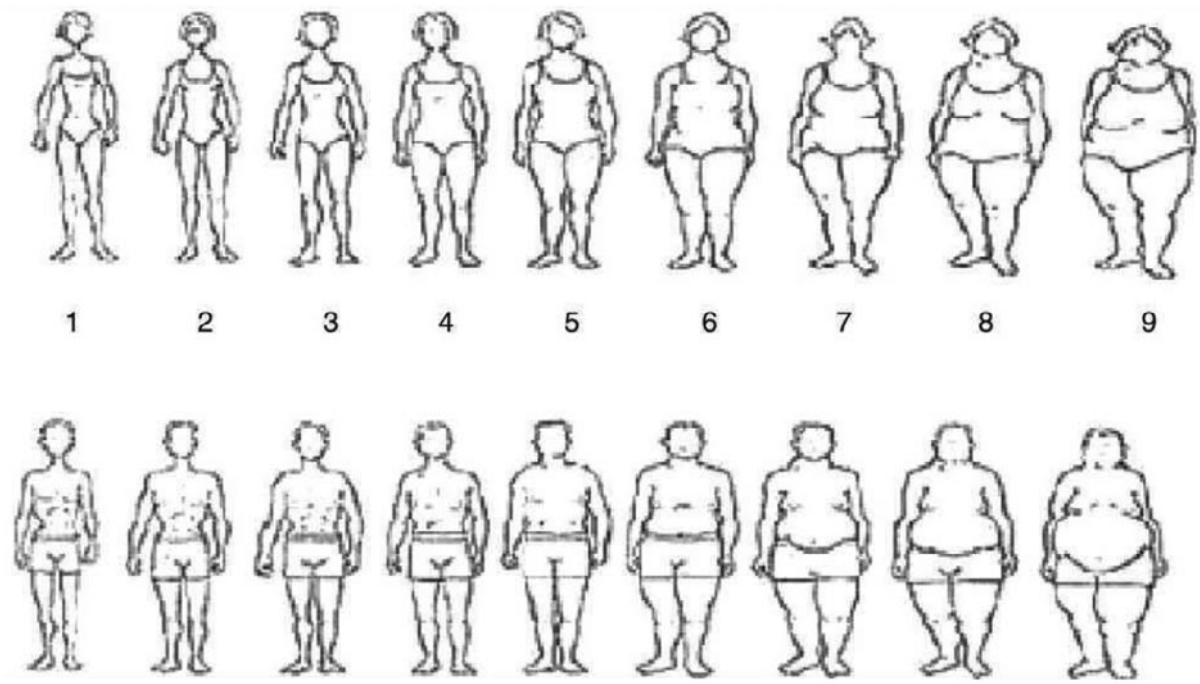
Uno de los predictores para el desarrollo de TCA, principalmente durante la adolescencia y juventud, es la autopercepción de la imagen corporal, es decir, cómo una persona se observa, siente y comporta con respecto a su propio cuerpo. De acuerdo con la literatura científica, la distorsión e insatisfacción con la propia imagen se ha asociado significativamente a un estado emocional negativo, a depresión, baja autoestima y seguimiento de dietas restrictivas[7,12]. De hecho, en el último documento de consenso para prevención de los TCA publicado en 2022 por las sociedades científicas con competencias en el tema (Sociedad Española de Nutrición Comunitaria, Sociedad Española de Pediatría Extrahospitalaria y Atención Primaria y Sociedad Española de Médicos de Atención Primaria) se hace especial énfasis en que la insatisfacción con la imagen corporal es el predictor más consistente, principalmente en el sexo femenino[13].

El periodo de la universidad es una fase crucial para el desarrollo, conocida como edad adulta emergente[14]. En este tiempo, muchos jóvenes dejan la casa familiar y comienzan una etapa de independencia, pasando a gestionar las cuestiones relacionadas con su alimentación. Según el metaanálisis de Harrer *et al.*[15] sobre 27 estudios realizados en este grupo poblacional, los TCA son altamente prevalentes entre los adultos jóvenes, si bien las universidades podrían ser un entorno óptimo para establecer programas destinados a su prevención. Según la citada revisión, la prevalencia promedio de TCA es mayor entre mujeres universitarias (54%) que entre sus pares hombres (19%).

El propósito del presente trabajo fue evaluar la asociación entre condición nutricional, percepción y satisfacción de la imagen corporal con el riesgo de desarrollar un TCA en una muestra de jóvenes universitarios españoles.

METODOLOGÍA

Se ha realizado una encuesta a través de la aplicación de *Google Forms* a 468 estudiantes universitarios (179 hombres y 289 mujeres) entre 18 y 30 años de edad. Dicho cuestionario incluyó un test de figuras[16] donde cada sujeto debía indicar con cuál de ellas se identificaba, cuál les resultaba más atractiva, cuál les parecía más saludable y qué silueta aspiraban tener. Como se representa en la Figura 1, a cada silueta le corresponde un Índice de Masa Corporal (IMC) concreto que los participantes desconocen. Además, se pidió a los encuestados que reportaran peso y estatura, y con estos valores se



Silueta	1	2	3	4	5	6	7	8	9
IMC	17	19	21	23	25	27	29	31	33

Arriba: siluetas femeninas. Abajo: siluetas masculinas. Análisis de la percepción de la propia imagen [en línea]. Grupo de investigación "epinut.ucm". Disponible en http://epinut.ucm.es/aplicaciones/percepcion-imagen.htm

Figura 1. Análisis de la percepción corporal (método adaptado de Stunkard y Stellard, 1990)

obtuvo el IMC auto-referido, estableciendo categorías nutricionales de acuerdo con las referencias de la Organización Mundial de la Salud[17].

Asimismo, se aplicó el EAT-26[18], un cuestionario que evalúa las conductas y actitudes relacionadas con la alimentación. Los encuestados indicaron la frecuencia de sus pensamientos, sentimientos y comportamientos en una escala tipo *likert*. La puntuación obtenida se encuentra en un rango de 0 a 26, de manera que si el sujeto obtiene hasta 9 puntos se considera que no presenta riesgo de TCA, si obtiene entre 10-19 puntos, se asume un bajo riesgo y a partir de 20 se interpreta que el riesgo de TCA es alto.

Para el estudio de cómo se perciben y cómo de satisfechos se encuentran los estudiantes universitarios consigo mismos, se idearon variables de percepción (IMC auto-referido - IMC percibido) y satisfacción (IMC auto-referido - IMC deseado).

Se calcularon parámetros descriptivos (medias y desviaciones estándar) y se llevaron a cabo test de contraste para variables cuantitativas y categóricas (T-de student, Chi-cuadrado). El análisis estadístico se realizó con el paquete estadístico SPSS (SPSS 23.0 para Windows, SPSS Inc.).

RESULTADOS

En la Tabla 1 se reportan los promedios correspondientes a las variables antropométricas y de los IMC percibido, deseado y considerado más saludable y atractivo. Como puede observarse, en la serie masculina, todos los IMC considerados son muy similares, mientras que en la serie femenina las divergencias son mayores. En la serie femenina, el IMC deseado, o el considerado como más atractivo, están por debajo del considerado por ellas como saludable. Las diferencias entre hombres y mujeres son significativas tanto para el IMC elegido como saludable, como para el señalado como más atractivo y deseado, no así para el IMC obtenido a partir de datos auto-reportados (Figura 2). En todos los casos, los hombres se decantan por valores supe-

Tabla 1. Medidas antropométricas auto-referidas y análisis de la percepción corporal (método adaptado de Stunkard y Stellard, 1990

Sexo	MEDIA ± DE	
	Varones (N = 179)	Mujeres (N = 289)
Estatura (cm)***	171,01 ± 9,31	163,38 ± 6,67
Peso (Kg)***	65,14 ± 14,69	59,66 ± 10,57
IMC auto-referido (Kg/m^2) (ns)	22,10 ± 3,79	22,34 ± 3,76
IMC Percibido (Kg/m^2) (ns)	22,99 ± 2,57	23,09 ± 2,50
IMC Deseado (Kg/m^2) ***	22,44 ± 1,64	21,61 ± 1,46
IMC Saludable (Kg/m^2) ***	23,05 ± 1,40	22,19 ± 1,52
IMC Atractivo (Kg/m^2) **	22,37 ± 1,57	21,77 ± 1,59
Puntuación EAT-26 (ns)	6,88 ± 6,66	8,43 ± 8,74

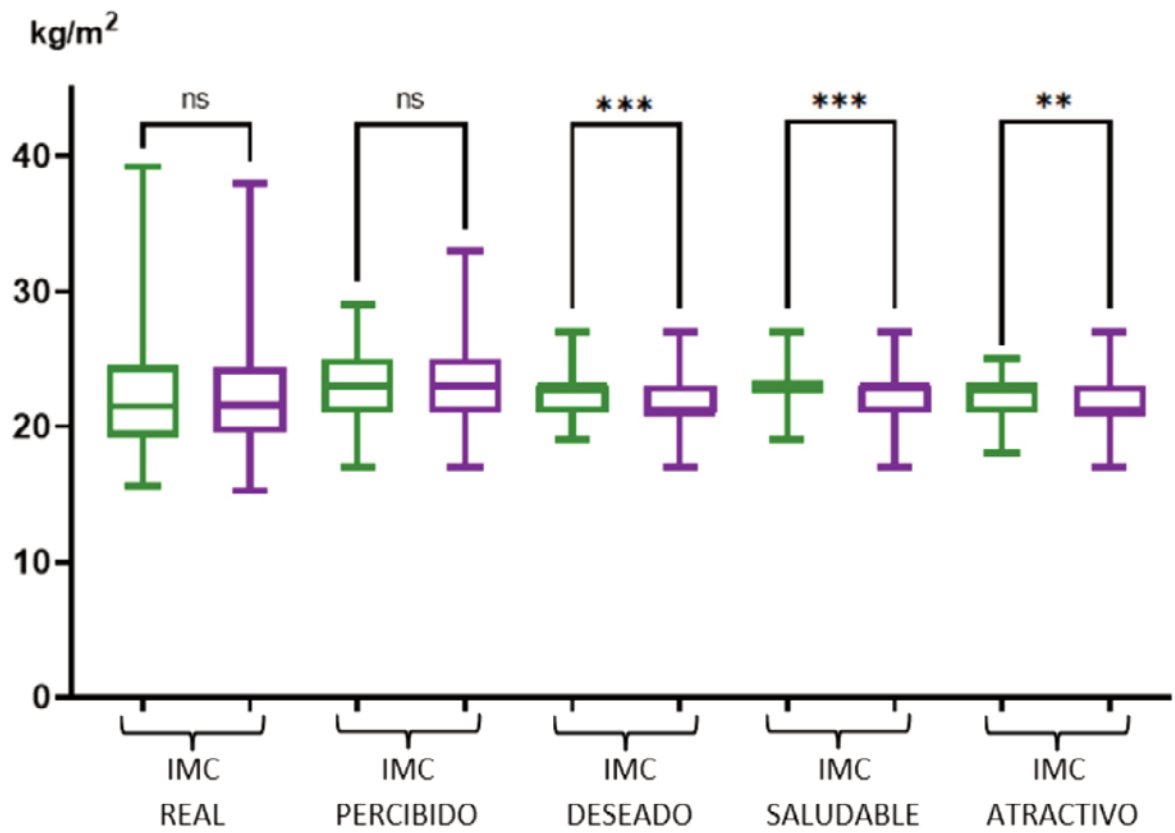
N: Tamaño muestral. IMC: Índice de Masa Corporal. Puntuación EAT-26: según la escala likert resultante del test EAT-26. Diferencias entre sexos * = p < 0,05; ** = p < 0,01; *** = p < 0,001; ns = no significativo.

riores de IMC, identificados como de mayor robustez. En promedio, las puntuaciones en el EAT-26 no mostraron diferencias entre sexos.

En la Tabla 2, se muestran los resultados correspondientes a la percepción y la satisfacción con la propia figura. En términos generales, los universitarios se perciben un poco mas gruesos y desean ser algo mas delgados. Cuando se

Tabla 2. Percepción y satisfacción corporal de los universitarios

		Media ± DE	TOTAL Media ± DE
Percepción *IMC auto referido IMC percibido*	Varones (N = 179)	-0,89 ± 2,98	-0,80 ± 2,66
	Mujeres (N = 289)	-0,75 ± 2,44	
Satisfacción *IMC auto referido IMC deseado*	Varones (N = 179)	-0,34 ± 3,75	0,32 ± 3,60
	Mujeres (N = 289)	0,73 ± 3,45	



. * = p < 0,05; ** = p < 0,01; *** = p < 0,001; ns = no significativo. En verde se representan los varones y en violeta las mujeres.

Figura 2. Diferencias sexuales para el IMC real auto-referido, percibido, deseado, saludable y atractivo en los universitarios

analiza esta cuestión en hombres y mujeres separadamente, se observa que, en promedio, las mujeres se perciben mejor que los varones. Por otra parte, los hombres quieren tener mayor peso, mientras que las féminas desean ser más delgadas.

En la Tabla 3, en la que se expresan los niveles de riesgo para desarrollar un TCA, se puede comprobar que las mujeres son más proclives a esta circunstancia ya que la proporción de chicas que obtienen una puntuación de riesgo (≥ 20 puntos) duplica la de hombres en la misma situación.

Tabla 3. Riesgo de Trastorno de Comportamiento Alimentario de acuerdo al test EAT-26[18]

		Sin riesgo ***≤ 9 puntos***	**Bajo riesgo** ***10-19 puntos***	**Alto Riesgo** ***≥ 20 puntos***
Varones * (N = 179)	N (%)	140 (78,2)	29 (16,2)	10 (5,6)
Mujeres ** (N = 289)	N (%)	199 (68,9)	57 (19,7)	33 (11,4)
Total (N = 468)	N (%)	339 (72,4)	86 (18,4)	43 (9,2)

N: Tamaño muestral. Diferencias entre sexos * = p < 0,05; ** = p < 0,01; *** = p < 0,001.

En la Tabla 4, se advierte que el exceso ponderal supera al peso insuficiente, sin diferencias significativas entre hombres y mujeres. La Figura 3 muestran la asociación entre la condición nutricional evaluada mediante IMC auto reportado y el riesgo de TCA diagnosticado con el EAT-26[18] y como queda patente, el comportamiento es diferente según el sexo, particularmente en las categorías de exceso ponderal en las que el desarrollo de TCA es mas probable en el sexo femenino. Por el contrario, el riesgo de TCA es algo más evidente entre los hombres con peso insuficiente que entre las mujeres de la misma condición.

Al analizar la relación entre el grado de percepción o satisfacción con su propia figura con el riesgo de desarrollar un TCA (Tabla 5), se constata que la primera no parece tener influencia, ya que la proporción de sujetos catalogados en bajo y alto riesgo, es prácticamente idéntica entre aquellos que se ven mas "gordos" de lo que son y los que se perciben mas delgados. Sin embargo, la satisfacción si resulta decisiva como determinante para el desarrollo de TCA, ya que la proporción de individuos ubicados en las categorías de bajo y alto riesgo es aproximadamente el doble entre quienes desearían ser mas delgados.

Tabla 4. Categorías nutricionales obtenidas a partir del IMC autorreferido

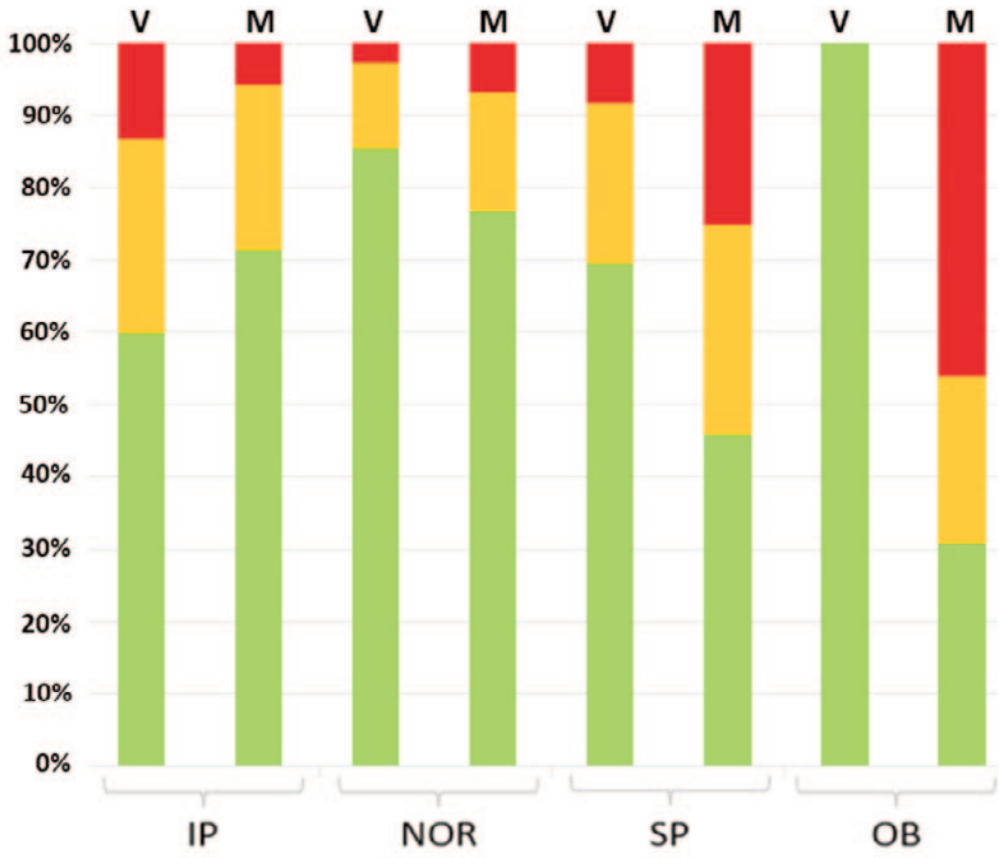
		CATEGORÍAS NUTRICIONALES			
		IP	**NOR**	**SP**	**OB**
Varones (N=179)	N (%)	30 (16,8)	110 (61,5)	36 (20,1)	3 (1,7)
Mujeres (N=289)	N (%)	35 (12,1)	193 (66,8)	48 (16,6)	13 (4,5)
Total	N (%)	65 (13,9)	303 (64,7)	84 (17,9)	16 (3,4)

IP: insuficiencia ponderal, NOR: normopeso, SP: sobrepeso, OB: obesidad.
N: Tamaño muestral (X^2= 3,28 ; p = 0,137).

Tabla 5. Asociación entre percepción o satisfacción con la propia imagen y riesgo de TCA evaluado mediante el test EAT-26[18]

		Percepción		**Satisfacción** ***	
		IMC Real < IMC Percibido	**IMC Real > IMC Percibido**	**IMC Real < IMC Deseado**	**IMC Real > IMC Deseado**
Sin riesgo *≤ 9 puntos*	N (%)	230 (49,1)	109 (23,3)	190 (40,6)	149 (31,8)
Bajo riesgo *10-19 puntos*	N (%)	44 (9,4)	42 (9)	32 (6,8)	54 (11,5)
Alto Riesgo *≥ 20 puntos*	N (%)	23 (4,9)	20 (4,3)	10 (2,1)	33 (7)
Total	N (%)	297 (63,5)	171 (36,5)	232 (49,6)	236 (50,4)

IMC: Índice de Masa Corporal. ** p < 0,001.



IP: insuficiencia ponderal, NOR: normopeso, SP: sobrepeso, OB:obesidad. Porcentaje (%) dentro de la categoría nutricional. Verde: sin riesgo (≤ 9 puntos); naranja: riesgo bajo (10-19 puntos), rojo: riesgo alto (≥ 20 puntos). V: Varones; M: Mujeres.

Figura 3. Asociación entre condición nutricional y categorías de riesgo para TCA evaluado mediante el test EAT-26[18]

DISCUSIÓN

El presente estudio surge de la necesidad de abordar un problema de salud pública de creciente relevancia en la población universitaria como son los TCA. Los jóvenes en esta etapa enfrentan transiciones psicológicas y sociales que los hacen especialmente vulnerables a las influencias socioculturales. Hoy en día, las figuras representadas en las redes sociales suelen ser delgadas, esbeltas y tonificadas, lo que puede favorecer en el individuo que las toma como referente una insatisfacción corporal que a su vez desencadene un TCA[19]. Del mismo modo, se pretende aportar evidencia empírica que visibilice las desigualdades entre sexos en la percepción o satisfacción corporal proporcionando datos útiles para diseñar estrategias de prevención y promoción de la salud.

Los resultados obtenidos, revelan algunas diferencias en la percepción de la imagen corporal entre hombres y mujeres, de manera que los hombres se perciben de una manera menos realista que las mujeres. Ellos tienden a percibir su peso corporal ligeramente por encima de la realidad y aspiran a obtener un IMC mayor. Asimismo, los varones presentan un bajo riesgo de TCA en todas las categorías nutricionales, aunque se observa que este se incrementa ligeramente tanto en la insuficiencia ponderal como en el sobrepeso. Esto podría interpretarse como el deseo de tener un cuerpo de mayor volumen y musculado, hecho probable teniendo en cuenta que la figura que desean es a la vez la que consideran más atractiva. Otros estudios previos sobre la relación entre factores biológicos, psicológicos o socioculturales con la conducta alimentaria y las estrategias para lograr cambios corporales en adolescentes van en la misma línea, demostrando que por lo general, mientras las niñas pretenden perder peso los niños intentan volverse más musculosos[20]. La investigación de Olivardia *et al.*[21], en universitarios estadounidenses llega a la misma conclusión mostrando además que la creencia de ser menos musculoso de lo que en realidad se es, constituye un motivo de insatisfacción corporal para los hombres y les conduce con mayor probabilidad a falta de autoestima y eventualmente a desordenes alimentarios.

Las universitarias españolas aquí analizadas, suelen percibir su peso corporal algo superior a la realidad, pero al contrario que los hombres, aspiran a obtener un peso menor y, al igual que los varones, el cuerpo deseado (más delgado) es también el que consideran más atractivo. Aunque la mayoría de las mujeres de la muestra no presenta un riesgo de TCA importante, este riesgo es superior al de sus pares varones. Estos resultados, también son consecuentes con lo descrito para adolescentes españoles y argentinos utilizando la misma metodología[22]. Particularmente en las mujeres, el riesgo de TCA se ve incrementado en las categorías nutricionales de sobrepeso y obesidad, posiblemente debido a la influencia de los estándares de belleza, que promueven la búsqueda de un cuerpo más delgado y esbelto[19].

Como se ha indicado anteriormente, los TCA se consideran un importante problema de salud, mayoritariamente en adolescentes. Se trata de patologías que habitualmente presentan altas tasas de comorbilidades psiquiátricas y médicas como la diabetes y el síndrome metabólico. En determinados casos, pueden incluso desembocar en la muerte del individuo, por lo que su prevención se centra en reducir o eliminar los factores que contribuyen a su desarrollo[23]. Según Tchounwou *et al.*[8] la prevalencia de desórdenes alimenticios aumentó en un 7,8% en el período comprendido entre el 2013 y el 2018, alcanzando una cifra de 5,8% en adolescentes. Además, la pandemia de COVID-19 ha provocado un mayor desarrollo y empeoramiento de los trastornos alimentarios, debido al aislamiento social, la ansiedad y estrés.

Según muestra la revisión sobre el tema llevada a cabo por Vaquero Cristobal *et al.* el problema de la insatisfacción corporal y los consiguientes comportamientos de riesgo que pueden conducir a un TCA, aparecen cada vez mas tempranamente. Como reportaron los mencionados autores el 55% de las niñas de entre 7 y 12 años desean estar más delgadas, mientras que en la adolescencia este porcentaje asciende al 80%. Los mencionados autores remarcaron que, según se deduce de toda a la bibliografía consultada, la insatisfacción corporal es clave dentro los posibles factores predisponentes.

Sin duda, los medios de comunicación, a través de la publicidad transmiten una imagen del cuerpo que poco tiene que ver con la variabilidad normal de la figura de hombres y mujeres reales. El ideal de belleza que transmiten, afecta sobre todo a las personas mas jóvenes que empiezan a asociar los cuerpos delgados y tonificados con los valores de éxito y aceptación social. Como demuestra la importante revisión sobre el tema publicada por de Diego *et al.*[25] la imagen que ofrecen las marcas es a menudo un modelo basado en la delgadez, suponiendo una mayor influencia negativa en los jóvenes que se sienten forzados a seguir ese ejemplo. Sin embargo, esta influencia podría ser un beneficio si en los medios y redes sociales se utiliza adecuadamente para la promoción de los cuerpos reales y el estilo de vida saludable.

Por todo esto, es importante regular este tipo de publicidad y ofrecer una imagen más real y variada de los cuerpos modelo, así como dar un enfoque dietético-nutricional al asunto. Este tipo de educación nutricional se basa en promover la educación individualizada, conseguir un estado nutricional adecuado, orientar la cooperación de familiares y personas cercanas para que el paciente obtenga un buen apoyo y se pueda contribuir a eliminar la distorsión corporal[26].

El presente estudio presenta algunas limitaciones. La muestra, conformada por un total de 468 universitarios, contiene un número bastante más elevado de mujeres (289). Por otra parte, las categorías nutricionales de IMC se han establecido a partir de los datos de peso y estatura auto-reportados. No obstante, la elección de instrumentos validados como el test de figuras[16] y el cuestionario EAT-26[18] garantizan el rigor metodológico.

CONCLUSIONES

Los universitarios de ambos sexos se perciben un poco más gruesos y desean ser algo más delgados, aunque en promedio las mujeres se perciben con mayor realismo que los hombres. Estos últimos, están más satisfechos con su imagen y desean tener mayor peso, mientras que las féminas desean ser más delgadas.

La prevalencia de alto riesgo de TCA es del 9,2% para la muestra en su conjunto, mayor en mujeres (11,4%) que en varones (5,6%).

Se encuentra una asociación entre categoría nutricional de acuerdo al IMC y riesgo de TCA, de distinto signo según el sexo. El alto riesgo de TCA es más frecuente en las mujeres con sobrepeso y obesidad, mientras en los varones se presenta con mayor proporción entre los sujetos con insuficiencia ponderal.

La percepción de la figura no se asocia de manera significativa con el riesgo de TCA, mientras que la satisfacción resulta determinante, ya que la proporción de individuos con bajo y alto riesgo de TCA es superior entre los que desearían ser más delgados, respecto a los que quisieran ser más corpulentos.

Estas discrepancias entre sexos y categorías nutricionales sugieren la necesidad de intervenciones específicas para abordar las preocupaciones relacionadas con la imagen corporal y los TCA, especialmente entre las mujeres con sobrepeso u obesidad. Además, resalta la importancia de promover una percepción más realista y saludable del peso corporal, así como llevar a cabo estrategias de prevención y detección temprana de los TCA en entornos universitarios.

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The relationship of chronic malnutrition to adolescent girls' cognition in Indonesia: A systematic review

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ABSTRACT

Background: Chronic malnutrition, including chronic energy deficiency, stunting, and anemia, significantly impacts cognitive development in adolescent girls in Indonesia.

Objective: A systematic review was conducted to examine the relationship between chronic undernutrition and cognitive function.

Method: In this systematic use the PRISMA framework. Studies from the past 10 years, including cross-sectional or cohort observational quantitative designs, were analyzed using Loney's critical appraisal tool. From an initial 781 articles, 13 met the inclusion criteria.

Result: Findings revealed anemia as a key factor affecting cognitive function and learning, with reduced hemoglobin levels linked to poor concentration, problem-solving, and academic performance ($p<0.05$). Anemic adolescents were 3 to 37 times more likely to exhibit poor learning outcomes (75%-92.5% low performance). Stunted adolescents had lower MMSE scores (median = 24, $p = 0.013$) and IQ (<84) compared to their non-stunted peers. The combination of anemia and stunting may exacerbate cognitive deficits, though research on this interaction is limited.

Conclusion: Anemia was identified as having the most pronounced impact on cognitive function, highlighting the need for targeted interventions to prevent and manage anemia, improve academic performance, and enhance the quality of life of adolescent girls. Further research is recommended to establish causal relationships and inform effective policy strategies.

KEYWORDS

Chronic Energy Deficiency, Stunting, Anaemia, Intelligence.

INTRODUCTION

Adolescent girls' nutritional issues are multifaceted and include anaemia, stunting, and chronic malnutrition, including Chronic Energy Deficiency (CED). Their academic potential and future productivity are at risk due to these nutritional problems, which have a significant impact on cognitive development in addition to physical health[1]. The 2018 Basic Health Research report, which revealed that the prevalence of CED among adolescent girls reached 23.6%, underscores the serious challenge Indonesia faces in this regard. Nearly one in four teenage girls still suffer from persistent energy deficits, according to the 2023 Indonesian Health Survey (IHS), which showed a modest decrease to 21.4% despite five years of interventions[2].

Surprisingly, among ASEAN nations, Indonesia has one of the lowest average cognitive levels. Indonesia's average cognitive score of 78.5 placed it 130th out of 199 countries in the 2022 World Population Review, below its neighbours Malaysia (87.6), the Philippines (81.6), and Laos (81.0). Given the strong correlations between poor cognitive performance and undernutrition, poor educational quality, early marriage, and other sociocultural factors, this emphasises the urgent need for effective interventions[3].

CED inhibits physical growth and brain development, which are essential for optimal cognitive function. A study showed that adolescents with CED have lower academic

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performance compared to those who are well-fed. Energy deficiency affects concentration, memory and critical thinking skills, all of which are important for academic success. Inadequate height or stunting also occurs in adolescent girls, resulting from chronic malnutrition during the growing years, which leads to impaired growth and brain development. Additionally, stunting has a major impact on both physical stature and brain development and is frequently caused by chronic malnutrition during growth phases[4]. Stunted adolescents typically have lower IQs, less capacity for learning, and worse academic results. Long-term health hazards, such as a higher chance of developing chronic illnesses as an adult, are also linked to stunting[5].

According to the 2023 IHS, anaemia, another common problem, affects about 24.1% of Indonesian adolescent girls, which is only marginally less than the 26.4% prevalence in 2018. Iron deficiency is the main cause of anaemia, which lowers oxygen delivery to the brain and affects cognitive function and academic performance[6]. Research has shown that a discernible drop in IQ scores is linked to even a 1 g/dL drop in haemoglobin levels. Likewise, it has been demonstrated that stunting reduces IQ scores by a number of points, highlighting its negative effects on cognitive ability[7].

Stunting, anaemia, and CED are all linked to one another, forming a vicious cycle. Anaemia, which is often caused by iron deficiency, leads to fatigue, decreased concentration, and poor cognitive performance. Iron is an important component in haemoglobin, which transports oxygen throughout the body including the brain. Lack of oxygen in the brain impairs cognitive function and decreases learning ability. Children with anaemia perform lower in cognitive tests and have lower academic scores. These three conditions are interrelated and exacerbate each other, creating a chain cycle that is difficult to break[8]. Given that Indonesia, the world's fourth most populous nation, is currently experiencing its demographic "golden period," it is imperative that the quality of its human resources be maximised. In addition to improving their academic and cognitive performance, addressing adolescent girls' malnutrition will have a significant impact on the social and economic advancement of the country[9].

This study aims to further examine the impact of chronic malnutrition in adolescent girls in Indonesia on their cognitive levels. With a better understanding of the relationship between CED, stunting, anaemia and cognitive development, more effective interventions can be formulated to improve the nutritional status and cognitive development of adolescent girls in Indonesia. This study also aims to identify which malnutrition conditions have the most significant impact on adolescent girls' cognition, so that health and nutrition programmed can focus on the most critical areas. Thus, appropriate interventions can be designed to break the cycle of malnutrition and improve the academic potential and quality of life of young Indonesians.

The long-term impact of addressing chronic nutritional problems in adolescent girls will have far-reaching positive impacts. Healthy and cognitively well-developed adolescents will have a greater chance of success in their education and career, which in turn will contribute to the economic and social development of the country. Therefore, it is important for governments, health institutions and communities to work together to implement effective and sustainable nutrition programmed to address CED, stunting and anaemia among adolescent girls.

METHODS

A systematic review using narrative analysis was conducted to explore the nutrition and dietary habits of adolescent girls in Indonesia. The review adhered to the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines to ensure a comprehensive and structured approach[10].

Options

Articles were included if they met the following criteria: (1) cross-sectional surveys, descriptive studies, baseline data from intervention studies, or other relevant observational research; (2) published between 2014 and 2024; (3) written in English or Bahasa Indonesia; (4) focused on adolescent girls in Indonesia aged 10 to 19 years; and (5) addressed topics such as severe energy deficiency (SEZ), stunting, anemia, and their cognitive impacts on adolescent girls.

Literature Search Strategy

The search strategy involved identifying English-language journal articles using keywords related to prevalence, adolescents, Indonesia, chronic malnutrition, stunting, and anemia, combined with the Boolean operator AND to refine results. For Indonesian-language databases, equivalent or translated terms were applied to ensure consistency.

Document Screening

The literature search, initiated on August 8, 2024, included three English-language databases (Scopus, ProQuest, and PubMed) along with four Indonesian-language journals indexed by the Indonesian Ministry of Research and Technology. Articles published from 2014 to 2024 were reviewed based on their titles, abstracts, and full-text content focusing on human participants. Additionally, grey literature was explored through a customized Google search and resources from Indonesian government bodies, NGOs, and UN organizations. Relevant materials were carefully assessed to confirm their eligibility

Data Collection

Data from the selected studies were systematically recorded in a structured template, including information on the author and publication year, study design, sample size, reported health conditions, participants' age, location (e.g., district, city), nutritional status, chronic energy deficiency, stunting, anemia, and the type of literature (e.g., journal article, report). Due to variations in study designs and outcomes, a narrative approach was used to synthesize the findings.

Study Appraisal

The selected studies underwent quality and bias assessment using a tool adapted from Loney et al. This tool evaluated full-text articles based on three main criteria: research method validity (up to six points), result interpretation (one point), and result applicability (one point), as shown in Table 1. Studies with a score of six or higher were included. To maintain rigor and reliability in the systematic review, the PRISMA checklist (prisma-statement.org) was used as a guiding framework, as depicted in Fig. 1.

Table 1. Critical appraisal process using Loney et al Critical appraisal of the health research literature[21]

No.	Title of article (authors)	Critical appraisal								Score
		Random sample or whole population	Unbiased sampling frame	Adequate sample size (>100)	Measures were the standard	Outcomes measured in an unbiased fashion	Adequate response rate (70%), refurse described	CI, subgroup analysis	Study Subjects described	
1	Different Results of Cognitive Impairment Screening in Adolescent Aged 10-12 Years with Normal and Short Stature in Pangandaran District Rodman Tarigan, et al (2017)[12]	Y	Y	Y	Y	Y	N/A	N/A	Y	6
2	Intercorrelations among Haemoglobin Level, Physical Fitness, and Cognitive Score in Adolescent Girls: A Cross-Sectional Study in Banggai District, Indonesia Risma Risma, Veni Hadju, et al (2024)[13] (13)	N	N	Y	Y	Y	N/A	Y	Y	6
3	Associations of Knowledge, Attitude, and Practices towards Anaemia with Anaemia Prevalence and Height-for-Age Z-Score among Indonesian Adolescent Girls Rina Agustina, et al (2021)[14]	Y	Y	Y	Y	Y	N/A	Y	Y	7
4	Analysis of the Relationship between Anaemia and Learning Performance among Adolescent Girls at Madrasah Aliyah Negeri (MAN) 1 Gorontalo Siti Rahasia K Baderan, et al (2024)[15]	Y	Y	Y	Y	N/A	N/A	Y	Y	6
5	The Relationship between Anaemia and Learning Achievement of Students at Bina Insani Junior High School" Pratiwi Retno Ayu, et al (2017)[16]	Y	Y	N	Y	N/A	N/A	Y	Y	5
6	The Relationship between Anaemia and Learning Achievement of Students at SMP Negeri Kelila, Mamberamo Tengah Regency in 2018 Jenny Anna Siauta, et al (2018)[17]	Y	Y	N	Y	Y	N/A	Y	Y	6

Y= yes, N= no, N/A= information not available in the paper.

Table 1 continuation. Critical appraisal process using Loney et al Critical appraisal of the health research literature[21]

No.	Title of article (authors)	Critical appraisal								Score
		Random sample or whole population	Unbiased sampling frame	Adequate sample size (>100)	Measures were the standard	Outcomes measured in an unbiased fashion	Adequate response rate (70%), refurse described	CI, subgroup analysis	Study Subjects described	
7	Relationship between Nutritional Status and Haemoglobin Level with Learning Achievement of Students of SMA Negeri 14 Palembang Manuntun Rotua, et al (2018)[18]	Y	Y	N	Y	Y	N/A	Y	Y	6
8	The Study of Nutrient Intake and Adolescent Girls' Quality of Life in a Rural Area of Indonesia Puspa Sari, et al (2022)[19]	Y	Y	Y	Y	Y	N/A	Y	Y	7
9	Factors Affecting Anaemia Status in Adolescent Girls Mulianingsih, M et al (2021)[20]	Y	Y	N	Y	Y	N/A	Y	Y	6
10	Anaemia among Adolescent Girls in West Java, Indonesia: Related Factors and Consequences on the Quality of Life Puspa Sari, et al (2022)[21]	Y	Y	Y	Y	Y	N/A	Y	Y	7
11	Iron Deficiency Anaemia and Associated Factors Among Adolescent Girls and Women in a Rural Area of Jatinangor, Indonesia Puspa Sari, et al (2022)[22]	Y	Y	Y	Y	Y	N/A	Y	Y	7
12	Understanding the pubertal, psychosocial, and cognitive developmental trajectories of stunted and non-stunted adolescents: protocol of a multi-site Indonesian cohort study Bernie Endyarni, et al (2024)[23]	Y	Y	Y	Y	Y	N/A	Y	Y	7
13	Relationship between anaemia, stunting and intelligence level among adolescent girls aged 13-15 years in South Galesong District, Takalar Regency, 2022, Susi Susanti, Veni Hadju (2023)[24]	Y	Y	Y	Y	Y	N/A	N/A	Y	6

Y= yes, N= no, N/A= information not available in the paper.

Nutrition Status

The nutritional status of adolescent girls can be classified into various categories. Chronic undernutrition is identified when their daily energy intake falls below the recommended caloric needs for their age and level of activity. Stunting is defined by a height below 150 cm, which is considered inadequate for their age. Anemia is diagnosed when their blood hemoglobin (Hb) level is less than 12 g/dL.

RESULTS

Results

The search identified 781 articles from reputable international and national journals, with 234 full-texts screened after duplicate removal. Following exclusions for access restrictions, title suitability, and content relevance, 13 articles included in the analysis.

Chronic Energy Deficiency (CED) and cognitive function. A study by Tarigan R, Mulyani S, Sari P, et al. (2017) in

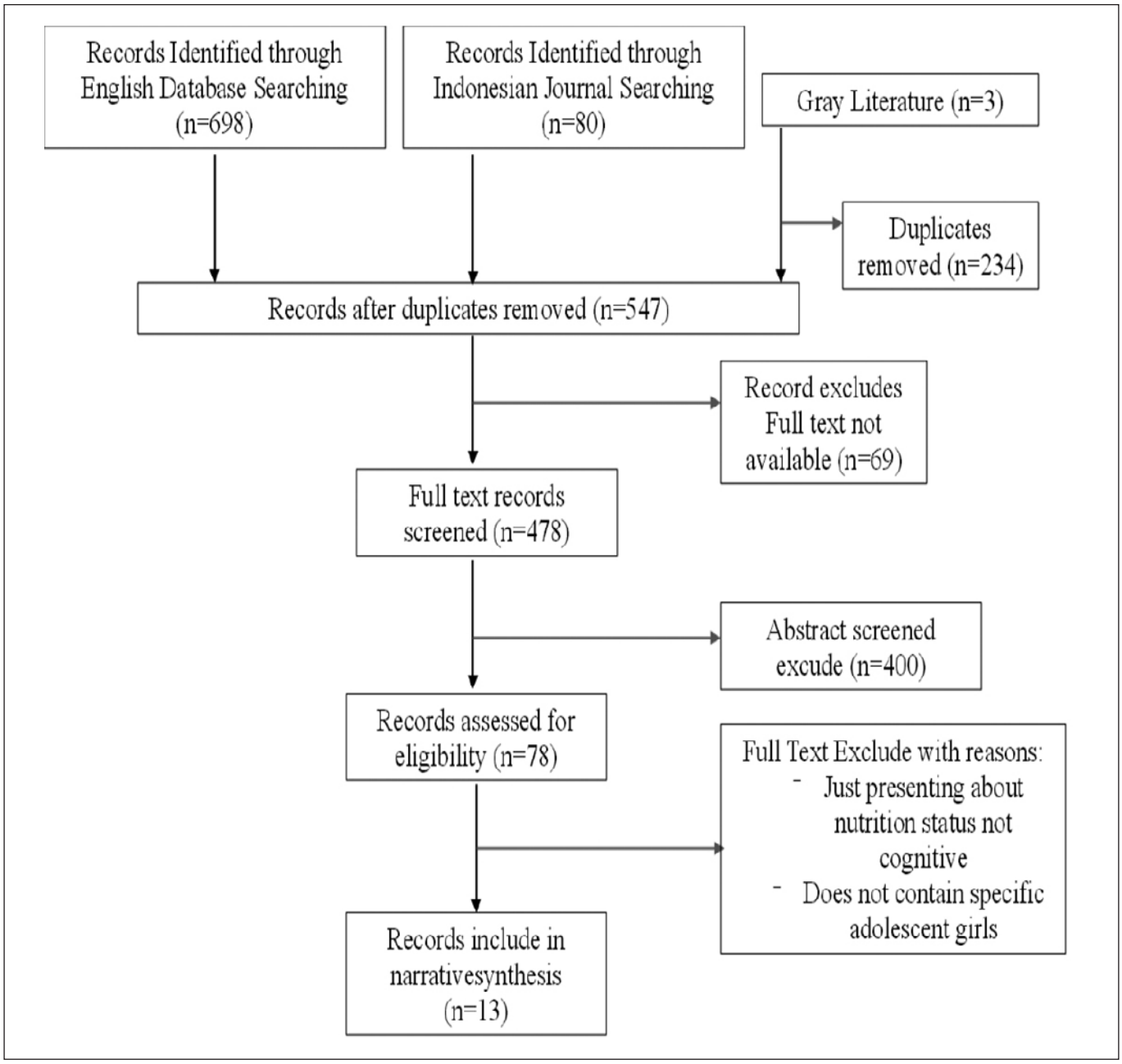

Figure 1. PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) Flow Diagram

rural Bandung found that nutritional intake, particularly carbohydrates, vitamin C, and fat, had a positive correlation with physical health which is directly related to optimal cognitive function. This study indicated that chronic energy deficiency can reduce the cognitive scores of adolescent girls with a significant correlation coefficient ($r = 0.15$, $p < 0.05$), which suggests that chronic energy deficiency can inhibit cognitive and learning abilities. In contrast, Risma R, Hadju V, et al. (2024) in rural Jatinangor found that CED had a greater impact on physical than cognitive aspects, where socioeconomic factors and overall nutritional intake had more influence on quality of life than cognitive function itself. Both studies agree that a balanced nutritional intake plays an important role in supporting cognitive function, but they differ in highlighting how much impact CED has on cognitive decline. The study by Agustina R, Syamsul R, et al. (2021) emphasised iron deficiency and carbohydrate as important factors, while the study by Baderan SRK, Nugroho R, et al. (2024) emphasised a holistic approach of social and economic factors[12-15].

Stunting and cognitive function. Stunting has a significant effect on reducing cognitive ability in adolescent girls.

Table 2. Studies included in the literature review based on level of study

Peer-reviewed literature							
No.	**Author**	**Study Type**	**Journal**	**Sample (Size)**	**Specific location**	**Nutrition Status**	**Results**
1	Rodman Tarigan (2017)	Cross-Sectional	American Journal of Clinical Medicine Research	Adolescent girls 10-12 years (n=144)	Pangandaran Regency, West Java, Indonesia	Stunting	The median MMSE score of adolescents with short height was 24 (range 14-30), while that of adolescents with normal height was 27 (range 9-30), with a significant difference in the median MMSE score between the two groups (median difference = -2.00, 95% CI (-3.00; -0.00), p = 0.013).
2	Risma (2024)	Cross-Sectional	Pharmacognosy Journal	Teenage Daughter 12-18 years (n=139)	Banggai, Central Sulawesi Indonesia	Anaemia (Hemoglobin)	Haemoglobin level and cognitive score in the study (r = 0.17, p = 0.053), indicating an association between low haemoglobin level and decreased cognitive score.
3	Rina Agustina, (2021)	Cross-Sectional	Food and Nutrition Bulletin	Adolescent girls 12-19 years (n=335)	Cimahi, Purwakarta, West Bandung	Anaemia	Improved nutrition-related Knowledge, Attitude, Practices (KAP) scores were not significant in reducing anaemia prevalence but were positively associated with increased height (Height-for-Age Z-score) in adolescent girls, which may positively impact cognitive development.
4	Siti Rahasia K (2024)		Journal of Indonesian Public Health Publications	Adolescent girls (n=120)	Gorontalo City	Anaemia	There was a significant association between anaemia and learning performance (p-value = 0.013) with an odds ratio (OR) of 3.11. Adolescent girls who are anaemic have a three times higher risk of having poorer learning performance compared to those who are not anaemic.
5	Pratiwi Retno Ayu (2017)	Cross-Sectional	AMERTA Nutrition	Adolescent girls (n=56)	Blitar Regency	Anaemia	There is a relationship between anaemia and students' learning achievement (p=0.042). Girls who are not anaemic will have better learning achievement.
6	Jenny Anna Siauta (2018)	Cross-Sectional	Journal for Quality in Women's Health	Adolescent girls (n=52)	Central Mamberamo Regency, Papua	Anaemia	There is a significant relationship between anaemia and learning achievement (p = 0.000). Of the 52 students studied, 37 students (92.5%) who were not anaemic had good learning achievement, while 9 out of 12 students (75%) who were anaemic had poor learning achievement. Students who are not anaemic have a 37 times greater chance of having good learning achievement than anaemic students.
7	Manuntun Rotua (2018)	Cross-Sectional	Palembang Poltekkes Health Journal	Adolescent girls (n=67)	South Sumatra	Anaemia (Hemoglobin)	There was no significant relationship between nutritional status and learning achievement (p = 0.379), but there was a significant relationship between haemoglobin levels and learning achievement (p = 0.046).

Table 2 continuation. Studies included in the literature review based on level of study

Peer-reviewed literature							
No.	**Author**	**Study Type**	**Journal**	**Sample (Size)**	**Specific location**	**Nutrition Status**	**Results**
8	Puspa Sari, et al (2022)	Cross-Sectional	Children (MDPI)	Adolescent girls (n=157)	Bandung, West Java	Intake (KEK)	Nutritional intake has a significant impact on the cognitive function of adolescent girls. Intake of carbohydrates, vitamin C and fat is positively correlated with physical health, which is one of the important indicators in supporting optimal cognitive function. Calcium intake was also shown to have a positive correlation with the psychological domain, which includes aspects such as concentration and learning ability. In addition, the results showed that iron deficiency, which is commonly associated with **anaemia**, can impair cognition and reduce learning ability and memory.
9	Mulianingsih, M et al (2021)	Cross-Sectional	Journal of Health Education	Teenage girls n=63	Mataram, NTB	Anaemia	There was a significant association between anaemia and decreased cognitive function, with a p value = 0.004, indicating that p<0.05, meaning the results were statistically significant. Anaemia also affects motor development and brain intelligence, which in turn negatively impacts work productivity and overall quality of life.
10	Puspa Sari, (2022)	Cross-Sectional	Nutrients (MDPI)	Adolescent girls 12-19 years (n=286)	West Java	Anaemia	Anaemia affects cognitive function, especially in terms of learning ability and concentration, with a p value <0.05. This indicates that there is a significant relationship between anaemia and decreased cognitive function in adolescent girls. Anaemic adolescents tend to have lower concentration and poorer academic performance compared to those who are not anaemic. Menstrual duration and upper arm circumference (MUAC) were the most influential factors on the incidence of anaemia, which indirectly affected their cognitive function.
11	Puspa Sari (2022)	Cross-Sectional	International Journal of Women's Health	Adolescent girls (n= 246)	Sumedang, West Java	Anaemia	Anaemia was found to have a significant impact on the cognitive function of adolescent girls. The mean cognitive function score was lower in the anaemic group compared to the non-anaemic group. The p value was 0.03, indicating strong statistical significance. Specifically, decreased haemoglobin correlated with decreased concentration and problem-solving abilities.

Table 2 continuation. Studies included in the literature review based on level of study

Peer-reviewed literature							
No.	**Author**	**Study Type**	**Journal**	**Sample (Size)**	**Specific location**	**Nutrition Status**	**Results**
12	Bernie Endyarni, (2024)	Cohort Study	Frontiers in Pediatrics	Teenage girls (n= 560)	Jakarta, Yogyakarta	Stunting	Adolescent girls who are stunted tend to have a lower average IQ compared to girls who are not stunted. Based on the Wechsler Intelligence Scale for Children-Fifth Edition (WISC-V), stunted adolescent girls more often fall into the very low (<70) to low (70-84) IQ category. Based on the same scale, non-stunted adolescent girls were more likely to fall into the average (85-115) to above average (116-130) IQ category.
13	Susi Susanti, Veni Hadju (2023)	Cross-Sectional	Thesis	Adolescent girls 13-15 years (n=247)	Takalar, South Sulawesi	Anaemia Stunting	The results showed that anaemia (p=0.017) and stunting (p=0.034) were significantly associated with intelligence level, while the combination of anaemia-stunting (p=0.622) was not significantly associated. One-Way ANOVA test showed a significant difference between anaemia, stunting, anaemia-stunting, and normal groups with a value of (p=0.003). Post Hoc Test results showed a significant difference in mean intelligence levels between the anaemia (p=0.004) and anaemia-stunting (p=0.041) groups compared to the normal group, but there was no significant difference between the stunting and normal groups (p=0.146).

Research in Pangandaran Regency by Ayu PR, Santosa A, et al. (2017) assessed cognitive function using the Mini-Mental State Examination (MMSE) in children with normal and short height, finding that the median MMSE score in children with short height was 24 (range 14-30) compared to 27 (range 9-30) in children with normal height. These results showed a significant difference with median difference = -2.00 CI 95% (-3.00; -0.00) p = 0.013, confirming that stunting may impair cognitive function. Another study by Siauta JA, Simanjuntak A, et al. (2018) in Jakarta, Yogyakarta, and East Java also highlighted that stunted adolescent girls tend to have lower IQ compared to non-stunted adolescents. The use of the Wechsler Intelligence Scale for Children-Fifth Edition (WISC-V) in this study showed that adolescents with stunting fell more into the low (<70) to very low (70-84) IQ category, while those without stunting fell more into the average to above average IQ category. Both studies consistently show that stunting adversely affects cognitive development and inhibits learning and logical reasoning[16,17].

Anaemia and its impact on cognitive function. Research provides consistent results regarding the negative effect of anaemia on learning ability and concentration. In a study by Rotua M, Hermawan R, et al. (2018) in Banggai Regency, it was found that low haemoglobin levels were directly related to decreased cognitive scores, with a correlation coefficient of r = 0.17 and p = 0.053, suggesting an association between anaemia and decreased cognitive function although not very significant. Research by Sari P, Nurhayati N, et al. (2022) in Gorontalo showed more significant results, where anaemic adolescent girls had a three times higher risk of having poor learning performance compared to those without anaemia. The odds ratio for this association was 3.111 with a p-value = 0.013, indicating a strong association between anaemia and reduced academic performance. In addition, research by Mulianingsih M, Dewi L, et al. (2021) in Jatinangor found that anaemia had a significant impact on the cognitive function of adolescent girls, with a p-value = 0.003 indicating strong statistical significance. Anaemia was found to correlate with decreased concentration and problem-solving abilities, which have a direct impact on academic performance. In a synthesis of multiple studies, anaemia was consistently associated with reduced cognitive function and

Table 3. Summary of Nutritional and Cognitive Impacts on Adolescents Based on Peer-Reviewed Studies

Author	Parameters	Prevalence/Value	Significant Relation
Rodman Tarigan (2017)	MMSE Median Score (Short stature vs Normal)	24 vs 27 (Significant, p=0.013)	Yes (Median difference = -2.00, CI 95% (-3.00; -0.00))
Risma (2024)	Haemoglobin and Cognitive Score Correlation	or = 0.17, p = 0.053	No
Rina Agustina (2021)	KAP Score and Anaemia Prevalence	Non-significant reduction in anaemia prevalence, Positive correlation with Height-for-Age Z-score	Positive correlation with height, no effect on anaemia
Siti Rahasia K (2024)	Anaemia and Learning Performance (OR)	OR = 3.11	Yes
Pratiwi Retno Ayu (2017)	Anaemia and Learning Performance (p-value 1)	p = 0.013	Yes
Jenny Anna Siauta (2018)	Anaemia and Learning Performance (p-value 2)	p = 0.000	Yes
Manuntun Rotua (2018)	Nutritional Status and Learning Performance	p = 0.379 (non-significant)	No
Puspa Sari et al. (2022)	Nutrient Intake and Cognitive Function	Positive correlation between carbohydrate, vitamin C, fat intake, calcium and cognitive/physical health	Yes (Correlation with cognitive function)
Mulianingsih, M et al. (2021)	Anaemia and Cognitive Function (p-value 1)	p = 0.004	Yes
Puspa Sari et al. (2022)	Anaemia and Cognitive Function (p-value 2)	p < 0.05	Yes
Puspa Sari et al. (2022)	Anaemia and Cognitive Function (p-value 3)	p = 0.03	Yes
Bernie Endyarni et al. (2024)	Stunting and IQ	Lower average IQ in stunted adolescents (WISC-V)	Yes (WISC-V score differences)
Susi Susanti, Veni Hadju (2023)	Anaemia, Stunting, and IQ	Anaemia (p=0.017), Stunting (p=0.034), Combined (p=0.622) (One-Way ANOVA, p=0.003)	Yes, for anaemia, stunting (Post Hoc)

academic performance in adolescent girls. Although the level of significance and strength of association varied between studies, these findings indicate that anaemia is an important risk factor affecting cognition and should receive attention in efforts to improve the quality of education and adolescent health[18-24].

DISCUSSION

The results of this study highlight the profound influence of nutritional deficiencies - particularly anaemia, stunting and chronic energy deficiency (CED) - on cognitive development in adolescent girls. These findings are particularly significant given that Indonesia is currently classified among nations with low average IQ scores compared to neighboring ASEAN countries, underscoring an urgent need for effective interventions. The consistent association between anaemia and cognitive deficits found in this study mirrors results from studies in other countries, such as India and sub-Saharan Africa. For example, research in Kenya showed that adolescent girls with anaemia had significantly lower cognitive scores than their non-anaemic peers. The researchers concluded that anaemia contributes to decreased brain function due to reduced oxygen-carrying capacity of the blood. Another study in India also linked low

haemoglobin levels to decreased cognitive abilities, especially in terms of attention span, memory and information processing speed[25].

Physiologically, anaemia, especially iron deficiency anaemia, reduces oxygen supply to the brain, resulting in altered neurotransmitter function, reduced plasticity of synapses, and, ultimately, decreased cognitive performance. In the Indonesian and international contexts, this relationship between anaemia and cognitive function is fairly consistent. Findings from this study revealed that for every 1 g/dL reduction in haemoglobin levels, there was an estimated decline in IQ score by approximately 2-3 points. The findings in this study, where anaemic adolescent girls had a three times higher risk of reduced academic performance, reflect a similar global pattern. However, what distinguishes the Indonesian study is the additional influence of other nutritional problems such as CED and stunting. The interaction between these multiple nutritional deficiencies exacerbates the impact on cognitive function, as shown in this study where adolescents who were simultaneously anaemic and stunted had poorer cognitive outcomes compared to those with only anaemia[26].

Stunting, which is also the focus of this study, has a well-documented global association with reduced cognitive ability. However, the Indonesian context provides its own layer of complexity. In this study, adolescent girls who were stunted showed lower median cognitive scores compared to their peers, with statistically significant differences. These results are consistent with studies in Guatemala and South Africa, where stunted children consistently perform worse on cognitive tests[27]. The scientific explanation for this correlation lies in the role of nutrition during brain development. Stunting, which results from chronic malnutrition in childhood, causes structural and functional changes in the brain, including reduced brain volume, impaired myelination and synapse dysfunction, all of which impact learning and memory[28].

In this study, it was estimated that stunted adolescents had IQ scores that were approximately 4-6 points lower compared to their non-stunted peers. Internationally, it has been observed that children who are stunted at an early age may never fully recover their cognitive potential, even with later nutritional interventions. This has significant implications for public health policy in Indonesia, where stunting rates remain high. While efforts to provide nutritional support to school-aged children are critical, this evidence suggests that stunting prevention should start much earlier, with a focus on nutrition from the preconception period, i.e. during adolescent girls. The emphasis on early intervention during adolescence is supported by findings from Peru, where a national programme targeting adolescent girls through nutrition education, supplementation and food fortification significantly reduced stunting and improved cognitive outcomes in the next generation. This suggests that the nutritional health of adolescent girls is highly influential on later foetal development, so improving nutrition during this phase can prevent stunting more effectively[29].

Another important aspect of this study is the role of CED, which appears to have a more complex impact on cognition. Although the Indonesian study showed an association between CED and lower cognitive scores, international comparisons revealed that this association may be moderated by other socio-economic factors. For example, in Bangladesh, although CED is associated with lower cognitive performance, the impact is less pronounced in families with better socioeconomic status, where factors such as better access to education and health services may mitigate the negative impact on cognitive function. This suggests that in Indonesia, addressing CED in adolescent girls may require a more holistic approach, which not only focuses on improving dietary intake, but also addresses broader social factors. The high rate of CED in adolescent girls in Indonesia compared to countries with similar income levels may reflect differences in food security, access to health services and education, which should be part of a national strategy to improve adolescent health. This highlights the importance of addressing not only nutritional deficiencies but also broader systemic issues, such as food security, education quality, and healthcare access, in tackling the challenges of CED in Indonesia[30].

The combined impact of these nutritional deficiencies highlights the need for integrated interventions. While anaemia, stunting and CED individually negatively impact cognitive function, their combined impact - as seen in this study where adolescents with anaemia and stunting experienced more severe cognitive deficits - suggests that a multi-faceted approach is needed. This includes longitudinal research to better quantify the compounded effects of these deficiencies on cognitive outcomes, which would strengthen the evidence base for targeted interventions. Programmes that only focus on one type of nutritional deficiency may not be able to address the spectrum of challenges faced by adolescents in resource-limited settings such as Indonesia. This is evident from a school nutrition programme in Brazil, where a comprehensive programme, which provided not only iron supplements but also a balanced diet rich in protein, carbohydrates and essential vitamins, resulted in significant improvements in cognitive function and academic achievement.

Given Indonesia's demographic status as the fourth most populous nation globally and its current "golden period" for improving human resources, addressing these nutritional challenges is critical. This systematic approach is not only in line with global trends but also highlights the unique challenges faced by adolescent girls in Indonesia. Addressing these issues requires a multi-faceted approach, including early interventions to prevent stunting, school-based pro-

grammes to address anaemia and CED, and broader public health strategies to improve food security and healthcare access. Given the profound impact of cognitive deficits on educational attainment and future economic productivity, investing in improved adolescent nutrition should be a priority in national health policy in Indonesia, as in other countries facing similar challenges.

Limitations of the Review

This review highlights the significant impact of chronic malnutrition, including chronic energy deficiency, stunting, and anemia, on the cognitive development of adolescent girls in Indonesia, identifying anemia as the most critical factor. However, it did not account for confounding factors such as genetics, environmental influences, and healthcare access, which could also affect outcomes. Additionally, the predominance of cross-sectional studies limits the ability to establish causality, underscoring the need for longitudinal research to better understand these relationships.

Opportunities for Further Research

Future research should utilise longitudinal studies to explore the causal relationship between chronic malnutrition and cognitive development of adolescent girls. In addition, expanding geographic and socio-economic coverage may provide a more comprehensive picture. Evaluation of community-based interventions and studies on the interaction of genetic, environmental and health service access factors are also important. Research on effective policy strategies to address nutrition in adolescent girls would be beneficial to formulate better and more sustainable interventions.

CONCLUSIONS

Adolescent girls' cognitive development is greatly impacted by nutritional issues like anaemia, stunting, and Chronic Energy Deficiency (CED), especially in low- and middle-income nations with high rates of undernutrition. Anaemia, which is frequently brought on by an iron deficiency, affects memory, focus, and critical thinking, which hinders academic performance and prolongs poverty cycles. Comprehensive approaches, such as routine health screenings, iron supplementation, fortified food initiatives, and nutrition education, are needed to address these issues. Better access to healthcare is also necessary. Enhancing cognitive potential and quality of life through these interventions is crucial for the socioeconomic development of impacted areas.

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Physical activity, percent body fat, visceral fat, ASMI, and blood pressure with obesity in indonesian older women: a cross-sectional study

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ABSTRACT

Obesity is increasingly becoming a significant public health issue worldwide, particularly among older adults. In Indonesia, the rise of obesity among older women is particularly alarming, contributing substantially to the burden of chronic illnesses. The primary risk factors for obesity include a sedentary lifestyle, and lower muscle mass, which can increase body fat, weight gain, and other associated health problems. This study investigated the prevalence of sarcopenia and identified associated risk factors, including sociodemographic characteristics, lifestyle factors, and comorbidities, among older women in Integrated Care Post (Posyandu). A cross-sectional design was employed to analyze the prevalence of obesity, low physical activity levels, high percentage of body fat, high level of visceral fat, low level of appendicular skeletal muscle index (ASMI), and elevated blood pressure (BP). A total of 154 older women aged 60 to 69 were selected as respondents from three subdistricts (Gunung Batu, Loji, and Pasir Mulya) using proportional random sampling. Data were collected through physical examinations and interviews utilizing a questionnaire. The results showed the prevalence of obesity was 42.20%, with low levels of physical activity (72.70%), 42.90% have high levels of %BF, while 37.00% exhibit high levels of visceral fat, preserved ASMI (55.20%), 94.80% showing elevated SBP and 83.80% DBP. According to Chi-square test, physical activity (OR = 2.05, 95%CI = 1.00-4.22), %BF (OR = 17.66, 95%CI = 5.75-54.25), VF (OR = 75.29, 95%CI = 21.24-266.85), ASMI (OR = 0.05, 95%CI = 0.02 – 0.12), and SBP (OR = 4.96, 95%CI = 0.96 – 25.45) were significantly associated with obesity ($p<0.05$). All in all, physical activity, %BF, visceral fat, ASMI, and SBP are risk factors for obesity among women aged 60-69. Further research needs to be conducted using a larger sample size and different study designs to explore additional factors associated with obesity in older adults.

KEYWORDS

Aging, body composition, cardiovascular health, chronic disease, exercise, female health, preventive health.

ABBREVIATIONS

ASMI: Appendicular Skeletal Muscle Index.

BMI: Body Mass Index.

DBP: Diastolic Blood Pressure.

IQR: Interquartile Range.

METs: Metabolic Equivalent Task.

SBP: Systolic Blood Pressure.

VF: Visceral Fat.

%BF: Body Fat Percentage.

INTRODUCTION

Obesity is a growing global public health concern, particularly for the elderly[1]. In Indonesia, the number of obese older women has been steadily increasing, which greatly increases the burden of chronic diseases. In Indonesia, the prevalence of overweight and obesity among those aged 60 and over in-

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creased from 13.6% and 21.8%, respectively, in 2018[2] to 14.4% and 23.4%, in 2023[3]. Women had a higher prevalence of poor health (15.3%) and obesity (31.2%) compared to a lower prevalence of poor health (13.6%) and obesity (15.7%) in the past[3]. The primary risk factors for obesity include a sedentary lifestyle, lack of physical activity, alcohol consumption, tobacco use, and lower muscle mass, all of which can contribute to weight gain and other health issues[4-8]. Recent research shows that obesity in older women primarily leads to increased functional decline, physical frailty, and risk of mortality[9,10]. A specific condition known as sarcopenic obesity, which involves both obesity and a decrease in muscle mass, significantly heightens the risk of impairment and limits daily activities[10].

Obesity is directly linked to several metabolic disorders, including diabetes, hypertension, dyslipidemia and cancer[11,12]. Research shows that individuals with a higher body mass index (BMI) are significantly more likely to develop these metabolic conditions, which complicates their overall health situation. Obesity primarily occurs due to an imbalance between energy intake and energy expenditure[13]. When energy intake exceeds energy expenditure, the excess energy is stored as fat and glycogen in subcutaneous adipose tissue (SAT) and in various organs[14]. As people ages, changes in body composition take place. From age 20 and 70, the percentage of fat-free mass, mainly composed of skeletal muscle, decreases by 40%. After age 70, both fat mass and fat-free mass continue to decline. Additionally, fat mass tends to redistribute with age, mainly accumulating in the visceral area, although deposits can also be found in the liver and skeletal muscle. The amount of body fat is determined by the balance between energy intake and expenditure. A significant factor contributing to the increase in fat mass with aging is decreased energy expenditure. Interestingly, energy intake in older adults does not appear to rise substantially and may even decrease over time[15].

The loss of fat-free mass is the primary cause of the 2-3% per decade decline in resting metabolic rate that occurs after the age of 20. About half of the loss in total energy expenditure with aging is due to a drop-in physical activity and an increase in inactive time, in addition to a decrease in resting metabolic rate[15]. The central redistribution of body fat leads to the production of pro-inflammatory cytokines[16]. Cytokines such as tumor necrosis factor alpha (TNF-α) and interleukin 6 (IL-6) contribute to muscle loss and sarcopenia due to their catabolic effects[17]. This reduction in muscle mass results in negative outcomes, including decreased mobility and increased frailty. The accumulation of fat in the central regions of the body results in the release of inflammatory cytokines, which, in turn, cause muscle loss and sarcopenia[16]. The decline in muscle mass has detrimental effects, leading to weakened muscles and reduced mobility[17]. Adipocyte hypertrophy and hyperplasia contribute to the growth of adipose tissue by causing fat to accumulate due to excessive calorie intake. Visceral fat develops when the amount of accessible fat exceeds the adipocyte's capacity to store it. This excess fat can then circulate and forms ectopic deposits in other organs. In addition to causing hypoxia, oxidative stress, and endoplasmic reticulum (ER) stress, visceral fat can impair vascularization and play role in the development of various related disorders[18].

The RISKESDAS 2018 report indicates that the prevalence of obesity among individuals over 18 years old is 38.46%, which is higher than the prevalence of 36.66% in West Java Province[19]. Based on previous research findings and reports, the factors related to obesity and its health risks require further investigation. Therefore, this study aimed to explore the factors associated with obesity among older women aged 60 to 69 in Bogor City.

RESEARCH METHOD

Study Design

A cross-sectional study was conducted in three subdistricts (Gunung Batu, Loji, and Pasir Mulya), West Bogor district of Bogor City, Indonesia, from September to October 2024. The study included 154 elderly women aged 60 to 69 years who were participants in the *Chronic Disease Management Program* and registered at an *Integrated Care Post* (Posyandu) within the Pasir Mulya Public Health Center's working area.

Data Collection

The sample selection was done using *proportional random sampling*. This process began with counting the number of subjects in each integrated care post, followed by the random selection of elderly subjects based on the established proportions. The inclusion criteria for this study are women aged 60 to 69 years who can communicate effectively and stand properly. Participants must have fasted for 10 to 12 hours before the visit. Respondents will be excluded if they miss either of the two scheduled visits. Information about the visits will be communicated by the respective *integrated care post cadres* via telephone or social media.

Data on exercise habits were gathered through interviews using a questionnaire. Specifically, the *International Physical Activity Questionnaire-Short* (IPAQ-SF) was used to collect information about daily physical activity over the past seven days. This questionnaire assesses an individual's physical activity level based on *Metabolic Equivalent Task* (MET) values for different activity types. The MET score is calculated by multiplying the type of physical activity by the intensity in minutes and days. The MET values are as follows: walking = 3.3 MET, moderate activity = 4.0 MET, and vigorous activity = 8.0 MET. Physical activity levels are classified as follows: Low: less than 600 MET-minutes per week; Moderate: 600 to less than 1500 MET-minutes per week; High: 1500 MET-minutes or more per week[20]. This questionnaire contains seven questions regarding the physical activity performed by the respondent over the past week, collected through an interview using the IPAQ Short Form.

The BMI measurement was conducted using a *Bio Impedance Analysis* (BIA) Karada Scan Body Composition Monitor (model HBF-375, OMRON, Japan) to assess weight, and a stadiometer (One Health) to measure height. The BMI categories follow the Asian population standards, which are defined as follows: underweight (BMI < 18.5); normal weight (BMI ≥ 18.5 and < 24.9); overweight (BMI ≥ 25.0 and < 27.0 kg/m²); and obese (BMI ≥ 27.0 kg/m²) [2]. Adipose tissue and other components of the body were categorized based on body fat percentage data. According to Gallagher et al., women were classified into three groups: normal (25%–34.9%), high (35.0%–39.9%), and very high (≥ 40%) [21]. The visceral fat levels were classified into two categories: Low (less than 10 points) and High (more than 10 points), based on the OMRON HBF-375 Guideline.

To calculate muscle mass, the percentage of total skeletal muscle relative to body weight is multiplied by 100. The appendicular skeletal muscle mass index (ASMI) is then determined by dividing the total skeletal muscle mass by the square of height (in kg/m²). For women, a low muscle mass is defined as an ASMI of less than 5.45 kg/m², while an ASMI greater than 5.45 kg/m² indicates preserved muscle mass[22,23]. Blood pressure (systolic and diastolic) was measured using an OMRON HEM-7120 digital sphygmomanometer. According to the Joint National Committee (JNC VIII), the classification of systolic and diastolic blood pressure is as follows: 1) Normal (<120 mmHg and <80 mmHg); 2) Prehypertension (120-139 mmHg or 80-89 mmHg); 3) Stage 1 hypertension (140-159 mmHg or 90-99 mmHg); 4) Stage 2 hypertension (≥160 mmHg or ≥100 mmHg) [24].

Statistical Analysis

Blood pressure, ASMI, visceral fat, physical activity, and body fat percentage are the independent variables, and BMI is the dependent variable. The continuous variable's normality was examined using the Kolmogorov-Smirnov test. For continuous variables and normal data distributions, the mean and standard deviation were used, whereas for non-normal data distributions, the median, minimum, and maximum were used. The categorical variables were expressed as frequency and percentage. To examine the association between the variables, a Chi-square test was used. Statistical significance was established at a p-value of less than 0.05.

Ethical Approval

The present study adhered to the principle of Declaration of Helsinki 2013 (latest revised in Finland 2024)[25], regarding research on human subjects. The study was approved by the Ethics Committee of the Research Ethics Committee Semarang State Health Polytechnic which granted ethical permission for this study with number 1062/EA/KEPK/2024. All subjects signed the informed consent forms before collecting the data.

RESULT

A total of 154 respondents (100%) completed the study protocol, as shown in Table 1. The findings indicate that the ma-

Table 1. Sociodemographic, anthropometric and clinical characteristics of the respondents

Characteristics	n = (154)	%
Occupation		
Employed	6	3.90
Unemployed	148	96.10
Physical activity		
Low	112	72.70
Moderate	19	12.30
High	23	14.90
Body Mass Index (BMI)		
Wasting	4	2.60
Normal	57	37.00
Overweight	28	18.20
Obese	65	42.20
Percent Body Fat (%BF)		
Normal	31	20.10
High	66	42.90
Very High	57	37.00
Visceral Fat (VF)		
Low	4	2.60
High	57	37.00
Appendicular Skeletal Muscle Index (ASMI)		
Low	69	44.80
Preserved	85	55.20
Systolic Blood Pressure (SBP)	22	14.30
Hypertension	146	94.80
Not Hypertension	8	5.20
Diastolic Blood Pressure (DBP)		
Hypertension	129	83.80
Not Hypertension	25	16.20

jority of respondents are unemployed (96.10%), engage in low levels of physical activity (72.70%), and are categorized as obese (42.20%). Additionally, 42.90% have high levels of body fat, while 37.00% exhibit high levels of visceral fat. Most respondents are classified as having preserved ASMI (55.20%). Furthermore, a significant number of respondents have hypertension, with 94.80% showing elevated systolic blood pressure and 83.80% demonstrating elevated diastolic blood pressure.

Table 2 shows that the median level of physical activity is 146.00 METs-min/week. The minimum recorded physical activity level is 0 METs-min/week, while the maximum is 19155 METs-min/week. This indicates a wide range of physical activity levels among the respondents. It appears that at least one respondent has the lowest physical activity level, while at least one has the highest. Lower levels of physical activity are associated with increased health risks, including obesity, heart disease, and type 2 diabetes.

The average BMI among respondents was 26.25 kg/m² (SD = 4.35), categorizing the mean value as overweight. The median percentage of body fat (%BF) among respondents was 38.95%. The minimum and maximum %BF recorded were 22.90% and 48.20%, respectively, indicating a wide range of body fat levels among individuals, with some having relatively low levels and others exhibiting relatively high levels. The median value of visceral fat among respondents was 10.50, with a minimum of 1.50 and a maximum of 55.0. This also shows a broad range of visceral fat levels, with some individuals having low levels and others having high levels. The median ASMI among respondents was 5.40, while the minimum and maximum values were 3.20 and 10.80, respectively. This indicates variability in ASMI, with some individuals having lower values and others maintaining higher levels of ASMI. The average SBP among respondents was 150.9 mmHg (SD = 4.35 mmHg), categorizing this average as hypertension. The median DBP was 90 mmHg, which also falls into the hypertensive category. The minimum and maximum DBP values ranged from 59 mmHg to 187 mmHg.

The relationships between physical activity, blood pressure, appendicular skeletal muscle mass index (ASMI), visceral fat (VF), body fat percentage (BF), and obesity are summarized in Table 3. The analysis revealed that the prevalence of obesity was significantly higher among respondents and significantly associated with low levels of physical activity ($p = 0.040$), high %BF ($p < 0.001$), high visceral fat ($p < 0.001$), low ASMI ($p < 0.001$), and elevated SBP ($p = 0.040$). However, no statistically significant association was found between DBP and obesity ($p = 0.340$).

DISCUSSION

The finding of this cross-sectional study was the relationship between physical activity, body fat percentage (%BF), visceral fat, appendicular skeletal muscle mass index (ASMI), and blood pressure concerning obesity. The prevalence of obesity among the participants in this study was 42.20%. This aligns with another cross-sectional study conducted in Indonesia that included 330 older women aged 60 years and above, which reported an obesity rate of 37.30% among the respondents[26]. A study conducted in China found that 19.4% of older women aged 60 and above were obese among a sample of 1,368 participants[27]. Another study conducted in Taiwan included 13,978 women aged 60 years and older, showing a prevalence of obesity at 36.64%[28]. Previous studies support the findings of this current research, indicating that older adults aged 60 and over tend to experience obesity in later life. Although the mean BMI in this study was 26.25±4.35, categorizing it as overweight, this condition—along with obesity—is a critical indicator of higher percentages of body fat and visceral fat[29].

Another body composition parameter measured in this study was body fat percentage (%BF) and visceral fat. Based on Table 1 and Table 2, more than half of the respondents

Table 2. Measurement of Physical Activity, BMI, %BF, VF, ASMI, and Blood Pressure

Variable	Mean±SD	Median (IQR)	95% CI
Physical Activity (METs-min/week)		146.00 (693)	
Body Mass Index (BMI) (kg/m²)	26.25±4.35		25.55-26.94
Percent Body Fat (%)		38.95 (5.5)	
Visceral Fat (point)		10.50 (6.6)	
Appendicular Skeletal Muscle Index (ASMI) (kg/m²)		5.40 (1.2)	
Systolic Blood Pressure (SBP) (mmHg)	150.91±20.98		147.57-154.25
Diastolic Blood Pressure (DBP) (mmHg)		90 (16)	

Table 3. Association of Physical Activity, % BF, VF, ASMI, and Blood Pressure with Obesity

Variable	Obese		Not Obese		p-value	OR value (95%CI)
	n	%	n	%		
Physical Activity						
Low	73	65.20	39	34.80	0.040	2.05 (1.00-4.22)
High	20	47.60	22	52.40		
Percent Body Fat (%BF)						
High	89	72.40	34	27.60	<0.001	17.66 (5.75-54.25)
Normal	4	12.90	27	87.10		
Visceral Fat (VF)						
High	74	96.10	3	3.90	<0.001	75.29 (21.24-266.85)
Low	19	24.70	58	75.30		
Appendicular Skeletal Muscle Index (ASMI)						
Low	19	27.50	50	72.50	<0.001	0.05 (0.02-0.12)
Preserved	74	87.10	11	12.90		
Systolic Blood Pressure (SBP)						
Hypertension	91	62.30	55	37.7	0.040	4.96 (0.96-25.45)
Not Hypertension	2	25.00	6	75.0		
Diastolic Blood Pressure (DBP)						
Hypertension	80	62.00	49	38.00	0.340	1.50 (0.63-3.56)
Not Hypertension	13	52.00	12	48.00		

(72.40%) had a high %BF, with a median of 38.9%, categorized as "high" according to Gallagher et al. Almost all respondents had high visceral fat, with a median of 10.50, which is considered "high" based on the cut-off point provided by the BIA Omron used for analysis.

Higher levels of %BF and visceral fat are associated with increased health risks, including obesity, heart disease, and type 2 diabetes. As shown in Table 3, %BF displayed a significant association with obesity ($p < 0.001$; OR = 17.66). This odds ratio indicates that respondents with higher %BF are 17.66 times more likely to be obese compared to those with normal %BF. A similar association was found with visceral fat levels ($p < 0.001$; OR = 75.29) regarding obesity. This suggests that respondents with higher visceral fat levels have a greater tendency to become obese compared to those with normal visceral fat. These findings align with a study by Tay et al., which also identified a correlation between higher BMI and increased %BF and visceral fat in older adults with obesity[29].

A study found that a higher percentage of body fat is associated with increased age ($p<0.050$). As women age, they naturally experience an increase in body fat and a decrease in lean muscle mass. Research indicates that older women tend to have higher body fat percentages than men, which may lead to an increased risk of sarcopenia (muscle loss) and other metabolic issues[27]. Visceral fat, which accumulates around internal organs, is particularly harmful because it contributes to inflammation and metabolic dysfunction. Research has shown that higher levels of visceral fat are linked to poorer health outcomes in older women, including an increased risk of chronic diseases. Additionally, visceral fat is more metabolically active than subcutaneous fat, posing

greater health risks[30]. Visceral fat accumulates when the amount of available fat exceeds what adipocytes can store. This excess fat can circulate in the body and create deposits in other organs. Along with causing hypoxia, oxidative stress, and endoplasmic reticulum (ER) stress, visceral fat may impede the formation of blood vessels and contribute to the development of various related health issues[18].

According to Table 3, there is a significant relationship between physical activity and obesity (p = 0.040; OR = 2.05). Among respondents with low levels of physical activity, 65.20% were obese, compared to only 47.60% of those with high levels of physical activity. The odds ratio indicates that respondents with lower physical activity levels are 2.05 times more likely to become obese than those with higher activity levels. This finding aligns with previous studies that suggest a link between physical activity and obesity[31,32], particularly among the elderly with physical mobility issues[32]. Research has indicated that older women who are overweight or obese spend an average of 9.2 hours each day being sedentary. This lack of physical activity increases their risk of various health issues, including inflammation and poor bone health[33]. A cross-sectional study involving 964 older adults found that 55% of the participants were female. The results showed that women were less physically active than men. Among the respondents, the most significant functional impairments were observed in obese women. Older women who are obese have significant impairments in their mobility and general functional ability, with lower extremity abilities like walking and stair climbing being the most affected[34]. According to current research, respondents with low physical activity are often characterized by sedentary behavior. The mechanisms through which low physical activity contributes to bone mass loss in overweight and obese populations are varied and physiologically plausible. Studies have shown that bone cells in the body can be significantly affected by mechanical stress and possess the ability to sense pressure[35]. When older adults who are overweight or obese engage in low levels of physical activity, their lower limbs remain inactive and weak for long periods. This lack of movement prevents bone cells from detecting changes in body weight, leading to a loss of bone mass in the lower extremities[33,35].

Skeletal muscle mass (SMM) is crucial for body composition, and its loss accelerates with age, increasing the risk of osteoporosis, fractures, poor quality of life, functional impairment, and mortality[36,37]. To assess whether older individuals have low lean mass or sarcopenia, a common measure used is the appendicular skeletal muscle index (ASMI). This index is calculated by taking the total skeletal muscle mass of the upper and lower extremities and correcting it for the square of height, using bioelectrical impedance analysis (BIA)[38-40].

ASMI was one of the variables measured in this study. The prevalence of ASMI, as shown in Table 1, was 44.80%, while the median ASMI was 5.40 kg/m² (as indicated in Table 2), which is considered lower than the cut-off points of 5.45 kg/m². Chi-square analysis revealed that lower ASMI was significantly associated with the presence of obesity (p < 0.001; OR=0.05). Among respondents with low ASMI, over one-quarter (27.50%) were classified as obese; surprisingly, 87.10% of respondents with preserved ASMI were also considered obese. The odds ratio suggested that respondents with low ASMI were 0.05 times less likely to be obese compared to those with preserved ASMI. Interestingly, this study also found a greater proportion of obesity among individuals with preserved levels of ASMI. In comparison to a previous study conducted by Liu et al, there are similarities in findings. That study discovered that obesity was a protective factor for sarcopenia when measured by BMI (p = 0.001; OR = 0.69), but acted as a risk factor when measured by body fat percentage (BF%) (p = 0.002; OR = 1.38). This suggests that the likelihood of sarcopenia decreases as BMI increases[27].

The appendicular skeletal muscle index (ASMI) can be used as a predictor for assessing the risk of muscle mass decline in obese populations, depending on how obesity is defined. In this study, obesity status was determined based on BMI rather than percentage body fat (%BF). Although a small number of obese participants showed low ASMI values, the calculated odds ratio, which was less than 1, should not be interpreted as a predictor of obesity. Instead, this odds ratio suggests that obesity may act as a protective factor against low ASMI. In older adults with obesity, multiple factors—including hormonal influences (such as leptin and myostatin), inflammatory responses, metabolic dysregulation (like insulin resistance), mechanical stimuli from physical activity, dietary intake, and complex cellular signaling pathways—play a role in regulating appendicular muscle mass through various mechanisms[41,42].

Blood pressure was the only blood parameter measured in this study. According to Table 1, almost all respondents were classified as hypertensive based on either systolic blood pressure (SBP) or diastolic blood pressure (DBP). As indicated in Table 3, only SBP showed a significant relationship with obesity (p = 0.040; OR = 4.96), while DBP did not show a significant relationship (p = 0.340). The odds ratio suggests that SBP is a predictor of obesity among the respondents. This finding aligns with two longitudinal studies: the Framingham Heart Study and the Nurses' Health Study. The Framingham Heart Study highlights that the likelihood of developing hypertension significantly increases with obesity. Individuals in the highest body mass index (BMI) quartile have an SBP approximately 16 mmHg higher and a DBP about 9 mmHg higher than those in the lowest quartile. Specifically, systolic blood pressure increases by roughly 4 mmHg for every 4.5 kg increase in weight[43]. According to the Nurses' Health Study, women who gained over 25 kg were 5.2 times more likely to develop hypertension than those who maintained their weight[44].

Blood pressure and obesity are connected through several mechanisms, including insulin resistance, increased sympathetic nerve activity, and changes in kidney function. Obesity can impair the kidneys' ability to excrete sodium and can lead to increased sodium reabsorption, which negatively affects overall kidney function. This can result in high blood pressure, driven by the activation of the sympathetic nervous system and the renin-angiotensin system[43]. The sympathetic nervous system is activated by the increased visceral fat associated with obesity. This activation leads to vasoconstriction and an increase in cardiac output, both of which contribute to elevated blood pressure. Additionally, insulin resistance often occurs alongside obesity. This condition promotes vascular smooth muscle contraction and causes endothelial dysfunction, which can further lead to hypertension[43].

CONCLUSION

This study highlights the association between low physical activity, high percentage of body fat (%BF), high visceral fat, and high systolic blood pressure (SBP) as risk factors for obesity among women aged 60-69. Interestingly, obesity in this study appeared to protect against low appendicular skeletal muscle index (ASMI) among the respondents. Although diastolic blood pressure (DBP) did not show a statistically significant relationship with obesity, it may still play a role in the clinical development of DBP in individuals with obesity. Since this study defined obesity using body mass index (BMI), considering the percentage of body fat may provide a clearer relationship with the other variables. We suggest conducting further research on obesity among the elderly population, using a larger sample size and different study designs, such as randomized controlled trials with exercise or dietary interventions. This would help to examine the effects of these interventions, or employing mixed methods to explore additional factors associated with obesity in older adults.

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Efecto de varios porcentajes de harina de cáscara de naranja (*Citrus sinensis*) sobre las propiedades fisicoquímicas, bromatológicas y sensoriales de galletas dulces

Effect of various percentages of orange (*Citrus sinensis*) peel flour on the physicochemical, bromatological and sensory properties of sweet cookies

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RESUMEN

Introducción: La cáscara de naranja es reconocida por sus propiedades biológicas que ejercen funciones importantes en el organismo.

Objetivo: evaluar el efecto de varios porcentajes de harina de cáscara de naranja (*Citrus sinensis*) sobre las propiedades fisicoquímicas bromatológicas y sensoriales de galletas dulces.

Materiales y métodos: se utilizó un diseño estadístico completamente al azar con arreglo factorial, donde se incluyeron tres concentraciones de harina de cáscara de naranja (HCN): T1:3% HCN, T2:5% HCN, T3:7%HCN, más un tratamiento control (0% HCN). Se determinó la composición fisicoquímica y microbiológica de la harina. Se elaboraron las galletas y posteriormente se efectuó una evaluación de la composición proximal, microbiológica, sensorial y textura del tratamiento con mejor aceptación sensorial. Las unidades experimentales se compararon mediante pruebas de Tukey.

Resultados y discusión: la composición proximal de la HCN obtuvo un contenido de proteína de 3,79%, humedad 8,42%, materia seca 91,58%, ceniza 5,8%, pH 4,88%, y acidez 0,35%. Los resultados de los análisis microbiológicos cumplen con los criterios de la norma INEN 616. La caracterización bromatológica fue estadísticamente significativa ($p<0,05$) entre tratamientos. El contenido de ceniza fue superior en T3 (1,38%), humedad (6,07%) y, grasa (18,33%), en tanto que el tratamiento T0 mostró un mayor contenido de proteína (8,37%), materia seca (97,28%) y pH superior en T1 de 6,73. Se cumplió con los criterios microbiológicos de la NTE INEN 2085. El análisis sensorial fue estadísticamente superior ($p<0,05$) en T1 para los atributos color (5,97), olor (6,01), sabor (5,74), textura (5,88) y consistencia (5,76). El análisis de textura del mejor tratamiento con aceptación sensorial obtuvo una dureza de 57,25N, relacionado con una baja adhesividad, cohesividad, gomosidad, elasticidad y viscosidad.

Conclusiones: la inclusión de la harina de cáscara de naranja en concentraciones en 3% presentó una mejor aceptación sensorial y cumple con los criterios de la NTE INEN 2085.

PALABRAS CLAVES

Calidad sensorial, cítricos, desarrollo de productos, propiedades reológicas.

ABSTRACT

Introduction: Orange peel is recognized for its biological properties that exert important functions in the organism.

Objective: to evaluate the effect of various percentages of orange peel (*Citrus sinensis*) flour on the physicochemical, bromatological and sensory properties of sweet cookies.

Materials and methods: a completely randomized statistical design with factorial arrangement was used, including

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three concentrations of orange peel flour (HCN): T1:3% HCN, T2:5% HCN, T3:7% HCN, plus a control treatment (0% HCN). The physicochemical and microbiological composition of the flour was determined. The cookies were made and then an evaluation of the proximal, microbiological, sensory and texture composition of the treatment with the best sensory acceptance was carried out. The experimental units were compared using Tukey tests.

Results and discussion: the proximal composition of the HCN obtained a protein content of 3.79%, moisture 8.42%, dry matter 91.58%, ash 5.8%, pH 4.88%, and acidity 0.35%. The results of the microbiological analyses meet the criteria of INEN 616. The bromatological characterization was statistically significant ($p<0.05$) between treatments. Ash content was higher in T3 (1.38%), moisture (6.07%) and fat (18.33%), while the T0 treatment showed a higher protein content (8.37%), dry matter (97.28%) and higher pH in T1 (6.73). The microbiological criteria of NTE INEN 2085 were met. Sensory analysis was statistically superior ($p<0.05$) in T1 for the attributes color (5.97), odor (6.01), flavor (5.74), texture (5.88) and consistency (5.76). The texture analysis of the best treatment with sensory acceptance obtained a hardness of 57.25N, related to low adhesiveness, cohesiveness, gumminess, elasticity and viscosity.

Conclusions: the inclusion of orange peel flour in concentrations of 3% presented a better sensory acceptance and complies with the criteria of NTE INEN 2085.

KEY WORDS

Sensory quality, citrus, product development, rheological properties.

INTRODUCCIÓN

La industria alimentaria en el Ecuador representa una de las actividades con un importante aporte sobre el crecimiento económico y social, cuyo enfoque se fundamenta en el desarrollo de la agricultura y la producción agroalimentaria, además de ser una fuente generadora de empleos que beneficia de manera directa e indirecta a diferentes familias vinculadas dentro de este sector[1]. A pesar del valor fundamental en la elaboración de alimentos se debe considerar que es una de las principales generadoras de residuos como cáscaras, semillas y otros componentes de productos agrícolas que al no ser tratadas adecuadamente inciden sobre negativamente sobre el ambiente[2].

Dentro de este ámbito, las cáscaras de frutos y vegetales constituyen un problema fundamental en la industria alimentaria, tanto por los volúmenes generados y por el impacto ambiental, considerando un aumento significativo relacionado con el aumento de la demanda de productos destinados para el consumo humano[3]. En este sentido se ha documentado que el procesamiento de las frutas genera un rendimiento entre el 40 y 45% con relación a peso inicial y entre el 45 y 60% en residuos[4].

La naranja *Citrus sinensis* es una fruta cítrica conocida por su importante aporte de vitamina C, vitaminas del grupo B, fibra, flavonoides (hesperidina y naringenina) y compuestos fenólicos que ejercen importantes funciones biológicas sobre el organismo[5]. La cáscara de naranja posee un perfil nutricional que integra la presencia de a de compuestos bioactivos, fibra dietética, aceites esenciales y antioxidantes que han sido objeto de estudio de diferentes investigaciones dentro de la industria alimentaria, farmacéutica y cosmética[6].

Las galletas son un alimento con un importante consumo a nivel mundial y a la vez forma parte de una alimentación equilibrada, debido al importante aporte de nutrientes esenciales en el organismo, además de que poseen principios digestivos y dietéticos de vital importancia[7]. Habitualmente las galletas son elaboradas a partir del uso de harina de trigo, grasas (de origen vegetal y animal), azúcares y agentes leudantes regulados por la industria alimentaria, además de ser enriquecidas con frutos secos, frutas deshidratadas y especias que le otorgan diferentes cualidades sensoriales[8].

Por lo tanto, con el desarrollo de la presente investigación se busca dar valor agregado a la cáscara de naranja mediante la elaboración de galletas dulces, considerando las nuevas tendencias de consumo de alimentos más saludables. Por lo expuesto anteriormente este estudio se desarrolló con el objetivo de evaluar el efecto de varios porcentajes de harina de cáscara de naranja (*Citrus sinensis*) sobre las propiedades fisicoquímicas bromatológicas y sensoriales de galletas dulces.

MATERIALES Y MÉTODOS

La investigación se llevó a cabo durante el periodo abril – agosto del 2024 en el Laboratorio de Procesos Agroindustriales en el área de Frutas y Hortalizas de la Facultad de Agrociencias, Extensión Chone de la Universidad Técnica de Manabí, geográficamente ubicada en el Km 2 ½ vía Boyacá, sitio Ánima, a 0°41’17’’ de latitud Sur y 80° 7’ 25.60’’ de longitud Oeste.

Materias primas

Las naranjas fueron recolectadas en los centros de acopio de cítricos del cantón Chone, en tanto que los demás insumos para la elaboración de galletas se adquirieron en el mercado local del cantón Chone provincia de Manabí.

Diseño experimental

Se utilizó un Diseño Completamente al Azar (DCA), con un arreglo factorial. Se formularon cuatros tratamientos, incluyendo tres réplicas por cada tratamiento con un total de doce unidades experimentales. El Factor en estudio A: representado por los porcentajes de Harina de Cáscara de Naranja

(HCN). La unidad experimental estuvo conformada por 600 g de masa para galletas en cada tratamiento.

En la tabla 1 se detallan los tratamientos en estudio del diseño experimental.

Tabla 1. Tratamientos en estudio del diseño experimental

Tratamientos	Códigos	% de HCN	Réplicas
1	T0	0	3
2	T1	3	3
3	T2	5	3
4	T3	7	3

En la Tabla 2 se describe las formulaciones con los niveles de inclusión de harina de cáscara de naranja.

Procedimiento experimental

Obtención de la harina de cáscara de naranja (HCN)

Para la obtención de la HCN se receptaron las naranjas con un estado de madurez intermedio y libre de la presencia de daños por cosecha y microbiológicos. Se procedió a lavar a las naranjas para eliminar todo tipo de impurezas para continuar con el pelado y cortado de la cáscara en porciones aproximadas de 3cm de ancho y 5 cm de largo; posteriormente se realizó un previo blanqueo con agua a temperatura de 80°C por 2 minutos para ser ubicadas en las bandejas y llevadas al proceso de secado (deshidratado) utilizando un deshidratador eléctrico (Food deshidratador FD-12). Los cortes de las cáscaras se deshidrataron a temperatura de 55°C por un tiempo de 5 horas y posteriormente enfriadas a una temperatura de 28°C. Las cáscaras deshidratadas fueron molidas mediante la utilización de un molino eléctrico compuesto por aspas de acero inoxidable para posteriormente envasarla en fundas Ziploc.

Elaboración de las galletas

Para la elaboración de galletas dulces se receptó la harina de trigo, la harina de cáscara de naranja y los demás insumos (azúcar, mantequilla y polvo de hornear), los cuales fueron pesados mediante la utilización de una balanza digital (marca CAMRY, capacidad de peso de 5000±1g), de acuerdo con las proporciones establecidas para la formulación según los tratamientos en estudio (Tabla 2). Se mezcló la harina de trigo, harina de cáscara de naranja y polvo de hornear sobre una bandeja metálica y en un recipiente tipo bowls se mezcló la mantequilla y azúcar hasta conseguir una mezcla homogénea de todos los insumos. Se continuó con el amasado por 10 minutos hasta que la masa sea uniforme y se dejó en reposo por un periodo de 30 minutos.

Luego se procedió con el moldeo de las galletas en la cual se utilizaron moldes de distintas figuras para cada tratamiento y posteriormente horneadas a una temperatura de 130°C por un tiempo de 10 minutos. El proceso de enfriado se realizó a temperatura ambiente por 30 minutos para el respectivo envasado en fundas ziploc. Se determinó el rendimiento de la obtención de la harina de cáscara de naranja considerando las entradas y salidas de las operaciones aplicadas.

Caracterización de las propiedades fisicoquímicas y microbiológicas de la harina de cáscara de naranja

La caracterización de la harina de cáscara de naranja se desarrolló considerando como referencia los requisitos de la norma NTE INEN 616[9], donde se consideraron los siguientes parámetros: proteína (NTE INEN-ISO 20483), humedad

Tabla 2. Formulación de los tratamientos en estudio de galletas dulces con HCN

Materia prima e Insumos	T0 (Control)		T1 (3% HCN)		T2 (5% HCN)		T3 (7% HCN)	
	%	g	%	g	%	g	%	g
Harina de trigo	50	300	47	282	45	270	43	258
Harina de HCN	0	0	3	18	5	30	7	42
Azúcar	26	156	26	156	26	156	26	156
Mantequilla	22	132	22	132	22	132	22	132
Polvo de hornear	2	12	2	12	2	12	2	12
Total	**100**	**600**	**100**	**600**	**100**	**600**	**100**	**600**

(NTE INEN-ISO 712), acidez (NTE INEN 521), grasas (NTE INEN-ISO 11085), materia seca (NTE INEN-ISO 712), ceniza (NTE INEN-ISO 2171), pH 10% (NTE INEN-ISO1842) y contenido mohos y levaduras (NTE INEN 1529-10, AOAC 997.02) y *E. coli*. (NTE INEN 1529-8). Finalmente se determinó tamaño de partículas de acuerdo con el método de la norma NTE INEN 517, el cual se desarrolló mediante el uso de tamiz de acero inoxidable de 4 mallas (500, 425, 125 y 45 µm).

Análisis bromatológicos y microbiológicos de las galletas dulces

Los análisis bromatológicos de los tratamientos en estudio se realizaron según los parámetros establecidos por la norma INEN 2085[10], donde se evaluó los contenidos de: ceniza (NTE INEN-ISO 2171), proteína (NTE INEN 519), humedad (NTE INEN 518), materia seca (NTE INEN-ISO 2171), grasa (NTE INEN-ISO 20483) y pH (NTE INEN 526). Los análisis microbiológicos se desarrollaron considerando los criterios Aerobios mesófilos (NTE INEN 1529-5), Mohos y levaduras (NTE INEN 1529-10).

Análisis sensorial

El análisis sensorial de las galletas dulces con varios porcentajes de HCN se realizó con un panel sensorial conformado por 90 jueces semi-entrenados, los cuales evaluaron propiedades organolépticas como: color, olor, sabor, textura y consistencia a través de un test de escala hedónica de 7 puntos (1 = me disgusta mucho; 2 = me disgusta moderadamente; 3 = me disgusta poco; 4 = ni me gusta ni me disgusta; 5 = me gusta poco; 6 = me gusta moderadamente; 7 me gusta mucho).

Análisis del perfil de textura

El análisis del perfil de textura se realizó al tratamiento con mejor aceptación sensorial. Se procedió con la preparación de las muestras de galletas para luego ser trasladadas al equipo de análisis de textura de la marca Shimadzu Universal Tester EZTest EZ-LX. Las variables analizadas fueron: dureza (N), cohesividad, adhesividad (N), gomosidad (N), elasticidad (N) y masticabilidad (N).

Análisis estadístico

El análisis estadístico se desarrolló mediante la utilización del Software InfoStat versión libre 2020. Se aplicó un análisis de varianza ANOVA y posteriormente en cada una de las unidades experimentales que presentaron diferencias significativas ($p<0,05$) se aplicó pruebas de comparación de medias de Tukey utilizando un intervalo de confianza del 95%. Los datos del perfil sensorial se trabajaron mediante estadística no paramétrica utilizando la prueba de contraste Kruskal Wallis al 5% de significancia.

RESULTADOS Y DISCUSIÒN

Composición proximal de la harina de cáscara de naranja

En la tabla 3, se describen los resultados de la composición proximal de la harina de cáscara de naranja.

Tabla 3. Propiedades fisicoquímicas y microbiológica de la harina de cáscara de naranja

H. de cáscara de naranja	Unidad	Valor
Proteína (6,25)	%	3,79
Humedad	%	8,42
Materia Seca	%	91,58
Ceniza	%	5,18
pH (10%)	—	4,88
Acidez	% ácido sulfúrico	0,35
E. coli	UFC/g	Ausencia
Mohos y Levaduras	UP/g	3,05E+01

El análisis del contenido de proteínas de la harina de cáscara de naranja demostró un bajo contenido de este nutriente con 3,79%, valor proporcional a la naturaleza del producto y a las diferencias de la harina de trigo que contiene valores que oscilan entre 8 a 15% de proteínas. A su vez al comparar con los requisitos de la NTE INEN 616[9], no cumplen con los requisitos descritos por la norma para productos de pastelería y panadería.

El contenido de humedad reportado para la harina alcanzó un promedio de 8,42%, el cual se encuentra dentro de los valores requeridos por la NTE INEN 616[9], donde se describe un valor máximo de 14,5%. Los resultados del estudio se encuentran cercanos a los reportados por Burgos y Inoñan[11], en harina de cáscara de cítrico documenta valores de 9,35% para la humedad, especificándose una humedad adecuada para este tipo de productos. Adicionalmente se garantiza la estabilidad de la harina durante el almacenamiento.

El contenido de materia seca (MS) en la harina de cáscara de naranja fue relativamente alto, con un valor de 91,58%, siendo menor al reportado por Muñoz, et al.[12] donde documenta un promedio de 96,21% de materia seca harina de productos cítricos, lo que deriva de la presencia de fibra conformada por pectina y celulosa, además de la presencia de azúcares, ácidos orgánicos y minerales.

En referencia al contenido de cenizas de la harina de cáscara de naranja se obtuvo un total de 5,18%, que indica un

importante aporte de minerales, donde se destaca la presencia de calcio, potasio y magnesio. En cuanto al contenido de cenizas, los valores reportados superan los requisitos máximos descrito por la NTE INEN 616[9], la cual especifica un total de 0,8% para harina utilizadas en productos de galletería.

Los resultados del contenido de pH de la harina de cáscara de naranja arrojo como resultados un valor de 4,88, el mismo que documenta valores ligeramente ácidos que se relacionan con la presencia de ácidos orgánicos de origen natural como el ácido cítrico y ácido sulfúrico. Estos resultados se encuentran cercanos a los reportados por (Velázquez y Díaz[13]), los cuales obtuvieron un promedio de 4,65 en pH.

En relación al contenido de acidez se documenta como resultados un total de 0,35% expresado como ácido sulfúrico, el cual deriva de la presencia de ácidos libres encontrados en la harina, sin embargo, se debe considerar que los valores se encuentran por encima de la norma de referencia NTE INE 616[9], donde se especifica un mínimo de 0,2%.

En cuanto a la caracterización microbiológica de la harina de cáscara de naranja se documenta la ausencia de *Escherichia coli*, lo que indica que la harina cumple con las condiciones sanitarias adecuadas y libre de la presencia de contaminación fecal (Doddabematti, et al.[14]), el cual se considera un riesgo significativo para la salud. Además, se documenta el cumplimiento de los estándares de calidad descritos en la NTE INEN 616[9].

De la misma manera se observa el cumplimiento de los requisitos microbiológicos en cuanto a la presencia de mohos y levaduras de acuerdo a la NTE INEN 616[9], donde se observa valores relativamente bajos (3,05E+01 UP/g), considerándose normal en productos que derivan de vegetales y subproductos secos como la cáscara de naranja, considerando que por las características propias de los cítricos la presencia de este tipo de microorganismos es limitada (Vera y Zambrano[15]). A su vez concuerdan con los reportados por Muñoz, et al.[16] al efectuar una caracterización de harina de subproductos cítricos donde documenta el cumplimiento de los requisitos descritos para la norma INEN 616[9].

El análisis del tamaño de partícula para la harina de cáscara de naranja muestra como resultados que la mayor parte de fracción de la harina presentó un tamaño de partícula de 425 µm donde se quedó retenido el 41,20%. Seguido se encontró que el 35,22% restante presentó un tamaño de partícula de 125 µm. En tanto que para el 15,27% presentó un tamaño de partícula de 500 µm. Esta mezcla en diferentes tamaños de partícula en la harina, entre finas y gruesas tiene implicaciones positivas sobre los productos de panadería como las galletas, reduciendo de manera directa la dureza de las galletas (Matos[17]).

Tabla 4. Análisis del tamaño de partícula de la harina de cáscara de naranja

Tamaño de malla (µm)	% de masa retenida
500	15,27
425	41,20
125	35,22
45	6,94
Fondo	1,39

El balance de masa para la obtención de la harina de cáscara de naranja durante el proceso de secado y molienda demostró un rendimiento del 23,63%, considerando el valor de entrada y salida obtenidos durante este proceso. Los resultados expuestos por Guamán[18], reportan como resultados rendimientos menores en el procesamiento en la pulpa de naranja, asociado a un mayor contenido de agua.

Composición bromatológica de las galletas

En la tabla 6 se describen los resultados de la caracterización bromatológica de las galletas elaboradas con la inclusión de los tres niveles de harina de cáscara de naranja.

Los resultados del contenido de ceniza muestran un comportamiento estadísticamente significativo (p=<0,001) evidenciando un aumento proporcional en el contenido de cenizas a conforme aumenta el nivel de inclusión de la harina de cáscara de naranja, alcanzando en el T0 el contenido de cenizas es el más bajo con un promedio de 1,11%, mientras que T3 alcanzó el valor más alto con 1,38%. Este aumento se relaciona con un mayor aporte de minerales como el calcio, potasio y magnesio en la cáscara de naranja. En relación al contenido de proteína de las galletas los valores se encuentran cercano a los reportados por Muñoz, et al.[16], quienes reportan valores de 9,00% en el tratamiento control, coinci-

Tabla 5. Balance de masa para la obtención de la harina de cáscara de naranja

Proceso	Entrada	Salida	Pérdidas	Rendimiento (%)
Deshidratación	2,385	0,705	1,68	23,63
Molienda	0,705	0,67	0,035	

Tabla 6. Composición bromatológica de las galletas con la inclusión de harina de cáscara de naranja

Tratamientos	T0 (Control) x̄±D.E.	T1 (3% HCN) x̄±D.E.	T2 (5% HCN) x̄±D.E.	T3 (7% HCN) x̄±D.E.	p-valor
%Ceniza	1,11±0,01 a	1,20±0,01 b	1,30±0,03 c	1,38±0,03 d	<0,001*
%Proteína	8,37±0,10 a	8,36±0,41 a	7,89±0,07 ab	7,61±0,18 b	0,010*
%Humedad	2,72±0,28 b	4,86±0,11 ab	4,79±0,19 ab	6,07±2,30 a	0,045*
%MS	97,28±0,28 a	95,14±0,11 ab	95,21±0,19 ab	93,93±2,30 b	0,045*
%Grasa	16,28±0,15 b	10,57±0,82 c	18,28±0,26 a	18,33±0,03 a	0,001*
pH	6,65±0,05 b	6,73±0,01 a	6,67±0,02 ab	6,54±0,01 c	0,002*

Los valores representan el promedio ± Desviación Estándar. Media con una letra en común en la misma columna no son significativamente diferentes (p<0,05) de acuerdo con la prueba de Tukey. *: significancia estadística. ns: no significativo.

diendo que un aumento en la sustitución de la harina de trigo disminuyo en contenido final de proteínas.

El análisis de varianza del contenido de proteínas mostró diferencias significativas (p= <0,001) entre tratamientos, siendo superior en el tratamiento control con 8,37% y menor en el tratamiento T3 con 7,61%, mostrando una reducción en el valor porcentual de proteína al aumentar la concentración de harina de cáscara de naranja, considerando que este tipo de harinas se caracteriza por un bajo aporte proteico, en comparación con la harina de trigo. En este sentido Bakar et al.[19], manifiesta que la harina de cáscara de naranja destaca por la presencia de compuestos bioactivos y su alto contenido en fibra, sin embargo, no es una fuente de proteínas. Los resultados del estudio difieren de los reportados por Lozano[20], donde al evaluar el contenido de proteína de galletas con la inclusión de cáscara de naranja muestran un aumento proporcional, alcanzado promedio de 8,50% al utilizar concentraciones del 10%. A su vez el contenido de proteína cumple con los criterios de calidad de la NTE INEN 2085[10], donde se especifica un mínimo de 3,0%.

El contenido de humedad presentó diferencias significativas (p=0,045) entre los tratamientos en estudio, siendo superior en el tratamiento T3 con 6,07%, y menor para el tratamiento control con 2,72%, el cual difiere de los reportados por Chávez, et al.[21], quienes al elaborar galletas con sustitución de harina de trigo reportan valores de 6,54% en el tratamiento control y 5,61% al sustituir 5% de la harina de trigo. Investigaciones preliminares documentan que la cáscara de naranja presenta un alto contenido de fibra dietética que contribuye con la retención de agua debido a su capacidad hidrofílica (Rani, et al[22]), lo que demuestra que a mayor concentración de la harina se encontró un aumento significativo en contraste con el tratamiento control. De la misma manera, se observa el cumplimiento de los requisitos de la NTE INEN 2085[10], en cuanto al contenido de humedad, donde el valor máximo es de 10%.

Por otro lado, al analizar el comportamiento estadístico de la variable materia seca (MS) se puede apreciar diferencias significativas (p=0,045), mostrándose superior en el tratamiento control con 97,28%, a diferencias del tratamiento T3 el cual fue menor con 93,93%, el cual es esperado debido al incremento de la humedad en este tratamiento, debido al comportamiento inversamente proporcional entre ambas variables.

Los resultados del análisis de varianza en el contenido de grasa en las galletas demostraron diferencias significativas (p=<0,001) entre los valores promedios de cada formulación, reportando un mayor aporte en los tratamientos T2 y T3 con 18,28 y 18,33%, respectivamente en cada tratamiento, en tanto que para el tratamiento T1 se obtuvo el menor contenido de grasa con 10,57%, muy cercano al reportado por Kolawole, et al.[23] quienes documentan valores de 9,72–10,44 g/100g.

En relación al análisis de varianza del pH de las formulaciones en estudio se determinó la presencia de diferencias significativa (p=<0,001), a pesar de no encontrarse cambios relativamente altos puede apreciarse que el tratamiento T1 tiene un pH más alto con 6,73%, en comparación con el tratamiento T3 el cual obtuvo un valor de 6,54%. De acuerdo con las especificaciones de la norma INEN 2085[10], el valor documentado cumple con los criterios de calidad descritos por la norma, donde se especifica un mínimo de 5,5 y máximo de 9,5.

El análisis de varianza para los atributos microbiológicos de las galletas dulces con la inclusión de los tres niveles de harina de cáscara de naranja demostró diferencias significativas (p=<0,001) en los valores reportados para la variable aerobios mesófilos, demostrando un aumento proporcional entre los valores reportados para tratamientos en estudio donde se observa una superioridad numérica en los tratamientos T1 y T3 con promedios de 3,43E+02 y 4,14E+02 UFC/g respectivamente, sin

Tabla 7. Composiciones microbiológicas de las galletas con la inclusión de cáscara de naranja

Tratamientos	Aerobios mesófilos	Mohos y Levaduras
T0 (Control) x̄±D.E.	1,17E+02±16,86 d	4,44E+01±11,41 bc
T1 (3% HCN) x̄±D.E.	3,43E+02±18,48 a	2,68E+01±2,35 c
T2 (5% HCN) x̄±D.E.	2,01E+02±7,09 b	6,01E+01±6,34 b
T3 (7% HCN) x̄±D.E.	4,14E+02±47,34 a	8,79E+01±6,05 a
p-valor	<0,001*	<0,001*

Los valores representan el promedio ± Desviación Estándar. Media con una letra en común en la misma columna no son significativamente diferentes (p<0,05) de acuerdo con la prueba de Tukey.

embargo, bajo los criterios expuestos por Das, et al.[24], los productos de panadería son considerados estables con valores bajos, por lo que se asume que las galletas son seguras para el consumo humano.

Con relación al contenido de Mohos y levaduras de las galletas dulces se encontró diferencias significativas (p=<0,001) entre los valores promedios reportados para las formulaciones, donde el tratamiento T3 alcanzó el mayor contenido de UFC en las galletas con un promedio de 8,79E+01, a pesar tener la mayor concentración de la harina se puede observar un crecimiento favorables para este tipo de microorganismos a pesar de las propiedades antimicrobianas reportados en la cáscara de naranja no se logró inhibir en crecimiento de este tipo de microorganismos permitiendo su proliferación, que además es incidida por la presencia de un mayor contenido humedad reportado en este mismo tratamiento, reportando valores superiores a los documentados por Quezada et al.[25], donde describe un total de 13 UPC/g en mohos y levaduras. Los resultados documentados en esta investigación cumplen con los criterios de calidad descritos por la NTE INEN 2085[10].

Análisis sensorial

Los resultados del análisis sensorial del atributo color de las galletas de harina de cáscara de naranja demostró la presencia de diferencias significativas entre los tratamientos evaluados. En este caso puede apreciarse que el tratamiento T1 demostró tener una mejor aceptación en este atributo, con una puntuación de 5,97 puntos acercándose a los rangos de calificación de me gusta moderadamente. No obstante, los valores reportados por Agüero, et al.[26], al sustituir harina de trigo en concentraciones de 5% documenta una mejor aceptación con respecto al color con puntuaciones de 8 puntos, utilizando una escala hedónica de mayor puntuación.

Por su parte la evaluación del atributo olor de las galletas con la inclusión de los tres niveles de harina de cáscara de naranja arrojó como resultados que se encontró diferencias significativas entre tratamientos, dando una mejor aceptación en el tratamiento T1 con una valoración de 6,01, para los demás tratamientos en estudio se observó una menor aceptabilidad, indicando que a pesar de encontrar mayores cantidades de harina de cáscara de naranja no se observó un efecto significativo en comparación con el tratamiento control, sin embargo, la valoración por parte de los catadores fue menor. Los resultados expuestos por Muñoz et al.[16] en la elaboración de galletas dulce con sustituciones de la harina de trigo muestran diferencias significativas en la calificación del atributo olor, con puntuaciones de superiores en el tratamiento con sustitución del 10%, donde se obtuvo valoraciones de 5,79 puntos.

El análisis sensorial del atributo sabor de las galletas con la inclusión de la harina de cáscara de naranja dio como resultados diferencias significativas entre tratamiento, destacando una mayor preferencia en el tratamiento T1, donde se logró una mejor aceptación con una valoración de 5,74 puntos, siendo más agradable para los catadores, seguido se observa una menor aceptabilidad el los tratamientos que incluyeron

Tabla 8. Evaluación sensorial de los tratamientos en estudio

Parámetros	T0 (Control) x̄±D.E.	T1 (3% HCN) x̄±D.E.	T2 (5% HCN) x̄±D.E.	T3 (7% HCN) x̄±D.E.	p-valor
Color	5,29±1,49 b	5,97±0,83 a	4,81±1,59 c	5,14±1,67 bc	<0,001*
Olor	5,11±1,19 b	6,01±0,88 a	4,78±1,65 b	4,87±1,66 b	<0,001*
Sabor	5,14±1,23 b	5,74±1,11 a	4,08±1,73 b	3,78±1,83 c	<0,001*
Textura	5,37±1,24 b	5,88±0,87 a	4,64±1,54 c	4,64±1,61 c	<0,001*
Consistencia	5,13±1,37 b	5,76±0,94 a	4,89±1,65 b	4,34±1,66 c	<0,001*

Los valores representan el promedio ± Desviación Estándar. Media con una letra en común en la misma columna no son significativamente diferentes (p<0,05) de acuerdo con la prueba de Kruskal Wallis. *: significancia estadística. ns: no significativo.

mayores niveles de harina, posiblemente relacionada con un aumento en el amargor de las formulaciones. De la misma manera, los resultados de Lozano et al.[27], reportan diferencias significativas en el atributo sabor de galletas dulces donde se sustituyó la harina de trigo por harinas no convencionales.

La valorización sensorial del atributo textura de las galletas demostró que la inclusión de la harina de cáscara de naranja generó una mejor aceptación en el tratamiento T1 con una valoración de 5,88 puntos, considerando que la mayor aceptación está vinculada a una mejor cohesión, firmeza o crujiente, características que suelen ser apreciadas en productos horneados. En este caso se puede apreciar que un aumento de la concentración de la harina desfavoreció la aceptabilidad de la textura

Con relación a la consistencia de las galletas se evidenció que la inclusión de 3% de cáscara de naranja alcanzó resultados favorables en cuanto a la aceptabilidad de este indicador, siendo superior en comparación con los demás tratamientos con una media de 5,76, a diferencia de los tratamientos donde se observó una menor aceptabilidad por parte de los catadores. Los resultados expuestos muestran un comportamiento diferente a los reportados por Soto, et al.[28], quienes al aumentar el nivel de sustitución de la harina de trigo en la elaboración de galletas dulces muestra una aceptación favorable con puntuaciones cercanas a 5 puntos.

Perfil de textura del tratamiento con mejor aceptación sensorial

El análisis de textura se desarrolló con el tratamiento que obtuvo una mejor aceptación sensorial, donde el tratamiento T1 destaco por su mejor aceptación en los atributos color, olor, sabor, textura y consistencia.

La evaluación de la textura del tratamiento con mejor aceptación sensorial arrojó como resultados un total de 57,25±17,90 N. En términos de masticabilidad los valores reportados para este tratamiento se consideran aceptables a pesar de que un aumento en los valores de textura para productos de panadería puede relacionarse con una textura más crujiente; sin embargo, se debe considerar la dependencia en la aceptación por parte de los consumidores.

Tabla 9. Evaluación del perfil de textura del tratamiento con mejor aceptación sensorial (N)

Parámetro	T1 (3% HCN) x̄±D.E.
Dureza (N)	57,50±17,90
Adhesividad (N)	-0,26±0,44
Cohesividad	-0,00±0,00
Gomosidad (N)	-0,89±0,13
Elasticidad (N)	0,00±0,00
Masticabilidad (N)	0,01±0,00
Viscosidad	0,03±0,01

Los valores representan el promedio ± Desviación Estándar.

Según Lozano[27] indica que las inclusiones de harina de cáscara de naranja en concentraciones del 10% reporta valores de textura de 31,85 N, en tanto, que con inclusión del 5% los resultados alcanzaron un promedio de 15,55N, evidenciando un aumento en la dureza al incrementar la concentración de la harina, asociado al retrogradación que provoca el almidón el cual experimenta un proceso de descomposición asociado con el horneado lo que desencadena la liberación de azucares que incrementan la textura en las galletas (Fitriani[29]).

Por su parte los resultados de la adhesividad en las galletas con inclusión de HCN en concentraciones de 3% alcanzaron un promedio de -0,26 N que indica una mínima resistencia para separarse al momento de recibir una fuerza externa, que a su vez se contrasta con una baja cohesividad (-0,00N) y gomosidad (-0,89N), característico de este de productos donde la textura es más blanda y no tiene la capacidad de recuperar su forma.

En cuanto a la elasticidad se observó valores de cero para este tratamiento el cual responde de manera directa a una nula presencia en la capacidad de estiramiento de las galletas, a su vez los valores de masticabilidad demuestran como resultados promedios de 0,01 N, que indica que el esfuerzo para masticar las galletas es mínimo, relacionado con una baja viscosidad que muestra que las galletas presentaron una textura quebradiza (Cabrera[30]). Los valores reportados en este estudio son cercanos a los reportados por Muñoz[16], con promedios de 0N para las variables elasticidad y 0N para la masticabilidad reportada en el tratamiento control y para el tratamiento que sustituyó el 10% de la harina de trigo.

La incidencia de la harina de cáscara de naranja en la elaboración de las galletas puede dar origen a la presencia de un producto con mayor dureza debido al importante aporte de fibras encontradas en la harina; sin embargo, se debe considerar la interacción con otros componentes como la humedad, el contenido de proteína y los almidones encontrados en la harina.

CONCLUSIONES

Los resultados del análisis fisicoquímico de la harina de cáscara de naranja demostraron un bajo aporte de proteínas y bajo contenido de humedad, y un alto contenido de minerales; los valores microbiológicos mantuvieron valores aceptables para su consumo. La composición bromatológica y microbiológica de las galletas demostraron el cumplimiento de los requisitos descritos en la norma INEN 2085 (2005). De acuerdo con la valoración sensorial de los tratamientos en

estudio se observó que la inclusión de la harina de cáscara de naranja en concentraciones de 3% mantuvo una mejor aceptabilidad en los atributos color, olor, sabor, textura y consistencia. El análisis del perfil de textura del tratamiento con mejor aceptación sensorial obtuvo un valor de dureza de 57,25±17,90 N asociado a una baja adhesividad, cohesividad, gomosidad, elasticidad y viscosidad.

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Propuesta para promover la alimentación saludable entre los tenistas de campo en la era de la infoxicación

Proposal to promote healthy eating among court tennis players in the era of infoxication

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RESUMEN

Introducción: la propuesta se centra en promover la alimentación saludable entre los tenistas de campo, abordando el impacto de la infoxicación, fenómeno caracterizado por la sobrecarga de información, muchas veces contradictoria y carente de rigor científico, que afecta negativamente las decisiones alimentarias. Para ello, se realizó un diagnóstico inicial con el propósito de identificar los medios de comunicación más utilizados y las necesidades de información en la academia, sentando las bases para diseñar estrategias efectivas de comunicación que fomenten hábitos alimentarios saludables.

Método: estudio descriptivo y explicativo con enfoque mixto. La muestra incluyó 50 participantes, de los cuales 32 eran deportistas y 18 empleados. Se utilizaron entrevistas semiestructuradas con entrenadores, personal administrativo y del servicio de alimentos, además de un cuestionario cerrado para los deportistas. El análisis de datos se llevó a cabo con herramientas como Microsoft Excel aplicando una estadística descriptiva.

Resultados: el 97% de los deportistas manifestó interés en recibir información sobre alimentación y nutrición, aunque el 91% afirmó no recibirla por parte de la academia. Los canales digitales como WhatsApp (78%) e Instagram (62,5%) fueron los más utilizados, destacando una preferencia clara por plataformas tecnológicas. Entre las temáticas de mayor interés, sobresalieron la alimentación para el rendimiento deportivo (75%) y la hidratación (65%).

Conclusión: se propone una comunicación estratégica basada en la diversificación de formatos, incluyendo capacitaciones presenciales, contenidos digitales interactivos y alianzas con expertos en nutrición. Estas acciones buscan garantizar que la información llegue de manera efectiva y confiable, contribuyendo al bienestar y al rendimiento deportivo de los tenistas, además de reducir el impacto de la infoxicación en sus decisiones alimentarias.

PALABRAS CLAVES

Educación nutricional; Deporte de alto rendimiento; Hábitos alimentarios; Estrategias comunicativas.

ABSTRACT

Introduction: Tennis players are inundated with contradictory advice that makes it difficult to make informed decisions about nutrition to optimize their performance, therefore, the objective of this study was to propose a strategic communication to promote healthy eating among tennis players.

Method: It had two qualitative and quantitative approaches. Interviews with 18 adult collaborators explored the perception of communication within the academy and the athlete's nutrition, while a survey of 32 adolescent athletes aged 15±7 years, of which 53% were men and 15% women, investigated the communication channels and preferred sources of nutritional information.

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Results: It is highlighted that the academy does not provide enough information about nutrition, evidencing a need for tennis players. 59% use social networks or other means to obtain nutritional information, while 41% consult health professionals.

Conclusion: It is crucial to adopt a strategic communication that adapts messages to the preferences of athletes to promote healthy eating. This will not only benefit their health and performance, but will also strengthen the comprehensive management of the academy and its relationship with the cultural, social and political environment.

KEY WORDS

Nutrition education; High-performance sport; Eating habits; Communication strategies.

INTRODUCCIÓN

En la sociedad actual, la alimentación saludable se ha convertido en un tema de gran relevancia y preocupación, especialmente en el ámbito deportivo. Los tenistas de campo, al igual que otros deportistas, están expuestos a un sinfín de información contradictoria sobre nutrición a través de diversas fuentes, como youtubers y personas sin conocimientos especializados. Esta problemática adquiere aún más importancia en el contexto de la salud pública y en relación con el tercer Objetivo de Desarrollo Sostenible de las Naciones Unidas (ODS 3), que tiene como objetivo "Garantizar una vida sana y promover el bienestar para todos en todas las edades".

Es fundamental reconocer el poder de los medios de comunicación como actores claves en la promoción de la salud, ya que difunden información a nivel mundial. En Colombia, el uso del internet es ampliamente extendido, con un 94% de la población entre 16 y 64 años utilizando esta herramienta, siendo YouTube y Facebook las redes sociales más usadas, seguidas de WhatsApp e Instagram[1].

Sin embargo, estas plataformas pueden tanto fomentar hábitos positivos como perpetuar conductas perjudiciales. Por ejemplo, Rosado et al.[2] identificaron que el uso frecuente de redes sociales está asociado con la promoción de estilos de vida saludables y la difusión de información nutricional, aunque también subrayaron los riesgos de información no confiable. Lamentablemente, se ha observado que estos medios de comunicación pueden desinformar, manipular, persuadir y convencer a grandes grupos de personas al difundir hechos engañosos o fuentes no verídicas. Esto puede llevar a una desinformación perjudicial y, en algunos casos, a trastornos de la alimentación.

En el artículo 'Medios de Comunicación: una potente influencia', publicado por López[3], se menciona: "Para nuestros jóvenes los medios de comunicación transmiten repetidamente mensajes no saludables en relación con el ideal de belleza, la figura corporal y la alimentación. Este tipo de mensajes ejercen una influencia negativa y perjudicial en los niños y en los adolescentes, que cada vez pasan un mayor número de horas expuestos a los medios de comunicación" (p. 178).

Otro aspecto crítico es el impacto de la publicidad en los hábitos alimentarios de poblaciones vulnerables. Soto y Martín[4] exploraron la influencia de la publicidad alimentaria en la obesidad infantil, destacando cómo los mensajes publicitarios pueden contribuir al consumo de alimentos ultraprocesados y a la adopción de hábitos poco saludables, especialmente entre los adolescentes. Esta situación pone de manifiesto la necesidad de intervenciones educativas y regulaciones más estrictas en torno a los mensajes nutricionales difundidos a través de los medios de comunicación.

Para abordar esta problemática y alinearse con el ODS 3 de la ONU, se propuso implementar una comunicación estratégica que promueva la alimentación saludable entre los tenistas de campo. El enfoque central de esta propuesta es brindarles información precisa y confiable sobre nutrición, evitando la influencia negativa de fuentes no cualificadas. Al proporcionarles información precisa y fundamentada, se capacita a los deportistas para tomar decisiones conscientes y saludables en relación con su alimentación, lo que no solo beneficia su bienestar personal, sino que también contribuye a la promoción de la salud pública al prevenir enfermedades relacionadas con la alimentación.

Por todo lo anterior, la comunicación estratégica desempeña un papel crucial al proporcionar a los tenistas de campo y a su entorno cercano una base sólida de conocimientos sobre una alimentación equilibrada y adecuada para su desempeño deportivo y bienestar en general.

Es importante destacar que los profesionales de la salud tienen la responsabilidad de promover diferentes aspectos que contribuyan a un estilo de vida saludable, siendo la alimentación uno de los aspectos más relevantes.

Por otro lado, y, de acuerdo con el Lineamiento Nacional de Educación Alimentaria Para Colombia[5], la nutrición es considerada como la promotora de una buena salud. Una buena nutrición es esencial no solo en la prevención de enfermedades de privación o déficit sino también de enfermedades crónicas por exceso de determinados nutrientes.

Teniendo en cuenta lo planteado, es oportuno recopilar información acerca de las percepciones y necesidades en comunicación en temas de alimentación de los deportistas tenistas, a fin de diseñar estrategias y acciones que permitan brindarles las herramientas necesarias para tomar decisiones correctas sobre su alimentación y preservar su bienestar en el ámbito deportivo.

MÉTODO

Se llevó a cabo un estudio descriptivo, explicativo y correlacional con enfoque mixto, utilizando una muestra de

50 participantes de una academia de tenis de campo durante los meses de enero y febrero del 2023. Esta muestra incluyó 32 deportistas, con edades comprendidas entre los 8 y 22 años, y 18 adultos empleados de la academia. Todos los participantes debían tener una vinculación mínima de 6 meses con la institución y la voluntad de participar en el estudio a través del diligenciamiento y firma del consentimiento informado.

Se utilizó un muestreo no probabilístico por conveniencia, determinado por las investigadoras. Inicialmente, se realizó un diagnóstico para identificar las fuentes de obtención de información sobre nutrición y los medios más utilizados. La recolección de datos se llevó a cabo mediante el uso de un cuestionario y 2 entrevistas semiestructuradas. Posteriormente, se desarrolló una propuesta destinada a promover una alimentación saludable entre los deportistas.

Diagnóstico inicial

Se realizaron entrevistas a los 18 empleados de la academia, los cuales fueron divididos en dos grupos: personal administrativo y entrenadores (13 participantes) y personal de servicio de alimentos (5 participantes).

Al personal administrativo y entrenadores se aplicó una entrevista de 9 preguntas abiertas (ver tabla 1) diseñadas para explorar el conocimiento sobre las formas, canales y temáticas de comunicación implementadas en el escenario deportivo. Adicionalmente, se indagó sobre las necesidades de comunicación en temas relacionados con alimentación saludable.

Por otra parte, a 5 empleados del servicio de alimentos dado su rol clave en la interacción directa con los deportistas y en la oferta alimentaria, se les realizó una entrevista compuesta por 8 preguntas (ver tabla 2). Esta tuvo como propó-

Tabla 1. Preguntas de la entrevista al personal administrativo y entrenadores

1. ¿La academia de tenis qué medios de comunicación utiliza para impartir información con sus usuarios?
2. ¿Cuáles son los medios de comunicación preferidos por los usuarios?
3. ¿Generalmente qué tipo de información se comunica?
4. ¿Se comparten temas de alimentación saludable?
5. De acuerdo con lo anterior ¿Qué tipo de información comparten en alimentación y nutrición?
6. ¿Considera relevante que se comuniquen temas de alimentación saludable y por qué?
7. ¿Qué temas en alimentación y nutrición considera que hace falta comunicar?
8. ¿Cuáles son los medios de comunicación a través de los cuales usted considera se debería transmitir información en temas de alimentación y nutrición?
9. ¿Con qué periodicidad considera usted se debería transmitir información en temas de nutrición a los usuarios?

Fuente: Elaboración propia.

Tabla 2. Preguntas de la entrevista al personal del servicio de alimentos

1. ¿Qué opina usted acerca de los alimentos y menú ofrecidos por la cafetería?
2. ¿Quiénes son los principales usuarios de la cafetería?
3. ¿Cuáles son los alimentos de mayor preferencia por los usuarios?
4. ¿Cómo se socializa a los usuarios los menús ofertados en el día?
5. ¿Cree usted que los usuarios hacen elecciones saludables de los alimentos a consumir?
6. ¿Considera usted que la academia realiza estrategias comunicativas para crear hábitos de alimentación saludable?
7. ¿En la cafetería ofrecen menús especiales para los deportistas?
8. ¿Qué sugerencia o comentario quisiera dar para que los usuarios prefieran menús saludables?

Fuente: Elaboración propia.

sito comprender sus percepciones sobre la oferta de alimentos y las decisiones alimentarias de los deportistas.

Por otra parte, se diseñó y aplicó a los 32 deportistas un cuestionario con 11 preguntas cerradas (ver tabla 3). Los criterios de inclusión exigían que los participantes entrenaran un mínimo de dos veces por semana durante al menos seis meses. El objetivo del cuestionario fue recopilar información sobre los canales de comunicación utilizados en la academia y las necesidades comunicación en torno a la alimentación saludable.

Análisis de datos

Los datos recopilados mediante los cuestionarios se organizaron en una hoja de cálculo de Microsoft Excel para su posterior análisis. No se recolectó información personal de los participantes, garantizando la confidencialidad de los datos. Los resultados de la encuesta fueron presentados en frecuencia y porcentaje. Para la presentación de los datos se emplearon tablas.

Cabe destacar que todos los procedimientos de la investigación se llevaron a cabo siguiendo los principios fundamentales de ética vigentes a nivel nacional e internacional; en conformidad con la Resolución 8430 de 1993[6], donde se establecen las disposiciones para realizar investigaciones en salud con participación humana; con la Ley 1581 de 2012[7] y con la Declaración de Helsinki[8], realizada en la Asamblea Médica Mundial.

RESULTADOS

La academia de tenis destaca la relevancia de brindar información veraz y confiable sobre temas de nutrición, reconociendo el impacto positivo que una alimentación adecuada tiene en el rendimiento deportivo. En este contexto, se recopilaron opiniones valiosas desde diversas perspectivas, incluyendo entrenadores, personal administrativo, colaboradores del servicio de alimentos y los propios deportistas.

Entrevista a entrenadores y administrativos

Fue un grupo conformado por 12 hombres y una mujer, cuyas edades oscilaban entre los 25 y los 60 años.

La mayoría de los entrevistados coincidió en que los principales medios de comunicación utilizados por la academia son WhatsApp, destacado por su rapidez y efectividad, seguido de las redes sociales, en particular Instagram, considerada ideal para llegar a los usuarios más jóvenes; y el correo electrónico, empleado como medio secundario para comunicaciones formales. Un entrenador mencionó: "definitivamente WhatsApp e Instagram son los más consultados por nuestros usuarios".

En cuanto al contenido compartido, se enfoca principalmente en actividades deportivas, como fechas de torneos, resultados y programación de entrenamientos. *"Comunicamos bastante, pero el enfoque principal siempre está en la programación de torneos"* (Entrenador del grupo élite).

Sin embargo, todos coincidieron en que no se comparten temas relacionados con la alimentación saludable, identificándose esto como una oportunidad de mejora significativa. El 100% de los entrevistados destacó la importancia de incluir información sobre nutrición, argumentando que estos temas impactan positivamente en el rendimiento y la recuperación de los atletas. Una participante afirmó: *"Los deportistas ne-*

Tabla 3. Preguntas realizadas en el cuestionario a los deportistas

1. ¿Qué canales de comunicación utiliza con mayor frecuencia? (puede seleccionar más de una respuesta)
2. ¿Conoce los canales de comunicación que tiene el Club de Tenis?
3. Si su respuesta anterior fue Sí, por favor indique ¿cuáles?
4. ¿Qué tipo de información recibe usted a través de los canales de comunicación del Club de Tenis?
5. ¿Considera usted que debería recibir información relevante que pueda favorecer el rendimiento deportivo?
6. ¿Actualmente recibe usted información en temas de alimentación y nutrición por parte del Club de Tenis?
7. Cuándo requiere información nutricional y de alimentación ¿Qué tipo de canales usted consulta?
8. ¿Cómo le gustaría informarse acerca de temas de alimentación y nutrición?
9. ¿De qué forma le gustaría visualizar esta información? (puede seleccionar varias respuestas)
10. ¿Con qué frecuencia le gustaría recibir información?
11. ¿Qué temas le gustaría recibir? (puede seleccionar más de una respuesta)

Fuente: Elaboración propia.

cesitan una guía seria, ya que enfrentan mucha desinformación en redes sociales".

Entre las temáticas prioritarias mencionaron la hidratación adecuada, el uso de suplementos y las dietas específicas según las etapas de entrenamiento, reforzando la idea de que como entidad formadora en deporte, es responsabilidad de la academia abordar estas áreas. Respecto a la frecuencia de comunicación, las opiniones oscilaron entre semanal y trimestral, con una inclinación mayoritaria hacia una periodicidad mensual, utilizando medios como WhatsApp, reuniones presenciales, capacitaciones en vivo y material impreso, como folletos, para llegar a los padres y deportistas más jóvenes.

Un entrenador enfatizó: *"Es importante utilizar plataformas accesibles para todos los públicos, pero las capacitaciones presenciales serían el medio más efectivo para lograr un verdadero impacto".* Además, se destacó el rol crucial de los mensajes educativos para influir en las elecciones alimentarias; un entrevistado sugirió: *"Colocar información visible sobre alimentación saludable en lugares estratégicos, como folletos en las cafeterías, podría ser una buena iniciativa".* Los entrenadores también señalaron la importancia de recibir formación en nutrición, indicando que su inclusión en estos procesos beneficiaría tanto al equipo como a los deportistas, uno de ellos afirmó: *"Nosotros como entrenadores también necesitamos aprender más sobre nutrición. Sería beneficioso para todos"*. En conjunto, las opiniones recogidas reflejan la necesidad de fortalecer la comunicación en temas de alimentación saludable, implementar estrategias efectivas y capacitar a todos los involucrados para maximizar el impacto positivo en la comunidad deportiva.

Entrevista al personal del servicio de alimentos

Las entrevistas se realizaron a 5 mujeres con edades comprendidas entre los 20 y los 50 años. En general, las entrevistadas consideran que la oferta alimentaria en las cafeterías del club es variada y, en términos generales, saludable, ya que incluye frutas, ensaladas de frutas, agua y bebidas hidratantes *"Es una oferta sana, ofrecemos frutas y ensaladas de frutas, sin embargo, en las mañanas ofrecemos fritos y los deportistas comen de todo"* administradora del servicio. Otro entrevistado menciona *"La oferta de alimentos tiene una visión de saludable, bajo en sal, y diariamente en el menú del día hay variedad".*

Por su parte, la gerente de una de las cafeterías indicó: *"Los alimentos ofrecidos son los mejores. La empresa siempre ha tenido la idea de comida saludable y así lo ha venido haciendo, sin embargo, tuvo que cambiar un poco porque los socios tienen gustos diferentes; algunos prefieren fritos, salsas y los deportistas también solicitan con frecuencia frituras".*

Así mismo, las entrevistadas identificaron como principales usuarios de las cafeterías a los deportistas, sus padres o acompañantes y, en menor medida, a los empleados del área administrativa. Mencionaron que las preferencias alimentarias varían según el horario y las opciones disponibles en cada cafetería. Durante el almuerzo, se destacan los menús del día, mientras que en la tarde predominan los jugos, batidos, frutas y bebidas para la hidratación. La interacción entre los empleados y los usuarios también influye en las elecciones alimentarias, como explicó un entrevistado de la cafetería auxiliar: *"Se le explica al usuario lo que hay y se ofrece la carta, muchas veces escoge no lo que ve en la vitrina sino lo que le es ofrecido",* evidenciando un proceso comunicativo clave en las decisiones de consumo.

Aunque los entrevistados coinciden en que las elecciones alimentarias suelen ser saludables, con la inclusión de carnes, frutas y ensaladas, también identificaron un alto consumo de dulces, especialmente entre los jóvenes: *"Considero que el 50% sí hace elecciones saludables porque otros eligen frituras y dulces; muchos piden proteína (carnes), ensalada y jugo sin azúcar".*

En cuanto a la promoción de hábitos de alimentación saludable, el 100% de los entrevistados indicó que no existen estrategias comunicativas que incentiven estos hábitos, lo que representa una importante oportunidad de mejora. Aunque no se ofrece un menú especial de forma regular, en eventos deportivos sí se brinda una oferta diferenciada, como arroz, pollo, carnes, parfaits, pastas y ensaladas. Un entrevistado señaló: *"En los eventos deportivos se ofrece una variedad de opciones específicas para los deportistas".*

Finalmente, los entrevistados resaltaron la importancia de la educación y la comunicación para influir positivamente en las elecciones alimentarias. Dos de ellos sugirieron la necesidad de más información sobre aspectos de nutrición y alimentación saludable *"Quizás que bajen el consumo de dulces a través de mensajes educativos, se podría influir bastante"*, *"Colocar información visible sobre alimentación saludable, como panfletos y folletos, sería una buena iniciativa".* Estas observaciones destacan la necesidad de integrar estrategias educativas y comunicativas que fomenten elecciones saludables, tanto en los menús como en la formación de los usuarios y colaboradores.

Encuesta a deportistas

Se encuestó un total de 32 deportistas, de los cuales el 53% eran hombres y el 47% mujeres. En términos de nivel socioeconómico, el 78% de los participantes pertenecía a los estratos 5 y 6, mientras que el 22% correspondía a los estratos 3 y 4.

El análisis de los medios de comunicación revela una clara preferencia por los canales digitales, con WhatsApp liderando con un 78%, seguido por redes sociales como Instagram, con un 62,5%. La baja utilización de medios tradicionales destaca un cambio significativo en las formas de comunicación, especialmente en poblaciones jóvenes o tecnológicamente conectadas, lo que resalta la importancia de adaptar

las estrategias a estas preferencias. Por otro lado, aunque los deportistas muestran un notable interés por temas de nutrición, la academia no está comunicando activamente este tipo de información. Ante esta carencia, los atletas señalaron que buscan información principalmente en redes sociales (44%) y consultan a profesionales de la salud (41%). En la Tabla 4 se presenta un resumen detallado de los resultados obtenidos en la encuesta.

Tabla 4. Uso de medios de comunicación utilizados por deportistas

Variable		N°	%
¿Qué canales de comunicación utiliza con mayor frecuencia? (puede seleccionar más de una respuesta)	WhatsApp	25	78,1
	Instagram	20	62,5
	Facebook	4	12,5
	Twitter	4	12,5
	Tik Tok	8	18,8
	Email	14	13,8
	Tv, radio y otros	3	9,4
¿Conoce los canales de comunicación que tiene el Club de Tenis?	Si	23	71,9
	No	9	28,1
Si su respuesta anterior fue Sí, por favor indique ¿cuáles?	WhatsApp	16	50
	Instagram	13	40
	Facebook	2	5
	Email	1	5
¿Qué tipo de información recibe usted a través de los canales de comunicación del Club de Tenis?	Fechas y torneos	17	53
	Horarios de entreno	8	25
	Información general	6	19
	Educación y capacitaciones	1	3
¿Considera usted que debería recibir información relevante que pueda favorecer el rendimiento deportivo?	Si	31	97
	No	1	3
¿Actualmente recibe usted información en temas de alimentación y nutrición por parte del Club de Tenis?	Si	3	9
	No	29	91
Cuándo requiere información nutricional y de alimentación ¿Qué tipo de canales usted consulta?	Redes sociales	14	44
	Profesional de la salud	13	41
	Coach	2	6
	Blog	2	6
	No me interesa	1	3

Fuente: Elaboración propia.

Tabla 4 continuación. Uso de medios de comunicación utilizados por deportistas

Variable		N°	%
¿Cómo le gustaría informarse acerca de temas de alimentación y nutrición? (puede seleccionar más de una respuesta)	Email	17	53
	Redes sociales	26	81
	Capacitaciones presenciales	17	53
	Material Impreso	8	25
	Videos: Youtube	3	9
	Otros: blog, en vivos, etc.	4	12,5
¿De qué forma le gustaría visualizar esta información? (puede seleccionar varias respuestas)	Reels y videos	19	59
	Capacitaciones presenciales	19	59
	Material impreso: boletines, cartelera, periódico	16	50
	Material digital: poster, infografías	14	44
	Podcast	7	22
	En vivo con expertos	13	41
¿Con qué frecuencia le gustaría recibir información?	Mensual	16	50
	Semanal	14	44
	Trimestral	1	3
	Semestral	1	3
¿Qué temas le gustaría recibir? (puede seleccionar más de una respuesta)	Alimentación saludable	24	75
	Alimentación antes, durante y después para un evento deportivo	24	75
	Hidratación en el deporte	21	65
	Suplementación deportiva	12	37

Fuente: Elaboración propia.

Propuesta para la promoción de la alimentación saludable mediante una Comunicación Estratégica.

Los resultados anteriores subrayan la necesidad de diseñar estrategias de comunicación alineadas con estos canales para maximizar la efectividad del alcance y la interacción con los deportistas, especialmente en temas clave como el rendimiento deportivo y la educación nutricional. Estos hallazgos indican que, para conectar eficientemente con esta población, las instituciones deben priorizar el uso de herramientas tecnológicas dinámicas y accesibles. En este sentido, es importante entender la comunicación estratégica como una herramienta integral que favorece la gestión global de la academia. Según Tironi y Cavallo[9], puede convertirse en un vínculo de la organización con su entorno cultural, social y político en una relación armoniosa y positiva desde el punto de vista de sus intereses u objetivos.

En cuanto a los mensajes o contenidos que se tenga planificado publicar, es importante que sean sencillos, claro y atractivos, utilizando un lenguaje no técnico que facilite su comprensión y amplíe su alcance. Un ejemplo relevante de esto es el trabajo realizado por Landaeta-Jiménez et al.[10], en el artículo 'Campaña de educación nutricional contra la malnutrición por medios de comunicación masivos en Venezuela' que trataron temas relacionados con problemas de nutrición utilizando la televisión y algunos impresos.

Para el desarrollo de la propuesta de comunicación estratégica, se proponen cuatro estrategias, con sus tácticas y duración que se describen en la Tabla 5.

El plan propuesto pretende optimizar todos los canales de comunicación actuales del Club de Tenis, y al mismo tiempo, replicar los temas de alimentación saludable de forma periódica y didáctica, lo que permitirá que la información llegue de manera asertiva a todos los públicos objetivos. Es importante establecer una interconectividad entre los medios, de modo que la misma información sea replicada de acuerdo con una periodicidad establecida. Además, se deben realizar evaluaciones periódicas y encuestas de satisfacción para valorar el impacto de la propuesta y realizar los ajustes necesarios.

Para lograr esto, es fundamental contar con un seguimiento para monitorear los factores que impactan de manera positiva o negativa la propuesta de comunicación estratégica para la promoción de la alimentación saludable y hacer las mejoras que sean necesarias, esto a futuro puede determinar los canales que tienen mayor potencial y valor para la academia.

DISCUSIÓN

La promoción de la alimentación saludable es un tema de vital importancia en el deporte, especialmente durante la etapa de la adolescencia, debido a los mayores requerimientos nutricionales asociados al crecimiento y desarrollo. Existe una preocupación compartida por parte de padres, entrenadores y deportistas tenistas en relación a una alimentación que favorezca un óptimo estado de salud y contribuya al rendimiento deportivo, es claro que la alimentación desempeña un papel fundamental, debido a que, el consumo de alimentos repercute directamente en el rendimiento deportivo, siendo esta quien ayude a procesos físicos de asimilación de la carga de entrenamiento y a la recuperación después de las largas jornadas de entrenamiento o competencias[11]. Además, según Rosado Álvarez y colaboradores, los deportistas jóvenes tienden a buscar información sobre nutrición principalmente en redes sociales lo que sugiere un riesgo de exposición a fuentes poco confiables y con objetivos comerciales[2].

En esta etapa de la vida, se ha evidenciado el riesgo de desencadenar algún trastorno alimenticio asociados a la actividad física, y con mayor razón cuando su único objetivo es conseguir una imagen que se adapte más a las exigencias sociales y culturales[12].

Según Behar[13], los grupos de riesgo incluyen estudiantes, adolescentes con sobrepeso, embarazadas, deportistas. El perfil predominante de los trastornos de la conducta alimentaria (TCA) se caracteriza por una alta motivación por la delgadez, perfeccionismo e insatisfacción corporal y baja conciencia interoceptiva. Además, la identificación con el estereotipo de rol de género femenino se ha asociado significativamente con los TCA en un 42,9%, especialmente la anorexia restrictiva, lo cual se considera un factor de riesgo para su desarrollo. Esto coincide con los hallazgos de Soto Núñez y Martín Salinas, quienes evidenciaron cómo los medios digitales, especialmente la publicidad alimentaria en redes sociales, fomentan el consumo de productos poco saludables y promueven estereotipos que contribuyen a trastornos alimentarios en niños y jóvenes[4].

Tabla 5. Estrategias, Tácticas y Acciones para la promoción de una alimentación saludable para la academia de tenis

Estrategia	Tácticas	Duración
Reorganizar y mejorar las formas de comunicación actual	*Crear plantillas institucionales diferenciadoras del contenido o formato a publicar	1 vez en el primer mes
Desarrollo de contenidos educativos atractivos	*Crear videos cortos y dinámicos con consejos prácticos sobre alimentación. *Diseñar infografías y gráficos informativos *Publicar artículos y blogs	Implementación continua una vez a la semana
Uso de redes sociales e interacción en tiempo real	*Crear contenido en vivo en Instagram, donde expertos en nutrición deportiva respondan preguntas y brinden consejos. *Realizar sesiones de preguntas y respuestas en redes sociales. *Compartir testimonios y casos de éxito	Implementación continua una vez al mes
Alianzas con profesionales de la salud y expertos en nutrición	*Invitar a expertos en nutrición para brindar charlas informativas. *Asesoramiento nutricional	Semestral. Establecer alianzas a largo plazo para una colaboración continua

Fuente: Elaboración propia.

Entre los factores de riesgo para la aparición de trastornos alimentarios se encuentran los intentos de perder peso, a menudo recomendados por entrenadores, amigos o familiares. Sin embargo, el problema radica en las fuentes de información utilizadas para tal fin, que suelen ser internet. Esto está relacionado con lo mencionado por el DANE[14], al mencionar que, según información del Ministerio de Educación, los jóvenes son los que más usan Internet 84,1% y el principal uso que se da del internet es para las redes sociales 82,3% seguido de comunicaciones instantáneas. En estos medios digitales se pueden encontrar información no verídica y carente de respaldo científico, promovida por personas no cualificadas que buscan fines comerciales, lo cual puede ser perjudicial para la salud. Este fenómeno también fue destacado por Ortiz Romaní y colaboradores, quienes mencionan que un estilo de vida saludable está significativamente influenciado por factores sociales, culturales y educativos, como el acceso a información adecuada y la interacción con profesionales de la salud[15].

Es así como los trastornos alimentarios se incrementan entre los adolescentes y jóvenes, quienes asocian la delgadez con el éxito y la belleza. Los movimientos en las redes sociales y el papel de los influencers han contribuido a que estos trastornos tengan un mayor impacto en estas dos poblaciones vulnerables. Existe una gran cantidad de mensajes y publicidades que fomentan la restricción alimentaria y las dietas. Además, el contexto de la pandemia ha tenido un efecto negativo al aumentar los síntomas asociados con los trastornos alimentarios[16].

En este sentido, los resultados obtenidos en las entrevistas y encuestas realizadas a personal de la Academia de Tenis evidencian la necesidad de implementar un plan de comunicación estratégica que se enfoque en brindar información relevante sobre alimentación y nutrición a los deportistas. Es importante reconocer que la comunicación estratégica no solo implica establecer canales de comunicación, sino adaptarlos a las preferencias y necesidades de los deportistas. Según los resultados, los deportistas prefieren utilizar WhatsApp y redes sociales, lo cual sugiere que tienen una mayor interacción con los medios digitales o que la organización ha optado por comunicarse a través de estos canales debido a la expansión de internet y al acceso en tiempo real a la información. Además, la pandemia de COVID-19 ha acelerado la conectividad digital[17]; sin embargo, es importante destacar que la comunicación directa y presencial sigue siendo valiosa para los deportistas, especialmente cuando se trata de temas tan relevantes como la alimentación y nutrición.

Para lograr una comunicación efectiva, los mensajes y contenidos deben ser simples, claros y atractivos, utilizando un lenguaje poco técnico. Esto facilitará su aceptación y aumentará su alcance entre los deportistas. Es necesario presentar la información de manera didáctica y periódica, aprovechando diferentes formatos como capacitaciones presenciales, actividades en vivo con expertos, reels y material impreso. La diversificación de los medios y formatos de comunicación garantizará que la información llegue de manera adecuada a los deportistas.

CONCLUSIONES

Se pudo determinar que los deportistas de la academia evidenciaron un interés significativo en recibir información sobre alimentación y nutrición, especialmente en relación con su impacto en el rendimiento deportivo y la recuperación. Sin embargo, el estudio reveló una falta de comunicación activa por parte de la academia en estos temas, lo que ha llevado a los deportistas a buscar información en fuentes externas, principalmente redes sociales y profesionales de la salud. Este contexto plantea una oportunidad clave para que la academia asuma un rol más activo en la educación nutricional, brindando contenidos confiables y científicamente respaldados mediante herramientas tecnológicas y formatos que resuenen con las preferencias de los usuarios.

Para abordar esta necesidad es crucial diversificar las estrategias de comunicación, integrando tanto medios digitales como formatos presenciales, que permitan un alcance efectivo y una interacción significativa con los deportistas. Además, se debe priorizar la capacitación de entrenadores y personal del servicio de alimentos para garantizar una alineación en los mensajes comunicados, convirtiéndolos en agentes activos de cambio hacia la adopción de hábitos alimentarios saludables. La implementación de evaluaciones periódicas asegurará la efectividad de estas estrategias, permitiendo ajustes que optimicen su impacto a largo plazo.

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Adherence to the Mediterranean diet and frequency of food consumption in high school students in Valencia – Spain

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ABSTRACT

Introduction: Adolescence represents a crucial developmental stage for addressing and modifying eating patterns that may contribute to the prevalence of overweight and obesity.

Objective: The aim of this research was to assess adherence to the Mediterranean diet (AMD) and the frequency of food consumption among secondary school adolescents in Valencia.

Method: The PREDIMED questionnaire was utilized to evaluate AMD, in conjunction with a food consumption frequency questionnaire administered to a cohort of 166 students aged 12 to 17 years.

Results: The primary findings of the study reveal that AMD is unrelated to weight or sex, with a higher percentage of normal-weight adolescents exhibiting high AMD. Conversely, there are instances of overweight students with high AMD and obese students with low AMD. The high AMD cohort tends to consume fruits and vegetables only 0 to 2 days a week, while dairy products are consumed 6 to 7 times a week. In contrast, the low AMD group consumes nuts, legumes, fruits, and vegetables 3 to 5 times a week. Both groups demonstrate a low daily intake of foods high in sugar and fat, along with a similar consumption frequency of cereals, starch, and tubers, with a higher representation of 3-5 times per week.

Conclusion: The findings suggest that a high AMD does not necessarily correlate with good health. Other variables, such as dietary food frequency, play a significant role in determining weight for age. Similarly, a low AMD in conjunction with a diet rich in healthy foods can contribute to good health in students.

KEYWORDS

Adolescent Nutrition, food habits, dietary patterns, health promotion, balanced diet, diet quality, lifestyle, school health, public health

INTRODUCTION

Malnutrition, in its diverse forms, presents a substantial global public health challenge. Presently, there is a dual burden of malnutrition, encompassing undernutrition and overweight, particularly prevalent in low- and middle-income countries[1]. Inappropriate dietary practices are contributing to the escalation of overweight and obesity, which have significantly increased over the past four decades compared to undernutrition. In 2016, a significant global issue emerged as more than 340 million children and adolescents were affected by excess malnutrition, with a prevalence of 18-19% in adolescent girls and boys respectively. This issue intensified by 2022, with over 390 million children and adolescents aged 5-19 years experiencing overweight, of whom 160 million were obese[2]. In Europe, individuals aged 11-15 exhibited overweight and obesity rates ranging from 11-33% and 10-23% respectively, with the highest prevalence observed in Mediterranean countries[3].

The ALADINO study, which stands for Surveillance of Nutrition, Physical Activity, Child Development, and Obesity in

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Spain, has revealed that over 30% of children and young people are overweight or obese, with boys being the most affected[4]. The 2016 Valencian Community Health Survey shows that the rate of overweight and obesity among children aged 2-17 has decreased compared to the 2010 survey, with 11.5% and 16.3% being overweight, and 9.3% and 12% being obese[5]. However, despite this reduction, overweight and obesity continue to pose a significant public health challenge in 2022, affecting 30% of children and adolescents, with a higher prevalence in boys than in girls. In the context of adolescent health, while gender differences in overweight do not yield significant disparities, this is not the case with obesity, where boys exhibit a higher incidence compared to girls. Moreover, it is observed that excess weight carries a more pronounced negative social impact among individuals from underprivileged social backgrounds and those with lower educational attainment[6]. Hence, it is imperative to prioritize nutrition, followed by physical activity, to mitigate the rising rates of overweight and obesity among adolescents in specific national contexts.

In childhood and adolescence, the presence of poor habits, unhealthy lifestyle choices, and a high body mass index may contribute to adverse alterations in metabolism and physiology, potentially resulting in endocrine disorders associated with childhood obesity[7]. Dyslipidemia emerges as a significant indicator in this demographic, amplifying the susceptibility to cardiovascular diseases in adulthood, a major contributor to global mortality rates. In addition to physical health implications, excessive weight can precipitate psychological and social challenges, including anxiety, depression, and the potential onset of eating disorders[8]. The perception of body weight has been found to correlate with low self-esteem, dissatisfaction with body image, increased likelihood of binge eating, and heightened risk of anxiety and depression. In children and adolescents, this perception is associated with overweight or obesity, thereby amplifying the susceptibility to chronic diseases[9]. Addressing overweight in children and young people is essential to prevent the development of chronic diseases. It is estimated that targeting this issue could potentially reduce up to 80% of cases of coronary heart disease and 90% of type 2 diabetes. Additionally, these measures have the potential to prevent approximately 30% of cases of certain cancers[10].

The Mediterranean dietary pattern has been widely acknowledged as one of the healthiest eating patterns globally. Research indicates that this diet is abundant in fiber, antioxidants, and mono- and polyunsaturated fatty acids, while being low in trans-fatty acids and sugary products. This not only promotes healthy weight maintenance but also decreases the risk of cardiovascular and hypertension disease, subsequently leading to reduced mortality[11]. Moreover, some studies propose that the Mediterranean diet may serve as a protective factor for overall mental health[12].

When considering the well-being of children and adolescents, it is crucial to acknowledge their limited autonomy in shaping their lives, including their dietary choices. These decisions, with far-reaching implications for their future, are often influenced by parents, caregivers, community leaders, government authorities, obesogenic environments, influential international corporations, and business leaders pursuing commercial interests[13]. This situation gives rise to significant inquiries concerning the essential health policies and strategies required to effectively address this issue. Since the early 2000s, numerous strategies have been implemented globally. These include the World Health Organization's Global Strategy on Diet, Physical Activity and Health, the European Food and Nutrition Action Plan 2015-2020 in Europe, and in Spain, the NAOS strategy (Strategy for Nutrition, Physical Activity and Obesity Prevention) since 2015[14]. The objective of these strategies is to foster healthy eating, promote physical activity, and prevent obesity in the populace. Furthermore, this initiative aims to improve key metrics such as fruit and vegetable consumption, obesity prevalence, and levels of physical activity. It also engages in collaborative efforts with the food industry and promotes healthy behaviors within environments such as schools and workplaces.

METHODS

The current study utilized a quantitative approach with an observational-descriptive methodology and a cross-sectional design, involving data collection at a specific point in time, without intentional intervention or manipulation of the study variables.

Sample

The research was conducted with a sample of 166 participants selected using non-probability purposive sampling from two schools in Valencia, Spain. The participants were chosen based on availability as provided by the authorities of the educational institutions. At the first school, questionnaires were administered to students in the 1st to 3rd year of ESO (Compulsory Secondary Education), while at the second school, students in the 1st and 2nd year of Baccalaureate were included. The questionnaires were developed for the purpose of assessing adherence to the Mediterranean diet (AMD). Additionally, participants were required to visit the Hospital Universitario y Politécnico La Fe in order to undergo measurement of their anthropometric data, encompassing weight, height, and body mass index. For the interpretation of anthropometric data, we used the World Health Organization's Z-score for child growth patterns based on BMI-for-age. The classifications are as follows: between 1 and - 1 (Normal weight), >1 or 2 (Overweight), >3 (Obesity), -2 (Acute malnutrition), -3 (Chronic malnutrition). Data collection was conducted by healthcare staff in the educational centers. The database created from this data collection was utilized for the research. Prior to participation, both the participants and their

legal representatives were duly informed about the studies objectives and provided their consent by signing an informed consent form prior to their involvement.

Adherence to the Mediterranean diet

To evaluate adherence to the Mediterranean diet, we employed the validated PREDIMED - prevention with Mediterranean diet-[15] and Food Consumption Frequency questionnaires[16]. The PREDIMED questionnaire, comprising 14 questions, is utilized to assess adherence to this dietary pattern by examining the consumption of foods characteristic of the diet. This includes high intakes of olive oil, vegetables, pulses, fish, nuts, white meat, and the use of sofrito (a mixture of onion, tomato, garlic, and leek cooked with olive oil). Additionally, it takes into account moderate consumption of red meat, processed meat, butter, margarine, cream, sugary drinks, wine, and non-homemade pastries. A score of 9 or above on this instrument indicates strong adherence to the Mediterranean diet. Owing to the reliability of its results, this tool has been extensively utilized in research[17,18]. The Food Consumption Frequency Questionnaire is composed of 45 items that inquire about the weekly frequency of consumption of various foods. This instrument enables the assessment of the habitual consumption of different food groups. The analysis of the Mediterranean diet encompassed various food groups, including Cereals, starch, and tubers (such as whole bread, rice, and pasta, and potatoes), Dairy products (including milk, yogurt, and cheese), Nuts (such as different types of nuts), Foods high in sugar or fat (e.g., chocolates, sweets, ice cream, and bakery products), Legumes (encompassing different types of legumes), Meats (encompassing fish, seafood, poultry, and beef), and Vegetables and fruits (encompassing various types of fruits, vegetables, and salads). The Drinks category was excluded from the analysis due to the inclusion of alcoholic beverages, which do not align with the study's focus. Furthermore, the Other Products category was omitted because it encompassed a heterogeneous mix of healthy and unhealthy foods. Nevertheless, questions regarding these categories were incorporated to offer additional context and enrich the discussion. Furthermore, it has been extensively utilized in academic research due to its ease of reproducibility and validity[19-21].

However, one of the main limitations of this study is its observational nature, which may introduce some ambiguity and subjectivity. The accuracy of the responses provided is assumed, but cannot be guaranteed. Therefore, this type of study should be viewed as generating hypotheses that need to be tested in clinical trials.

Statistical Analysis

To analyze the anthropometric data and the results of the Mediterranean diet adherence questionnaire, the study employed descriptive statistics and Pearson's correlation test with a 95% confidence level. The analysis was conducted using SPSS v.25 for Windows (Statistical Package for the Social Sciences; Chicago, Illinois). Data from the PREDIMED questionnaire and the Food Consumption Frequency Questionnaire underwent analysis utilizing R software (version 1.1.456 - 2009-2018 RStudio, Inc.) and the Tidyverse package. Bar charts were generated to visualize the distribution of consumption of various food groups in relation to adherence to the Mediterranean diet, employing the ggplot2 library. Furthermore, to achieve a more comprehensive analysis of factors linked to food consumption, models were fitted using the lme4 package.

Ethical aspects

This study received approval from the Ethics Committee of the University of Valencia under procedure number HI549632894683. The approval confirms that the research adheres to the principles outlined in the Declaration of Helsinki, the Council of Europe Convention on Human Rights, and the current regulations in Spanish legislation regarding biomedical research, personal data protection, and bioethics.

RESULTS

Table 1 presents the analysis of socio-demographic data from a sample of 166 participants, indicating that 44.5% (n=74) were male and 55.4% (n=92) were female, aged between 12 and 17 years. Notably, 68.6% of adolescents, encompassing both genders, demonstrated high AMD, while

Table 1. Adherence to the Mediterranean diet and body mass index

Adherence	High ADM		Low ADM		p.v
	%	n	%	n	
BMI Ranges					0.116
Thinness	0	0	3.8	2	
Underweight	7	8	3.8	2	
Normal weight	71.1	81	69.2	36	
Overweight	14.9	17	9.6	5	
Obesity	7	8	13.5	7	
Sex					0.691
Male	45.6	52	43.3	22	
Female	54.4	62	57.7	30	

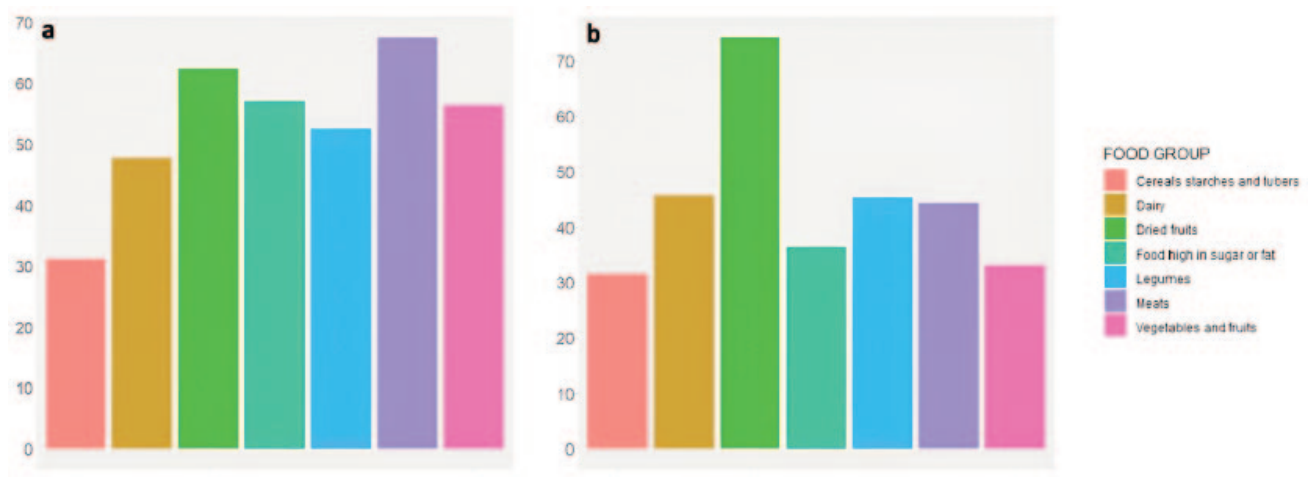
AMD: adherence to the Mediterranean diet. BMI: body mass index. Pearson's correlation test at 95% confidence level. p.v: *p*-value.

31.4% exhibited low adherence. The research findings indicate that there is no statistically significant association between adherence to the Mediterranean diet (AMD) and body mass index (BMI). The data suggests that a majority of individuals, irrespective of their AMD level, maintain a normal weight. Among those with high AMD, 14.9% were found to be overweight, while in the low AMD group, 13.5% were classified as obese. Notably, thinness was not prevalent in either group. Furthermore, the analysis revealed no significant variations in the variables, thus establishing that AMD does not exert an influence on body weight, regardless of gender.

In Figure 1, the depicted data illustrates the dietary habits of individuals with high and low AMD in relation to the consumption frequency (0-2 times per week) of specific food groups. The data reveals that 56.5% of the high AMD group consumes vegetables and fruits only a few times a week, while this figure stands at 33.1% in the low AMD group. Furthermore, the high AMD group exhibits a higher prevalence of consuming other healthy food groups, such as dairy, nuts, legumes, and meats, only 0-2 times per week (47.7 - 67.6 - 57.1 - 52.5%), as compared to the low adherence group (45.8 - 44.4 - 36.4 - 45.4 %). In contrast, the low AMD group (74.3%) consumes unhealthy foods high in sugar or fat only twice per week, whereas the high AMD group (62.5%) also consumes them twice per week. This indicates that the low AMD group consumes a lower quantity of superfluous foods throughout the week. Similarly, the intake of cereal, starch, and tubers demonstrates a comparable pattern, with both groups consuming these foods twice a week (31.2 y 31.5 % for high and low adherence respectively).

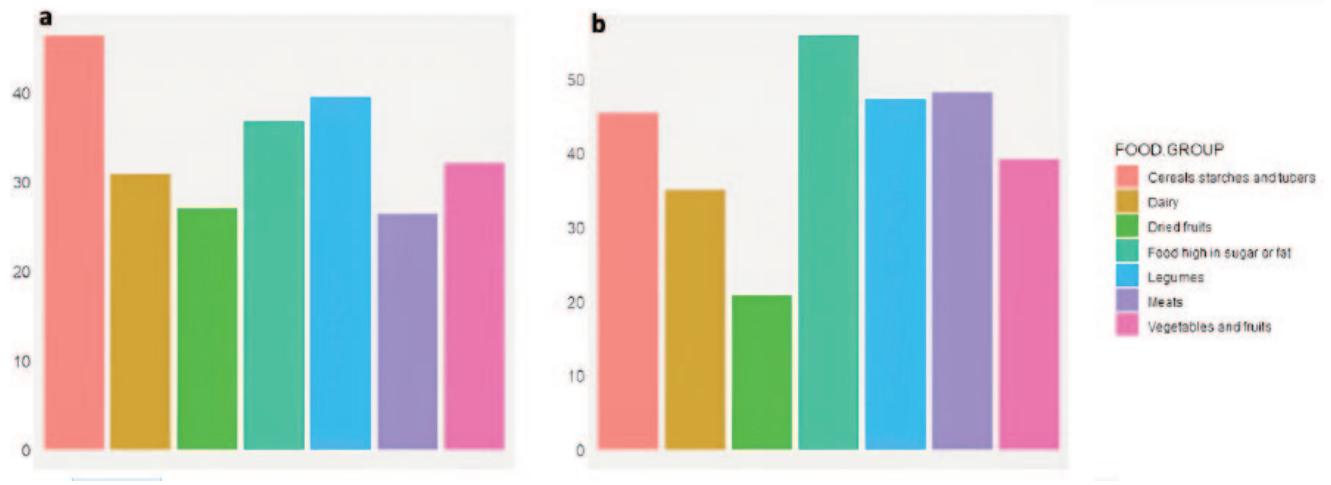
Figure 2 depicts the dietary patterns of individuals with AMD, showcasing their consumption of foods 3 to 5 days per week. The data reveals that adolescents with low adherence to the Mediterranean diet exhibit a higher frequency of consuming nuts (48.2% compared to 26.4% in high adherence) and legumes (55.9% compared to 36.8%) within the 3 to 5 times per week range. Moreover, the consumption of nutritious foods such as dairy, legumes, and vegetables and fruits 3 to 5 times per week is more prevalent in the low AMD group (35.1 - 55.9 - 39.2%) than in the high AMD group AMD (30.9 – 36.8 – 32.1%). In the other hand, the high AMD group (27%) demonstrates a higher frequency of consuming foods high in sugar or fat (3 to 5 times a week) compared to the low AMD group (20.8%). This implies that low AMD adolescents have a lower frequency of consuming unhealthy foods 3 to 5 times a week compared to high AMD adolescents. Additionally, both groups exhibit a similar percentage of intake of cereals, starch, and tubers (46.4 – 45.4% for high and low adherence respectively).

Figure 3 illustrates that both the high and low AMD groups have a higher frequency of food consumption, specifically 6 to 7 times per week. It is noteworthy that the low AMD group exhibits a higher intake of vegetables and fruits per week, constituting 27.7%, in contrast to the high AMD group at 11.4%. Moreover, adolescents with high AMD demonstrate a higher consumption of dairy products 6 to 7 times a week, with percentages of 21.4% and 19.2% for the low adherence group, respectively. Healthy foods such as nuts, legumes, and meats have similar consumption rates in both the low AMD group (7.7 - 7.7 - 7.4%) and the high AMD group (6.1 - 6.1 - 8%). When analyzing the almost daily consumption of differ-



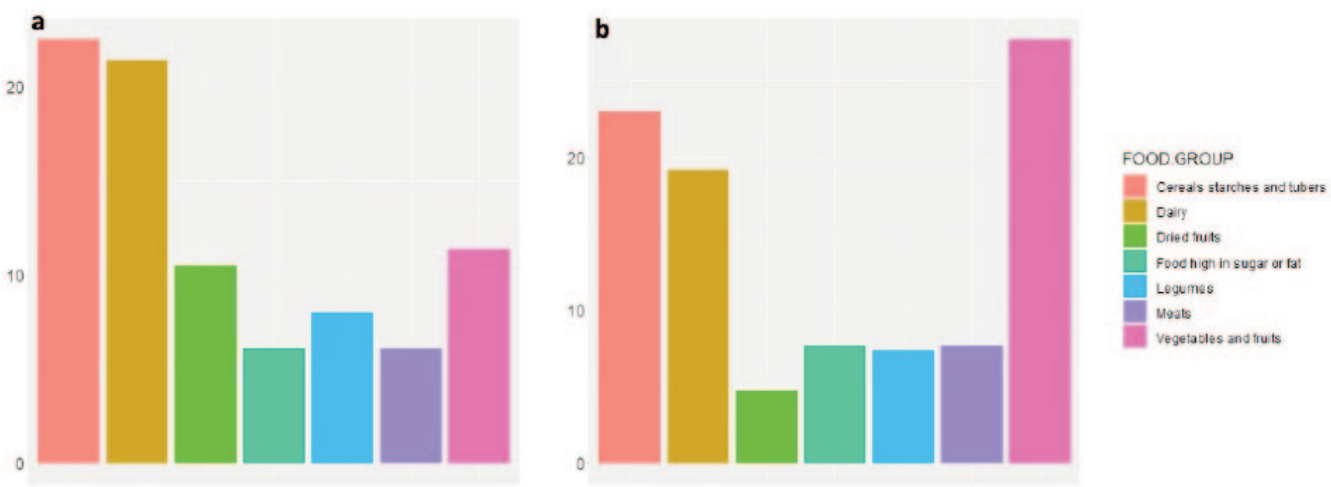
a: Group with high adherence to the Mediterranean diet. **b:** Group with low adherence to the Mediterranean diet. The vertical axis indicates the percentage of adherence to the Mediterranean diet.

Figure 1. Adherence to the Mediterranean diet and frequency of food consumption 0-2 times per week



a: group with high adherence to the Mediterranean diet. **b:** group with low adherence to the Mediterranean diet. The vertical axis indicates the percentage of adherence to the Mediterranean diet.

Figure 2. Adherence to the Mediterranean diet and frequency of food consumption 3-5 times per week



a: group with high adherence to the Mediterranean diet. **b:** group with low adherence to the Mediterranean diet. The vertical axis indicates the percentage of adherence to the Mediterranean diet.

Figure 3. Adherence to the Mediterranean diet and frequency of food consumption 6-7 times per week

ent food groups, there is low consumption of foods high in sugar or fat, with 4.8% for the low adherence group and 10.5% for the high adherence group. Similarly, in the 0 to 2 and 3 to 5 groups, the consumption of cereals, starch, and tubers shows a similar percentage of consumption (22.5 – 23% high and low adherence respectively).

DISCUSSION

The anthropometric data obtained from this study indicates that the majority of adolescents (70%) fall within the normal weight range. This is consistent with findings from diverse regions in Europe, which suggest a decline in the prevalence of overweight and obesity within this demo-

graphic[22]. The ALADINO study further reinforces this trend by demonstrating a reduction in excess weight since 2011, with stabilization observed between 2015 and 2019[23]. Furthermore, the Valencia Health Survey reveals low levels of overweight (less than 20%) and obesity (less than 10%) among adolescents, consistent with the results of our study, which found an average of 10% obesity and 12% overweight in this population[6]. In addition, numerous studies have indicated that overweight tendencies often manifest during childhood and persist into adolescence and adulthood. For instance, Geserick et al. observed that 90% of children with childhood obesity continued to exhibit the condition during adolescence[24]. Furthermore, additional research suggests that a significant proportion of overweight adolescents are predisposed to remain overweight into adulthood, consequently heightening their susceptibility to chronic non-communicable diseases[25].

The findings of this study revealed that 68.6% of adolescents exhibit a high adherence to the Mediterranean diet. Research conducted across several Spanish provinces, including Valencia, demonstrated that the majority of adolescents consistently adhere to this dietary pattern[26]. However, when adherence was analyzed in relation to body mass index, the findings indicated that adolescents with a higher adherence to the Mediterranean diet also had higher prevalence of obesity compared to those with low adherence. The apparent contradiction of this finding in relation to the traditionally associated weight control benefits of the Mediterranean diet may stem from unaccounted factors such as varying levels of physical activity, specific dietary consumption patterns, or disparities in the perception and reporting of food consumption. These results underscore the imperative for further investigations to elucidate the underlying factors contributing to this unexpected association. The influence of the Mediterranean diet on excessive weight has been established, indicating that optimal adherence to this diet may play a crucial role in disease prevention and maintenance of a healthy body weight. However, it should be noted that the Mediterranean diet is not the sole solution for addressing malnutrition[27]. Furthermore, recent research suggests that there is not a significant correlation between this type of diet and body weight[28].

In the context of dietary intake, it is pertinent to highlight that the regular consumption of fruits and vegetables by adolescents who closely adhere to the Mediterranean diet aligns moderately with the stipulated dietary standards. The Mediterranean diet advocates for a daily intake of 2 to 3 servings of fruits and vegetables, whole grains, as well as daily portions of dairy products, nuts, and olive oil, among other components. Furthermore, it recommends a weekly consumption of 3 to 4 servings of fish, 1 to 2 servings of eggs, and 1 serving of non-lean and red meats, with occasional indulgence in sweet food products[29].

The research reveals a marginal 9% variance in the non-adherence to the Mediterranean diet among adolescents, specifically in the consumption of fruits and vegetables. This trend is observed across multiple food categories, including dairy products, starches, cereals, tubers, nuts, and pulses. These results are consistent with the findings of Grams et al. (2022), indicating that Spanish children exhibit adequate intake of fruits, vegetables, fish, and dairy products, irrespective of their adherence to the Mediterranean diet[30].

The consumption of non-essential foods, such as chocolates, biscuits, cakes, and ice cream, is prevalent among adolescents with high adherence to dietary guidelines, often exceeding a frequency of three times a week and occasionally being consumed daily. This dietary behavior runs counter to the principles of the Mediterranean diet and suggests a shift towards a more Westernized dietary pattern. The consumption of these non-essential foods, particularly those classified as ultra-processed, has raised concerns in Spain due to the high sugar content present in over 80% of these products[31]. A meta-analysis has indicated a correlation between free sugars in the diet and their impact on blood pressure and serum lipids[32]. Moreover, adolescents with high adherence to ultra-processed foods tend to consume a greater quantity of beverages, including soft drinks and alcoholic beverages, compared to those with low adherence. It is essential to recognize that these beverages contribute significantly to the intake of empty calories and free sugars within this food category.

Based on the data presented, it is suggested that although Mediterranean countries exhibit a higher prevalence of overweight, adherents of a Mediterranean diet appear to face a reduced risk of developing coronary heart disease in the future, provided they adhere to the appropriate dietary guidelines[33]. It is important to note that persistent consumption of sugar-rich ultra-processed foods, as observed in the present study, may lead to additional health complications, even among those following a Mediterranean diet. It is imperative to consider that adolescence plays a pivotal role in shaping and modifying changes in both personality and lifestyle, as these dietary and physical activity patterns tend to persist into adulthood.

CONCLUSIONS

The study underscores a paradox in the adherence to the Mediterranean diet among adolescents. It reveals that while a significant proportion of those with high adherence restrict their consumption of superfluous foods high in sugars and saturated fats, they do not meet the recommended frequency of consumption for essential healthy foods such as fruits, vegetables, legumes, and nuts. This inconsistency suggests that self-reported high adherence does not necessarily correspond to an optimal dietary pattern, potentially contributing to the co-occurrence of overweight and obesity in this demographic. Inadequate consumption frequency of healthy foods may compromise the potential health benefits of the Mediterranean diet

and have adverse effects on the anthropometric indicators of adolescents.

Additionally, it was observed that adolescents with low adherence exhibited, in certain instances, a heightened frequency of consuming specific healthy foods. This raises questions about the reliability of using adherence classification as a predictor of a healthy dietary pattern. This finding underscores the necessity of redefining adherence assessment criteria to encompass not only the diversity of foods consumed, but also the frequency of consumption.

In light of these findings, it is advisable to implement educational and intervention strategies aimed at not only promoting adherence to the Mediterranean diet, but also ensuring an adequate frequency of consumption to maximize its benefits. Further research is imperative to explore the underlying factors contributing to suboptimal consumption frequency in adolescents with high adherence to the Mediterranean diet, with the aim of establishing more precise guidelines to steer this demographic towards a genuinely healthy dietary pattern. These endeavors are crucial for enhancing the long-term health of adolescents and mitigating the onset of chronic diseases in adulthood.

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Prácticas alimentarias maternas y estado nutricional del preescolar en Lima

Maternal feeding practices and nutritional status of preschool children in Lima

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RESUMEN

Objetivo: Determinar la relación entre las prácticas alimentarias maternas y el estado nutricional del preescolar.

Material y métodos: El diseño de la investigación es no experimental, enfoque cuantitativo, observacional, descriptivo y transversal. La muestra estuvo conformada por 117 preescolares de 3 a 4 años y sus respectivas madres. La recolección de datos fue mediante una encuesta que consta de 21 preguntas sobre prácticas alimentarias. Se evaluaron las medidas antropométricas de los preescolares: peso (kg) y talla (m) y además se consideró la edad en años y meses. Se aplicó la prueba estadística prueba exacta de Fisher para relacionar las variables prácticas alimentarias maternas y el estado nutricional del preescolar, con un nivel de significancia de 0,05.

Resultados: El 75% de las madres que realizan prácticas inadecuadas tienen hijos con sobrepeso. También evitan brindar o preparar refrescos y/o bebidas altas en azúcar (35%) y el 46% frituras en la dieta. El 15,4% consumieron frutas y verduras diariamente. Asimismo, existe relación entre las prácticas alimentarias maternas con el estado nutricional (p=0,001), con el peso para la talla (p=0,001), peso para la edad (p=0,006) y no existe relación con la talla para la edad (p=0,173).

Conclusión: Las madres tuvieron prácticas alimentarias inadecuadas, el consumo de frutas y verduras no fueron diarias y pocas veces evitan dar preparaciones como refrescos y/o bebidas altas en azúcar y frituras en la dieta. Es necesario implementar estrategias para mejorar las prácticas alimentarias del consumo de los alimentos variados y de estación en diversas preparaciones nutritivas, mejorar las técnicas culinarias saludables.

PALABRAS CLAVE

Alimentación; Talla; Peso; Preescolares (Fuente: DeCS BIREME).

ABSTRACT

Objective: To determine the relationship between maternal feeding practices and the nutritional status of preschool children.

Material and methods: The research design was non-experimental, quantitative, observational, descriptive and cross-sectional. The sample consisted of 117 preschoolers aged 3 to 4 years and their respective mothers. Data collection was by means of a survey consisting of 21 questions on feeding practices. Anthropometric measurements of weight (kg) and height (m) were taken. Fisher's exact test was applied to relate the variables maternal feeding practices and the nutritional status of the preschooler, with a significance level of 0.05.

Results: Seventy-five percent of mothers who engage in inappropriate practices have overweight children. They also avoid providing or preparing soft drinks and/or drinks high in sugar (35%) and 46% avoid fried foods in their diet. 15.4% consumed fruits and vegetables on a daily basis. Likewise,

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there is a relationship between maternal feeding practices with nutritional status (p=0.001), with weight for height (p=0.001), weight for age (p=0.006) and no relationship with height for age (p=0.173).

Conclusion: Mothers had inadequate feeding practices, the consumption of fruits and vegetables was not daily and they rarely avoid giving preparations such as soft drinks and/or drinks high in sugar and fried foods in the diet. It is necessary to implement strategies to improve dietary practices of consumption of varied and seasonal foods in various nutritious preparations, improve healthy cooking techniques.

KEYWORDS

Feeding; Height; Weight; Preschoolers (Source: DeCS BIREME).

LISTA DE ABREVIATURAS

OMS: Organización Mundial de la Salud.

CENAN: Centro Nacional de Alimentación y Nutrición.

MINSA: Ministerio de Salud.

I.E.P: Institución Educativa Pública.

INTRODUCCIÓN

En la actualidad una adecuada alimentación previene enfermedades a futuro, esta se debe iniciar desde la lactancia, pero muchas personas ignoran que cuando el niño va creciendo, crece simultáneamente la exploración de alimentos; es decir, que al crecer se debe brindar al niño diferentes tipos de alimentos que ayuden en su crecimiento y desarrollo, esto le permitirá adquirir un estilo de vida saludable, mientras tanto su alimentación dependerá de su madre o cuidador.

La madre es quien selecciona los alimentos del niño y debe poseer conocimientos básicos sobre las prácticas alimentarias, ello es importante para una adecuada alimentación y está relacionado con las costumbres, valores, símbolos, referencia sobre alimentos y tipos de preparación alimentaria, al no tener conocimiento previo puede afectar el estado nutricional del niño.

Según la OMS en el año 2016 unos 41 millones de niños menores de 5 años tienen obesidad y sobrepeso, anteriormente era solo una problemática de países de altos recursos, hoy en día dichos trastornos se han incrementado en países de bajos y medianos recursos, una clara muestra de este incremento es África, donde los niños con sobrepeso aumentaron alrededor de un 50% para el año 2000, en el continente asiático para el año 2016 hubo un aumento de la mitad de los niños menores de 5 años con sobrepeso y obesidad[1].

UNICEF[2] evidenció cifras alarmantes de niños menores de cinco años que padecen de una inadecuada ingesta de alimentos y un sistema alimentario que ha estado fracasando durante muchos años, anteriormente en el 2018 en Latinoamérica y en el Caribe fueron 4,8 millones de niños menores de cinco años que empezaron a padecer retraso en la estatura, 0,7 millones presentaron emaciación y unos 4 millones tenía sobrepeso y obesidad[2].

La OMS[3] mencionó que este problema aumenta con el pasar de los años, en el año 2025, se espera minimizar en un 40% la cifra de niños menores de 5 años en todo mundo que experimenta una desaceleración en la altura y evitar que maximicen los niveles de sobrepeso en la infancia[4].

Asimismo, en el Perú el último informe Gerencial SIEN (Sistema de información del Estado Nutricional de niños y gestantes Perú) – HIS 2023 en niños menores de 5 años brindan datos actualizados sobre el estado nutricional, donde se puede observar que la desnutrición, sobrepeso y obesidad sigue siendo un problema de salud pública en el Perú. Para el año 2023 el 15,7% de niños presentan desnutrición crónica, 1,8% presentan desnutrición aguda, 5.6% sobrepeso y el 1,7 obesidad%, estas cifras siguen siendo vigiladas por las cifras alarmantes que a pesar de contar con programas y tener metas no se ve un descenso significativamente progresivo, los factores causales de estos indicadores siguen para el sector urbano la falta de conocimientos y los recursos[5].

UNICEF[6] nos muestra que en los niños y niñas peruanos menores de 5 años se evidencia una malnutrición por exceso de peso de forma frecuente, teniendo un 4.9% en zonas rurales y el doble en áreas urbanas con un 10%, lo cual son considerados como un problema de alto riesgo.

Existe poca evidencia publicada sobre las variables, por ello, el objetivo del estudio fue determinar la relación entre las prácticas alimentarias maternas y el estado nutricional del preescolar.

MÉTODOS

El diseño de la investigación es cuantitativo, correlacional, transversal y fue desarrollado en la I.E.P. Institución Educativa Inicial 670 Paul Poblet, ubicado en el distrito de Pachacamac, Lima, durante el periodo de mayo hasta julio del 2023.

Población y muestra

La población incluye a las madres de familia con sus respectivos hijos preescolares, que son un total de 167 preescolares. El tamaño de muestra fue de 117 madres de familia con hijos en edad preescolar.

Los criterios de inclusión fueron los preescolares que asistieron de manera regular a las clases, madres e hijos que aceptaron participar voluntariamente y las madres que se encargaron de la alimentación del preescolar. Los criterios de exclusión fueron preescolares que presentaron algún tipo de enfermedad o encontrarse en estado de recuperación o tratamiento por al-

guna patología u alguna operación que pueda interferir en una alimentación habitual dentro de la recolección de datos, madres que no firmaron el consentimiento informado.

Variable e Instrumentos

Se empleó el cuestionario sobre prácticas alimentarias maternas[7], se sometió a un juicio de expertos conformados por seis profesionales de nutrición humana quienes revisaron las 21 preguntas con alternativas en escala de Likert (1: nunca, 2: algunas veces, 3: casi siempre y 4: siempre). Los expertos evaluaron el instrumento con una escala dicotómica y con cinco criterios (claridad, coherencia, objetividad, permanencia y relevancia).

Para determinar la validez de contenido se aplicó V–Aiken y se obtuvo un promedio de 0.97, mostrando una validez muy alta por parte de los jueces y la confiabilidad del cuestionario se realizó mediante una prueba piloto conformada por 36 madres, a través del alfa de Cronbach, con un resultado de 0,711 que indica que el instrumento es aceptable y así garantiza la validez del instrumento.

La variable de prácticas alimentarias se categorizó en 2 niveles (adecuado e inadecuado), mediante un proceso de baremación a través del percentil 50. Los valores del baremo fueron: prácticas alimentarias inadecuadas (24-60) y prácticas alimentarias adecuadas (61-96).

Para la variable estado nutricional, se realizó la técnica de antropometría, registrándose el peso (kg) y la talla (cm). La medición del peso y de la talla se dio mediante las indicaciones de la norma técnica de salud para el control del crecimiento y desarrollo de la niña y el niño menor de cinco años[8]. Además, se consideró la edad en años y meses.

El estado nutricional de los niños se evaluó a través de los índices antropométricos de Peso/Edad (desnutrido >= -3DE, normal >= -2DE a <= +2DE y obesidad > +3DE), Talla/Edad (talla alta > +2DE, talla normal >= -2DE a <= +2DE, talla baja >= -3DE y talla baja severa < -3DE), Peso/Talla (Obesidad > +3DE, sobrepeso <= +3DE, normal >= -2DE a <= +2DE, desnutrido >= -3DE y desnutrido severo < -3DE), utilizando los estándares de la OMS[9].

Recopilación de los datos

Se utilizaron las medidas antropométricas para obtener la información sobre el estado nutricional del preescolar, para ello se recolectó las informaciones de peso y talla a los preescolares, realizando las correctas mediciones con ayuda de la guía técnicas[8].

El cuidado de la toma de peso es fundamental por lo que se utilizó el instrumento de la balanza electrónica y para determinar la altura se utilizó el tallímetro móvil de 3 cuerpos de madera utilizando la técnica correcta[8].

Se obtuvo el permiso y autorización del director de la Institución educativa Inicial Paul Poblet. Para el desarrollo de la investigación, las madres e hijos participaron de manera voluntaria. Las madres firmaron el consentimiento. La investigación aplicó las normas bioéticas establecidas por la Declaración de Helsinki[10], el Código Nacional de Integridad Científica, emitido por el Consejo Nacional de Ciencia y Tecnología (CONCYTEC)[11].

Análisis estadístico

Se utilizó el Software SPSS 27 para el desarrollo del análisis de datos. Se realizó un análisis descriptivo de los datos. Las variables de la investigación son de tipo ordinal y nominal, por lo tanto, se utilizó la prueba exacta de Fisher para determinar la relación entre la variable prácticas alimentarias de las madres y el estado nutricional del preescolar. Se estableció como nivel de significancia $p<0,05$.

RESULTADOS

Se realizó la toma de muestra de 117 preescolares con sus respectivas madres que brindaron su autorización, un 46,2 % fueron niñas y un 53,8 % niños. El 50,4% fueron preescolares de 4 años y el 49.6% fueron de 3 años (Tabla 1).

El 45,3% de las madres tienen 2 hijos seguido de las madres que tiene un solo hijo (23,69%), el 36,8% tiene secundaria completa, el 49,6% es ama de casa, mientras que el 47% trabaja fuera del hogar, el 73,5% son convivientes y el 39,3% de las madres tienen más de 36 años.

En la tabla 2, se evidencia que el 31,6% casi siempre consumen carnes rojas y vísceras de 3 a 4 raciones por semana, el 42,7% consumen algunas veces pescados y mariscos de 2 a 4 raciones por semana, el 54,7% siempre consumen lácteos de 2 a 4 raciones por semana y el 51,3% siempre consumen de 3 a 4 raciones de huevo de gallina por semana.

Por otro lado, el 15,4% consumieron frutas y verduras diariamente, asimismo el 59% algunas veces consumen frutos secos. El 33,3% desinfecta algunas veces las frutas y verduras y el 43,6% nunca consumió aceite de oliva. Por otro lado, el 35% evita brindar o preparar refrescos y/o bebidas altas en azúcar, el 46% evita brindar frituras en sus preparaciones.

En la tabla 3, se muestra que el 34,2% evidenciaron exceso de peso. El 75% de las madres que realizan prácticas inadecuadas y sus hijos están con sobrepeso.

También se observa en la tabla 3, 5 y 6 se muestra que relación entre las prácticas alimentarias maternas con el peso para la talla (p=0,001), peso para la edad (p=0,006) y el estado nutricional global (p=0,001). Asimismo, no se evidenció relación significativa entre las prácticas alimentarias de las madres y la talla para la edad (Tabla 4).

Tabla 1. Características sociodemográficas de la madre e hijo

Variables	n	%
Sexo de los hijos		
Femenino	54	46,2
Masculino	63	53,8
Número de hijos		
1 hijo	28	23,9
2 hijos	53	45,3
3 hijos	24	20,5
4 hijos	11	9,4
5 hijos	1	,9
Grado de instrucción de la madre		
Primaria incompleta	11	9,4
Primaria completa	31	26,5
Secundaria incompleta	21	17,9
Secundaria completa	43	36,8
Superior/Técnico	11	9,4
Ocupación de la madre		
Estudiante	4	3,4
Trabaja fuera del hogar	55	47,0
Ama de casa	58	49,6
Estado civil de la madre		
Soltera	23	19,7
Casada	5	4,3
Viuda	3	2,6
Conviviente	86	73,5
Edad de la madre		
21-25 años	12	10,3
26-30 años	24	20,5
31-35 años	35	29,9
36 a más años	46	39,3
Total	117	100,0

En la tabla 6, muestra que existe relación entre las prácticas alimentarias de las madres y el estado nutricional de los preescolares. El 59% de los preescolares obtuvieron un estado nutricional normal, seguido de un 33,4% de exceso de peso y el 7,7% con desnutrición crónica y aguda. El 86,4% de las madres que realizan prácticas inadecuadas tienen hijos con exceso de peso (el 75% con sobrepeso y el 11,4% con obesidad).

DISCUSIÓN

Las prácticas alimentarias son conductas reflejadas por los factores sociales que están presentes en dicha madre o familia, siendo evidenciado por las investigaciones donde cada madre brinda la alimentación a sus hijos según criterios de hábitos alimentarios, conocimientos y creencias donde pueden ser correctas e incorrectas.

Una adecuada conducta de prácticas alimentarias maternas se realiza en el proceso de alimentación del niño, esto para contribuir al normal estado nutricional del preescolar, contribuyendo a la prevención de enfermedades no transmisibles a largo plazo. Mientras que los malos hábitos en la alimentación, resultan un elemento de riesgo al estado nutricional[12].

Los resultados del estudio muestran que el 59% de los preescolares obtuvieron un estado nutricional normal, seguido de un 33,4% de exceso de peso. Además, el 86,4% de las madres que realizan prácticas inadecuadas tienen hijos con exceso de peso, el 64,1% de los preescolares presentaron peso normal para la talla. Al respecto el estudio de Tarazona[13] realizado en niños entre 3 y 5 años, hallaron que el 94,4% presentó peso normal para la edad, el 88,2% evidenció peso normal para la talla y el 94,4% presentó talla normal para la edad. Otro estudio evidenció un 75,1% de los niños tenían un peso adecuado para su talla y solo el 1% de los niños padecían de desnutrición aguda severa[14].

Por otro lado, se evidenció que existe una relación entre las prácticas alimentarias maternas y estado nutricional del preescolar (p=0,001), también existen muchos factores que influyen en las prácticas alimentarias adecuadas, como el lugar de procedencia, accesibilidad de alimentos, acceso a agua potable, factor económico, educación de la madre. Al respecto el estudio de Tarazona[13] refiere que el nivel de conocimiento materno sobre alimentación saludable se relacionó significativamente con el estado nutricional en niños entre 3 a 5 años de edad (peso para la edad y peso para la talla), los hallazgos de la investigación muestra que las prácticas alimentarias maternas se relaciona significativamente con el estado nutricional (peso para la talla y peso para la edad), por tanto los conocimientos y las prácticas contribuyen positivamente en un estado nutricional óptimo en los niños preescolares.

Por otro lado, las prácticas alimentarias sobre el consumo de frutas y verduras no fueron las adecuadas, solo el 15,4% consumieron frutas y verduras diariamente y el 33,3% desin-

Tabla 2. Prácticas alimentarias maternas de los preescolares

Prácticas alimentarias maternas	Nunca	Algunas veces	Casi siempre	Siempre
	n (%)	n (%)	n (%)	n (%)
Consumo de alimentos				
1. ¿Consume su hijo/hija de 4 a 6 raciones de cereales al día (arroz, trigo, maíz, avena, quinua, pan, etc.)? Ejemplo: 1 ración = ½ taza = 1 pan = 1 puño 	0 (0)	6 (5,1)	71 (60,7)	40 (34,2)
2. ¿Consume su hijo/hija de 2 a 4 raciones de pescados y mariscos por semana? Ejemplo: 1 ración = 1 presa chica = 1 palma de la mano 	4 (3,4)	50 (42,7)	57 (48,7)	6 (5,1)
3. ¿Consume su hijo/hija de 3 a 4 raciones de carnes blancas por semana (pollo, pavita, gallina, pato y cuy)? Ejemplo: 1 ración = 1 presa chica = 1 palma de la mano 	2 (1,7)	17 (14,5)	69 (59)	29 (24,8)
4. ¿Consume su hijo/hija de 3 a 4 raciones de carnes rojas y vísceras por semana? Ejemplo: Hígado, mollejita, carne de res, etc. 	14 (12)	63 (53,8)	37 (31,6)	3 (2,6)
5. ¿Consume su hijo/hija de 3 a 4 raciones de huevo de gallina por semana? Ejemplo: 1 ración = 1 huevo	1 (0,9)	5 (4,3)	51 (43,6)	60 (51,3)
6. ¿Consume su hijo/hija de 2 a 4 raciones de legumbres por semana? (frejoles, lentejas, pallares, etc.) Ejemplo: 1 ración = ½ taza = 1 puño 	1 (0,9)	15 (12,8)	74 (63,2)	27 (23,1)
7. ¿Consume su hijo/hija frutos secos de 3 a 7 raciones por semana (maní, pasas, almendra, avellana, nueces, etc.)? Ejemplo: 1 ración = ¼ taza = 1 puñado 	19 (16,2)	69 (59)	27 (23,1)	2 (1,7)
8. ¿Consume su hijo/hija lácteos de 2 a 4 raciones por semana (leche, yogur y queso)? Ejemplo: 1 ración = taza de leche = 1 taza de yogur = 20 gr de queso = equivalente a tu pulgar 	0 (0)	5 (4,3)	48 (41)	64 (54,7)
9. ¿Consume su hijo/hija aceite de oliva de 3 a 6 raciones por día? Ejemplo: 1 ración = 1 cucharadita = punta de pulgar 	51 (43,6)	43 (36,8)	20 (17,1)	3 (2,6)
10. ¿Consume su hijo/hija verduras y hortalizas mayores a 2 raciones por día (lechuga, cebolla, tomate, col, brócoli, etc.)? Ejemplo: 1 ración = ½ plato de comida = 2 manos 	4 (3,4)	34 (29,1)	61 (52,1)	18 (15,4)
11. ¿Consume su hijo/hija frutas, mayor a 3 raciones por día (fresa, manzana, plátano, uva, etc.)? Ejemplo: 1 ración = 1 manzana = 2 duraznos = 1 taza de uva	0 (0)	9 (7,7)	61 (52,1)	47 (40,2)
12. ¿Consume su hijo/hija de 4 a 8 vasos de agua al día?	1 (0,9)	22 (18,8)	55 (47)	39 (33,3)

Tabla 2 continuación. Prácticas alimentarias maternas de los preescolares

Prácticas alimentarias maternas	Nunca	Algunas veces	Casi siempre	Siempre
	n (%)	n (%)	n (%)	n (%)
13. ¿Evita preparar alimentos que contengan carnes procesadas? Ejemplo: embutidos, salchichas, chorizos, etc.	0 (0)	21 (17,9)	41(35)	55 (47)
14. ¿Evita brindar o preparar refrescos y/o bebidas altas en azúcar? Ejemplo: gaseosas, infusiones.	3 (2,6)	24 (20,5)	49 (41,9)	41 (35)
15. ¿Evita brindar dulces y/o productos de pastelería a su hijo/ hija? Ejemplo: tortas, alfajores, empanadas de carne, mil hojas, etc.	0 (0)	17 (14,5)	35 (29,9)	65 (55,6)
16. ¿Evita brindar frituras a su hijo/ hija? Ejemplo: pollo a la brasa, pollo frito, hamburguesa, pollo broaster, etc.	0 (0)	23 (19,7)	48 (41)	46 (39,3)
Higiene de alimentos				
17. ¿Lava las manos de su hijo/hija antes de que coma sus alimentos?	0 (0)	0 (0)	5 (4,3)	112 (95,7)
18. ¿Lava las frutas y verduras antes de que sus hijos consuman de forma cruda o cocinada?	0 (0)	1 (0,9)	3 (2,6)	113 (96,6)
19. ¿Desinfecta las frutas y verduras antes de que sus hijos consuman de forma cruda o cocinada?	18 (15,4)	39 (33,3)	42 (35,9)	18 (15,4)
20. ¿Prepara sus alimentos en un ambiente libre de insectos y animales?	0 (0)	0 (0)	3 (2,6)	114 (97,4)
21. ¿Utiliza utensilios desinfectados?	3 (2,6)	15 (12,8)	42 (35,9)	57 (48,7)

Tabla 3. Relación entre las prácticas alimentarias de las madres y el peso para la talla de los preescolares

			Peso/talla				Total	p
			Desnutrición	Normal	Sobrepeso	Obesidad		
Prácticas alimentarias de las madres	Inadecuado	n	2	4	33	5	44	0,001
		%	4,5	9,1	75,0	11,4	100	
	Adecuado	n	0	71	2	0	73	
		%	0,0	97,3	2,7	0,0	100	
Total		n	2	75	35	5	117	
		%	1,7	64,1	29,9	4,3	100	

fecta algunas veces las frutas y verduras, la poca frecuencia de consumo de las frutas y verduras pueden afectar los requerimientos de los micronutrientes, que son importante para el correcto funcionamiento del organismo. El estudio de Jiménez et al.[15], hallaron que los preescolares consumen con más frecuencia frutas y verduras que cereales o comida rápida, siendo el plátano y la zanahoria los preferidos.

Es importante las prácticas adecuadas sobre el manejo de las técnicas de preparación de las frutas y verduras, las cuales deben ser consumidas desinfectadas en su forma natural o enteras sin procesar para aprovechar sus nutrientes y fibra.

Por otro lado, solo el 35% de las madres evita brindar o preparar refrescos y/o bebidas altas en azúcar. Un estudio

Tabla 4. Relación entre las prácticas alimentarias de las madres y la talla para la edad de los preescolares

			Talla/edad			Total	p
			Talla baja	Normal	Talla alta		
Prácticas alimentarias de las madres	Inadecuado	n	3	39	2	44	0,173
		%	6,8	88,6	4,5	100,0	
	Adecuado	n	4	69	0	73	
		%	5,5	94,5	0,0	100,0	
Total		n	7	108	2	117	
		%	6,0%	92,3	1,7	100,0	

Tabla 5. Relación entre las prácticas alimentarias de las madres y el peso para la edad de los preescolares

			Peso/edad		Total	p
			Normal	Sobrepeso		
Prácticas alimentarias de las madres	Inadecuado	n	39	5	44	0,006
		%	88,6	11,4	100	
	Adecuado	n	73	0	73	
		%	100,0	0,0	10	
Total		n	112	5	117	
		%	95,7	4,3	100	

Tabla 6. Relación entre las prácticas alimentarias de las madres y el estado nutricional de los preescolares

			Estado nutricional					Total	p
			Desnutrición crónica	Desnutrición aguda	Normal	Sobrepeso	Obesidad		
Prácticas alimentarias de las madres	Inadecuado	n	3	2	1	33	5	44	0,001
		%	6,8	4,5	2,3	75,0	11,4	100	
	Adecuado	n	4	0	68	1	0	73	
		%	5,5	0,0	93,2	1,4	0,0	100	
Total		n	7	2	69	34	5	117	
		%	6,0	1,7	59,0	29,1	4,3	100	

evidenció en los preescolares que el 75 % elige las gaseosas y el 89% los jugos en sus diversas formas, estos patrones de consumo en edades tempranas incrementan las caries dentales, perjudicando la salud dental[16]. Por su parte, Jimenez et al.[15], refieren que los preescolares consumen las aguas frescas y los jugos industrializados, siendo éstas las bebidas de su elección.

Así mismo el consumo excesivo de este tipo de bebidas favorece una dieta de baja calidad nutricional, es necesario establecer estrategias de intervención y prevención, en las que se promocione el agua y la leche sin azúcar como las bebidas fundamentales en la dieta del niño, este incremento de bebidas aumenta con la edad, y el consumo en los adolescentes (740 ml/día) duplica al de los preescolares (388 ml/día) [17]. Farro et al.[18], en su estudio hallaron un consumo de azúcar semanalmente de 511,2 g.

La investigación evidenció que el 46% de las madres evita brindar frituras en preparaciones a sus hijos. Al respecto la investigación de Farro et al.[18], mostraron que los niños en edad preescolar tienen un consumo muy alto y alto de azúcar (>10% Valor calórico total (VCT)) y el 13% reportó consumo alto y muy alto de grasas (>30%VCT). Asimismo, la ingesta de grasas semanalmente fue 230,2 g.

Eun et al.[19], manifestaron que los malos hábitos alimenticios y la ingesta inadecuada de nutrientes están relacionados con la obesidad en la infancia, la obesidad infantil y adolescente siguen el mismo camino de la obesidad en la edad adulta y se ha relacionado con muchas enfermedades crónicas, como la diabetes tipo 2, la hipertensión y las enfermedades cardiovasculares. Además, está vinculada a la mortalidad en la edad adulta y la muerte prematura.

La nutrición tiene un rol preponderante en la infancia porque constituye una etapa trascendental dentro del proceso de desarrollo, que se caracteriza por formación de las bases biológicas, psicológicas y sociales que marcarán al individuo por el resto de su vida[20]. Ballonga et al.[21], plantearon que la adecuada nutrición en la infancia debe incluir minerales esenciales y vitaminas que necesita el organismo y la carencia de estos elementos produce una deficiencia en la dieta originando fatiga, limitación en la capacidad de aprendizaje, problemas de inmunidad, entre otras consecuencias.

El comportamiento materno tiene influencia sobre el comportamiento de salud de los niños, es decir, las conductas y actitudes relacionadas con la salud materna con respecto a las prácticas de alimentación y la autoeficacia se vinculan con las conductas relacionadas con la salud de los niños, incluidas las conductas alimentarias, la actividad física y sedentarismo[22]. Un desequilibrio entre la ingesta calórica y la actividad física es una de las principales causas de la obesidad infantil y adolescente, los factores ambientales son exclusivamente importantes para el desarrollo de la obesidad entre niños y adolescentes[19].

Una alimentación y nutrición adecuada puede estimular a los preescolares a un buen desarrollo físico y cognitivo. Es necesario fomentar el consumo de frutas y verduras y evitar ofrecer o preparar frituras, refrescos y/o bebidas altas en azúcar, urge implementar programas de educación en alimentación y nutrición para fortalecer el crecimiento y desarrollo adecuado en la etapa preescolar, escolar, adolescencia y adultez.

Las limitaciones del estudio fueron no considerar las porciones, cantidades de los alimentos, la valoración del recordatorio de 24 horas. Los resultados no pueden ser extrapolados a otros contextos.

CONCLUSIÓN

Las madres tuvieron prácticas alimentarias inadecuadas, el consumo de frutas y verduras no fueron diarias y pocas veces evitan dar preparaciones como refrescos y/o bebidas altas en azúcar y frituras. Es necesario implementar estrategias para mejorar las prácticas del consumo de los alimentos en diversas preparaciones, mejorar las formas de consumo y técnicas culinarias saludables.

considerando que nuestro país tiene una gran diversidad alimentaria y así se puede garantizar una cobertura adecuada del requerimiento de macronutrientes y micronutrientes en la dieta del preescolar.

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Phytochemical compounds, vitamin C levels, and antioxidant activity of soursop leaves (*Annona muricata Linn*) tea powder under various drying durations

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ABSTRACT

Introduction: Soursop leaves (*Annona muricata Linn*) possess numerous properties that play a significant role in preventing various diseases, such as antibacterial, antioxidant, anticancer, anti-inflammatory activities, and their ability to act as immunomodulators. Degenerative diseases are primarily caused by the harmful effects of free radicals. Oxidative stress induced by free radicals leads to various degenerative diseases that can damage the body. Antioxidants mitigate this by donating electrons to free radicals, thereby playing a crucial role in the body's defense mechanisms.

Aim: This study aims to analyze the phytochemical compounds, vitamin C levels, and antioxidant activity of soursop leaf tea powder under varying drying durations.

Methods: This quantitative research employed a descriptive design based on laboratory testing. Phytochemical compounds were analyzed qualitatively, vitamin C levels were measured using the titration method, and antioxidant activity was determined using Ultra Violet-Visible (UV-Vis) Spectrophotometry with the 2,2-diphenyl-1-picrylhydrazyl (DPPH) method. A one-way Analysis of Variance (ANOVA) was used for statistical analysis, as the data obtained followed a normal distribution.

Results: The results revealed that all samples tested positive for phytochemical compounds, including flavonoids, saponins, tannins, alkaloids, and terpenoids. A significant effect of drying duration variations on vitamin C levels and antioxidant activity was observed, with a p-value < 0.05.

Conclusion: In conclusion, soursop leaves are a promising source of natural bioactive compounds, with drying at 50°C for 3 to 6 hours effectively preserving vitamin C content and enhancing antioxidant activity. However, extending the drying time to 12 hours may lead to a slight reduction in these beneficial properties. Statistical analyses confirm that drying time significantly affects both vitamin C levels and antioxidant activity in soursop leaf tea powder.

KEYWORDS

Antioxidant Activity, Drying Durations, Soursop Leaves, Tea Powder, Vitamin C Levels.

INTRODUCTION

On a global scale, the percentage of deaths attributed to non-communicable diseases (NCDs) steadily increased to 73.9% in 2019. Consequently, the percentage of deaths from NCDs declined to 70.0% in 2020 and 65.3% in 2021. Advancements in the prevention, diagnosis, and treatment of NCDs have contributed to a consistent reduction in premature mortality[1]. Consistent with global trends, Indonesia has experienced a steady decline in the prevalence of degenerative diseases over the past ten years. The prevalence of degenerative diseases diagnosed by doctors in Indonesia (all ages) decreased between 2013 and the present, with cancer prevalence dropping from 1.4% to 1.2%, heart disease from 1.5% to 0.85%, stroke from 12.1% to 8.3%, and diabetes mellitus from 2.1% to 1.7%[2,3].

Understanding the role of oxidative stress is crucial in addressing degenerative diseases. Oxidative stress, driven by free radicals, disrupts the balance between reactive oxygen species (ROS) production and antioxidant defenses, leading to cellular damage and the progression of conditions like cardiovascular disease and cancer. Antioxidants from diet or en-

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dogenous systems help neutralize ROS and protect biomolecules such as nucleic acids, proteins, and lipids. Deficiency or dysfunction of key antioxidants, like the catalase enzyme, exacerbates oxidative stress and has been linked to age-related degenerative diseases, including diabetes, hypertension, and Alzheimer's disease[4]. These insights highlight the importance of exploring natural antioxidant sources, such as soursop leaves, to mitigate oxidative stress and its harmful effects.

Oxidative stress plays a critical role in the progression of various diseases, emphasizing the need for effective antioxidant interventions. Tea, the second most consumed beverage globally, is highly valued for its antioxidant properties, largely attributed to its phenolic content. Research shows that free phenolic compounds exhibit significantly higher antioxidant activity compared to bound phenolic compounds. Additionally, studies on spiced herbal tea blends highlight the importance of ingredient selection and combinations in enhancing antioxidant benefits[5]. These findings emphasize the potential of herbal teas, such as soursop leaf tea, as functional beverages with health-promoting properties.

Soursop (*Annona muricata Linn.*), a member of the *Annonaceae* family, is widely used in traditional medicine due to its diverse pharmacological properties, including anticancer, antiulcer, antidiabetic, antibacterial, antiviral, and wound-healing effects. These effects are attributed to its bioactive compounds, such as acetogenins, alkaloids, flavonoids, phenolics, and vitamins. A study has demonstrated the antioxidant potential of soursop leaf extracts, with IC_{50} values of 14.48 µg/mL, depending on extraction methods[6]. Recent research has further optimized extraction conditions, achieving strong free radical scavenging activity with an IC IC_{50} value of 35.51 µg/mL. The presence of flavonoids, tannins, and saponins in soursop leaves underscores their potential for use in herbal medicine formulations[7]. Although soursop leaves have yet to be widely incorporated into specific food products, tea products offer a promising avenue for their utilization. The rich bioactive composition of soursop leaves makes them a valuable ingredient for herbal teas, aligning with the growing interest in functional beverages with health-promoting properties. This has led researchers to explore the feasibility of producing tea with soursop leaves as the primary ingredient. The study is motivated by the public's growing preference for herbal alternatives in treatment. Researchers aim to analyze the phytochemical compounds, vitamin C levels, and antioxidant activity of soursop leaf tea powder prepared under varying drying conditions.

MATERIALS AND METHODS

Type and Design

This study employed a descriptive research design based on laboratory testing. The research involved preparing soursop leaf tea drinks with varying drying durations: 0-hour (P0), 1-hour (P1), 3 hours (P2), 6 hours (P3), and 12 hours (P4). Testing was conducted in duplicate to evaluate antioxidant activity, vitamin C levels, and phytochemical composition.

Location and Time

The study on the effect of drying time on the phytochemical compounds, vitamin C levels, and antioxidant activity of soursop leaf tea powder was conducted from November 23 to 29, 2022, at the Research Laboratory of the Faculty of Mathematics and Natural Sciences, Tadulako University.

Tools and Materials

The materials used for sample preparation were soursop leaves, which were dried for varying durations: 0-hour, 1-hour, 3-hour, 6-hour, and 12-hour. Materials for phytochemical screening included soursop leaf sample solution, magnesium powder, concentrated HCl, distilled water, 5% ferric chloride solution, Dragendorff reagent, glacial acetic acid, and concentrated sulfuric acid. For vitamin C analysis, the materials used were soursop leaf samples, 25 mL distilled water, 0.01 N iodine solution, and 1% starch indicator, and **ascorbic acid standard**. The antioxidant activity analysis utilized soursop leaf sample solutions, ethanol, 96% alcohol, DPPH (2,2-diphenyl-1-picrylhydrazyl) solution, and **ascorbic acid**. The tools used for sample preparation included an oven, blender, aluminum foil, and containers. Tools used in phytochemical screening included Petri dishes, dropper pipettes, 10 mL measuring cups, test tubes, tube racks, spatulas, 50 mL beakers, and aluminum foil. For determining vitamin C levels, the tools utilized were an oven, 100 mL measuring cup, ten 50 mL Erlenmeyer flasks, aluminum foil, scales, a shaker, funnel, filter paper, container, spatula, 10 mL measuring cup, dropper pipette, 5 mL measuring cup, titration apparatus (50 mL burette), and a 50 mL beaker. The tools used for antioxidant activity analysis included an oven, scales, 100 mL Erlenmeyer flask, 100 mL measuring cup, aluminum foil, filter paper, funnel, spatula, 10 mL measuring cup, 10 mL beaker, a 100–1000 µL dropper pipette, a 20–200 µL dropper pipette, and a **UV-Vis spectrophotometer** (for absorbance measurement at 517 nm). Gloves, goggles, and lab coats were used during the experiments to ensure safe handling of chemicals, including hydrochloric acid (HCl), sulfuric acid, and iodine, and to maintain a safe laboratory environment.

Stages

The initial stages of the research involved sample preparation, which included drying the samples for varying durations (0-hour, 1-hour, 3-hour, 6-hour, and 12-hour). Subsequent stages included phytochemical screening, determination of vitamin C levels, and analysis of antioxidant activity.

Working Procedure

Sample Preparation

The procedure followed in this study was based on the research conducted by Adri et al. (2013)[8]. Fresh soursop leaves were picked directly from the tree, selecting the third to fifth leaves from the base of the stem. The leaves were collected in the morning to ensure optimal phytochemical content, as metabolite levels are typically higher during this time. After harvesting, the leaves were washed under running water until clean, drained, and air-dried. To remove excess surface moisture, the leaves were air-dried in the shade for 30 minutes before being subjected to oven drying. Each sample was then dried in a 50°C oven for varying durations (0-hour, 1-hour, 3-hour, 6-hour, and 12-hour). Once dried, the samples were ground into a fine powder using a blender, which was thoroughly cleaned between samples to prevent cross-contamination and ensure the integrity of the powdered samples. The powdered soursop leaf samples were stored in airtight containers, kept away from light, and maintained at room temperature to preserve their integrity and prevent the degradation of bioactive compounds.

Phytochemical Compound Screening

Phytochemical screening involves a color test reaction using specific color reagents. In this study, qualitative phytochemical screening was performed to identify the presence of flavonoids, alkaloids, tannins, terpenoids, and saponins in soursop leaf tea powder. **Flavonoid Testing:** A 1.0 mL sample of the alcoholic solution was placed in a test tube, followed by the addition of a small amount of magnesium powder and a few drops of concentrated HCl (Shinoda reagent). A positive reaction was indicated by the appearance of an orange, pink, or red coloration in the solution. **Saponin Testing:** A 2.0 mL sample solution was mixed with an equal volume of distilled water in a test tube and shaken thoroughly. A positive result was indicated by the appearance of foam that remained stable for at least 10 minutes. **Ttkan annin Testing:** One milliliter of the sample solution was placed in a test tube and mixed with a 5% ferric chloride solution. A positive reaction was indicated by the formation of a dark greenish-black or brown precipitate [9].

Alkaloid Testing: A 1.0 mL sample was placed into a test tube and mixed with 2–3 drops of Dragendorff's reagent. The reagent was freshly prepared and stored under appropriate conditions to ensure its activity and reliability during the alkaloid test. Dragendorff's reagent was prepared by dissolving 8.0 grams of bismuth nitrate ($Bi(NO_3)_3 \cdot H_2O$) in 30% (w/v) nitric acid (HNO_3). Separately, 4.15 grams of potassium iodide (KI) were dissolved in 50 mL of distilled water. The two solutions were combined and allowed to stand for 24 hours to ensure complete reaction. Following this, the mixture was filtered using filter paper to remove any precipitates, and the filtrate was diluted with distilled water to a final volume of 100 mL. A positive reaction was indicated by the formation of an orange precipitate, confirming the presence of alkaloids in the sample[10]. **Terpenoid Testing:** To test for the presence of terpenoids, 1.0 mL of the extract was mixed with 5 drops of glacial acetic acid in a test tube. Following this**,** 1.0 mL of concentrated sulfuric acid was carefully added to the mixture. The test tube was observed for any color change. A positive result was indicated by the formation of a violet or brownish red color in the solution, confirming the presence of terpenoids[11].

Notes: The sample volumes used in the tests (1.0 mL, 2.0 mL) were carefully measured to ensure proper mixing and clear visualization of the results. Reagents such as concentrated HCl, sulfuric acid, and ferric chloride were stored in airtight containers and handled with care under controlled conditions to maintain their quality and ensure accurate results. Control samples, including blank solutions and samples known to lack specific phytochemicals, were used to validate the specificity of observed color changes or precipitate formation during the tests. For validation, standard solutions of known phytochemicals, such as quercetin for flavonoids and tannic acid for tannins, were tested alongside the samples to ensure accuracy and reliability of the results.

Determination of Vitamin C Levels

The levels of vitamin C in the sample were measured using iodometric redox titration, employing a starch indicator solution. An iodine (I_2) solution of known molarity was gradually added to the sample until the equivalence point was reached. The endpoint was indicated by a color change to dark blue, which occurred due to the formation of the iodine-starch complex. The vitamin C content was determined by calculating the volume of iodine solution required to reach the endpoint, based on the known concentration of iodine[12].

Antioxidant Activity Analysis

The antioxidant activity of the concentrated extract was evaluated using the spectrophotometric method with the DPPH reagent (2,2-diphenyl-1-picrylhydrazyl). A solution of the extract was prepared, and an aliquot was mixed with a DPPH solution. The reaction mixture was incubated for a specified period of time, and the decrease in absorbance was measured at a suitable wavelength, typically at 517 nm, using a spectrophotometer. The antioxidant activity was determined by comparing the absorbance of the sample to that of a control, with a greater decrease in absorbance indicating higher antioxidant activity[13].

Data Processing

Phytochemical Screening: The presence of flavonoids, alkaloids, tannins, terpenoids, and saponins in the sample

was indicated by a positive result, marked as (+). Conversely, the absence of these compounds was indicated by a negative result, marked as (-). **Determination of Vitamin C Levels:** The results indicated that the highest vitamin C concentration was obtained from one of the drying variations. **Antioxidant Activity Analysis:** The antioxidant activity was quantitatively measured using the DPPH method, and the results were expressed as IC_{50} values. A lower IC_{50} value indicates greater free radical scavenging activity. Antioxidant compounds were categorized based on their IC_{50} concentrations as follows: Very strong: IC_{50} < 50 ppm; Strong: IC_{50} between 50–100 ppm; Moderate: IC_{50} between 101–150 ppm; and Weak: IC_{50} between 151–200 ppm**.** Data from the antioxidant activity analysis, including the percentage of inhibition and IC_{50} values obtained through UV-Vis spectrophotometry, were analyzed using Microsoft Excel. The mean IC_{50} values from the initial and subsequent measurements were used to determine the deviation.

The percentage of inhibition was calculated using Equation 1:

$$\%inhibition = \frac{(A_{control} - A_{sample})}{A_{control}} \times 100$$

Where:

$A_{control}$ = Absorbance of the control sample.

A_{sample} = Absorbance of the test sample.

A linear plot of percentage inhibition (% inhibition) versus concentration was analyzed using Equation 2:

$$y = a + bx$$

Where:

x = Concentration of the measured substance.

y = Percentage of inhibition.

The IC_{50} value was determined as the x value corresponding to a y value of 50% in this equation[13].

Data Analysis

Phytochemical screening was analyzed descriptively. Statistical analyses were performed for vitamin C levels and antioxidant activity. The data for vitamin C levels showed a normal distribution, with a p-value of 0.341, while the data for antioxidant activity also demonstrated a normal distribution, with a p-value of 0.451. Both p-values (≥ 0.05) confirm that the data are normally distributed. Further analysis of normally distributed data was conducted using the ANOVA (Analysis of Variance) test, with a significance threshold of p-value < 0.05.

RESULTS

Phytochemical Compounds Screening

The phytochemical screening results in Table 1 provide an overview of the presence of key bioactive compounds in soursop leaf tea powder samples, with varying drying times. All five samples (P0 to P4) were tested for five different phytochemicals: flavonoids, saponins, tannins, alkaloids, and terpenoids. These results suggest that drying time does not significantly affect the presence of these phytochemicals in soursop leaf tea powder, as all compounds were detected across all drying times (from 0 hour to 12 hours). This consistency highlights the potential of soursop leaf tea powder as a source of various bioactive compounds with therapeutic properties.

Vitamin C Levels

Table 2 demonstrates that increased drying time generally leads to higher vitamin C content in soursop leaf tea powder, particularly between P2 (3-hour) and P3 (6-hour) of drying. However, the P4 (12-hour) drying time did not show a significant improvement compared to the 3-6 hour drying times and even showed a slight reduction in vitamin C content. Based on this data, it appears that drying times between 3 and 6 hours are optimal for preserving or enhancing the vitamin C levels in soursop leaf tea powder. Statistical analysis indicates a signifi-

Table 1. Phytochemical Screening Results of Soursop Leaf Tea Powder Samples

Phytochemical type	Sample					Description
	P0 (0-hour)	P1 (1-hour)	P2 (3-hour)	P3 (6-hour)	P4 (12-hour)	
Flavonoids	+	+	+	+	+	Showed a red color
Saponins	+	+	+	+	+	Formed stable foam for 10 minutes
Tannins	+	+	+	+	+	Changed to a blackish-green color
Alkaloids	+	+	+	+	+	Formation of orange precipitates
Terpenoids	+	+	+	+	+	Showed a brownish-red color change

(+) Indicates the compound is present in the sample.

Table 2. Vitamin C levels of soursop leaf tea powder samples per 100 g

Sample	Drying time	Average of vitamin C Level ± standard deviation (mg/100g)	p-value
P0	0 hour	16.9 ± 0.04	0.000
P1	1 hour	17.1 ± 0.02	
P2	3 hours	34.3 ± 0.28	
P3	6 hours	34.5 ± 0.09	
P4	12 hours	34.2 ± 0.14	

Table 3. IC_{50} Value (ppm) and antioxidant activity of sample

Sample	Average of IC_{50} ± SD (ppm)	Antioxidant Activity Classification	p-value
P0 (0-hour)	59.4 ± 0,6	Strong	0.000
P1 (1-hour)	50.8 ± 0,4	Strong	
P2 (3-hour)	42.9 ± 0,08	Very Strong	
P3 (6-hour)	38.3 ± 0,21	Very Strong	
P4 (12-hour)	47.3 ± 0,73	Very Strong	

cant effect of drying time at 50°C on the Vitamin C levels of soursop leaf tea powder, with a p-value < 0.05. The p-value for the comparison between the samples is 0.000, indicating a statistically significant difference in vitamin C content as drying time increases. These findings suggest that longer drying times may help retain or enhance the vitamin C content in soursop leaf tea powder. The comparison of Vitamin C levels among soursop leaf samples is presented in Table 2 and illustrated in Figure 1.

The graph in Figure 1 indicates that longer drying times result in higher vitamin C levels, up to a specific threshold (3 hours), after which the levels stabilize.

Antioxidant Activity

Table 3 shows that the IC_{50} values decrease as the drying time increases up to 6 hours (P3), indicating an improvement in antioxidant activity. The decrease in IC_{50} reflects better free radical scavenging activity, as a lower IC_{50} value signifies a stronger antioxidant. At 12 hours (P4) of drying, while the antioxidant activity remains classified as "Very Strong", there is a slight increase in IC_{50} compared to the 6-hour (P3) sample, suggesting a potential reduction in antioxidant potency with prolonged drying time. The statistical significance of the results (p-value = 0.000) confirms that the changes in IC_{50} values are reliable and not due to random fluctuations, further strengthening the conclusion that time influences antioxidant potential in this sample. The antioxidant activity of the samples is presented in Table 3 and illustrated in Figure 2.

Figure 2 shows that as the drying time increases, the IC_{50} value strengthens up to 6 hours, after which it decreases with further drying.

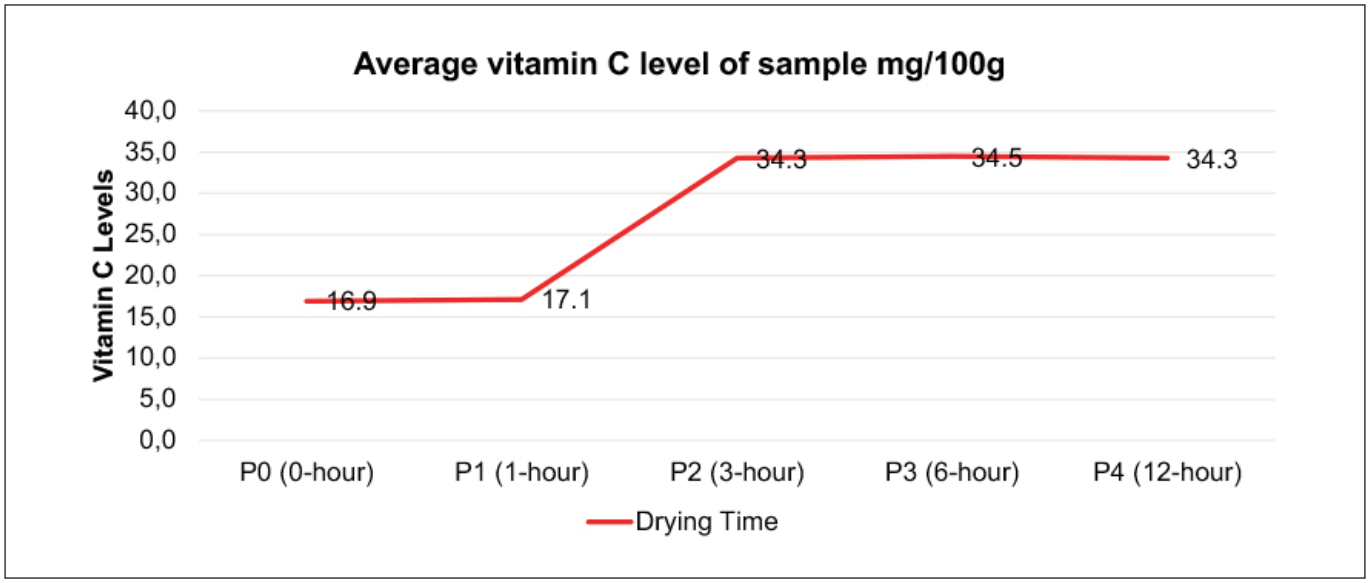

Figure 1. Graph of average vitamin C levels in soursop leaf tea powder sample

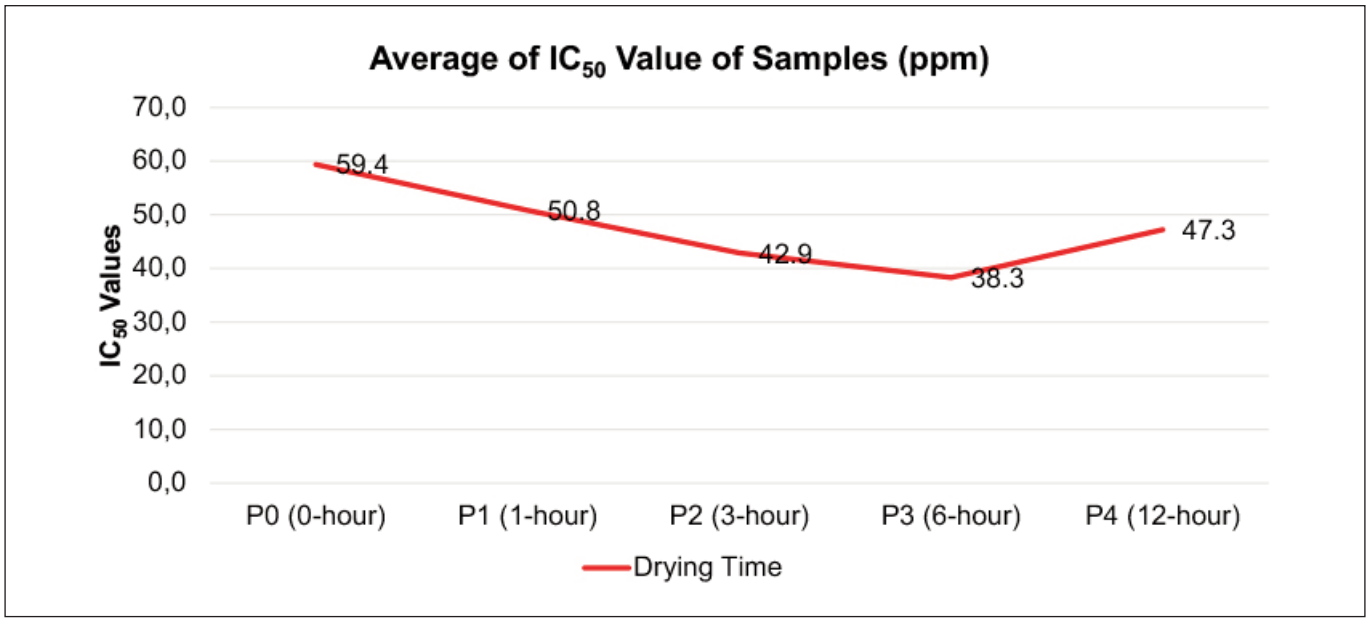

Figure 2. Graph of average IC_{50} value of sample

DISCUSSION

Flavonoids are one of the key chemical constituents found in soursop leaves, known for their medicinal properties. Flavonoids are a diverse group of polyphenolic compounds found in plants, classified into six primary categories: flavones (e.g., apigenin and luteolin), flavonols (e.g., quercetin and myricetin), flavanones (e.g., naringenin and hesperidin), catechins or flavanols (e.g., epicatechin and gallocatechin), anthocyanidins (e.g., cyanidin and pelargonidin), and isoflavones (e.g., genistein and daidzein). These compounds can exist as aglycones (without attached sugars) or as glycosides (with attached sugar molecules). Flavonoids are recognized for their diverse biological activities, including anti-inflammatory, antioxidant, antibacterial, antiviral, antiallergic, cytotoxic, and anticancer effects. They are also utilized in the treatment of neurological disorders and possess vasodilatory properties. Additionally, flavonoids have been shown to inhibit the activity of various enzymes, such as hydrolases, hyaluronidase, alkaline phosphatase (ALP), arylsulfatase, cAMP phosphodiesterase, lipase, and alpha-glucosidase kinase[c].

Saponins are a diverse group of naturally occurring plant secondary metabolites found in various foods, including grains, pulses, green leaves, and sea creatures. They consist of a hydrophilic sugar moiety linked to a lipophilic aglycone, resulting in an amphiphilic nature and unique functional properties. Saponins have been reported to exhibit a wide variety of biological activities, including anti-inflammatory, antioxidant, antibacterial, antiviral, antiallergic, cytotoxic, and anticancer effects. They can induce apoptosis in cancer cells, inhibit tumor cell proliferation, and suppress angiogenesis. Saponins also inhibit the production of pro-inflammatory cytokines and enzymes, thereby reducing inflammation and alleviating symptoms in conditions like arthritis and inflammatory bowel disease. They serve as adjuvants and immunostimulants, enhancing the immune response to infections and improving vaccine efficacy. Additionally, saponins possess antioxidant activity, helping to neutralize free radicals and oxidative stress in the body. They can form non-soluble compounds with cholesterol and other sterols, inhibiting their absorption and leading to a reduction in blood cholesterol levels, specifically LDL cholesterol. Saponins exhibit antimicrobial effects against a wide range of pathogens, including bacteria, viruses, fungi, and protozoa, by disrupting microbial cell membranes and interfering with their replication[15].

Tannins are convoluted, constrictive, and deliquescent polyphenols, with bioavailability that reduces intestinal absorption. Tannins have a range of health implications. While they are known for their anti-nutritional effects, decreased digestibility, mutagenic and carcinogenic potential, and hepatotoxic activity, they may also act as co-promoters of various diseases. However, recent studies have highlighted their numerous health benefits, including antioxidant, anti-cancer, anti-allergy, anti-inflammatory, anti-parasitic, and antimicrobial properties. Despite their astringent nature, which limits their use in the food industry, tannins have extensive applications in the pharmaceutical field[16].

Alkaloids are nitrogen-containing compounds commonly found in plants and are characterized by their heterocyclic structures. Alkaloids exert significant biological effects on both humans and animals. They interact with α- and β-re-

ceptors, providing antipsychotic and antihypertensive effects, blocking presynaptic alpha-2 adrenergic receptors, and exhibiting mild anti-diuretic properties. Additionally, alkaloids function as antineoplastic agents and demonstrate anti-inflammatory, demulcent, ganglionic blocking, anti-spasmodic, insecticidal, and hepatoprotective properties[17].

Terpenoids are a very prominent class of natural compounds produced in diverse genera of plants, fungi, algae and sponges. Terpenoids possess a wide range of biological activities, including cancer prevention, antimicrobial, antifungal, and antiviral properties. They also demonstrate the ability to lower blood sugar levels, reduce inflammation, combat parasites, and improve memory. Furthermore, terpenoids exhibit significant therapeutic potential against diseases such as cancer, malaria, tuberculosis, and various viral and bacterial infections[18].

The results of this research align with those of Nuryani et al. (2018), where the extract from boiling *Daruju* leaves tea was found to contain phytochemical compounds, including flavonoids, alkaloids, phenols, steroids, tannins, and saponins[19]. Similarly, these findings are consistent with research conducted by Iskandar (2020), in which phytochemical tests on *Uncaria tomentosa* leaves, used as an ingredient for making tea, revealed the presence of alkaloids, flavonoids, polyphenols, triterpenoids, steroids, saponins, and tannins through qualitative analysis[20].

Vitamin C levels

The drying process can degrade soursop leaf tea powder because vitamin C is highly susceptible to oxidation and destruction at elevated temperatures. In this study, oven drying was carefully controlled, with the temperature maintained at 50°C and not exceeding 60°C. Research by Saputera et al. (2012) demonstrated that drying temperature significantly affects vitamin C levels in roselle leaf tea ($p < 0.05$). Their study found that drying roselle leaves at 50°C resulted in a vitamin C content of 27.926 mg/100 g [21]. This value is lower than the vitamin C levels observed in the current study, which were 34.5 ± 0.09 mg/100 g. Similarly, Puspitasari et al. (2017) reported a continuous decline in the vitamin C levels of kombucha tea after the seventh day of fermentation[22]. On the other hand, Guerra et al. (2023) reported the vitamin C content of ripe Shiraca fruit at 108.35 mg/100 g [23].

Antioxidant activity

The concentration of an extract that reduces DPPH activity by 50% is known as the IC_{50} value. Antioxidant activity increases as the IC_{50} value decreases. The findings of this study align with those of Harningsih and Wimpy (2018), who reported that a 2:1 blend of cherry and soursop leaves exhibited very strong antioxidant activity, with an IC_{50} value of 6.9126 ppm when tested using the DPPH method[24]. In this study, the strongest antioxidant activity was observed during drying in P3 (6 hours). However, in P4 (12 hours), antioxidant activity declined significantly, suggesting that prolonged drying weakens antioxidant effects. Drying also impacts the water content of the sample, which plays a crucial role in microbial growth. Managing water activity and storage conditions can help reduce microbial contamination and aflatoxin production in medicinal herbs. Sorption isotherms (adsorption analysis) can identify optimal drying conditions to reduce water activity, control *Aspergillus flavus* growth, and prevent damage from excessive drying. This approach also minimizes costs by reducing the drying time to an ideal level[25].

Antioxidants are stable molecules capable of donating electrons to free radicals, thereby neutralizing their harmful effects. They primarily mitigate cellular damage by scavenging free radicals. Low molecular weight antioxidants interact with free radicals without being consumed, halting chain reactions before essential biomolecules are damaged. Research by Anggorawati et al. (2016) demonstrated that avocado leaves, when processed as herbal tea, exhibited the highest antioxidant activity at a drying time of 30 minutes, with an IC_{50} value of 24.863 µg/ml [26]. Similarly, Adri et al. (2013) found that antioxidant activity in soursop leaf tea was influenced by drying variations. At a drying time of 150 minutes, the antioxidant activity was 82.16 µg/ml, and the IC_{50} value decreased as drying time increased. Furthermore, Veliz et al. (2025) reported in their study that dried hibiscus flowers have an antioxidant capacity indicated by values ranging from 13.60 mg mL^{-1} - 14.22 mg mL^{-1} [27].

Oxidative stress occurs when there is an imbalance between free radical production and the body's antioxidant defenses. This condition is linked to damage to various molecules, such as lipids, proteins, and nucleic acids[28]. Oxidative stress can arise from trauma, infections, heat injury, hyperoxia, toxins, or excessive exercise. Injured tissues generate enzymes like xanthine oxidase, lipoxygenase, and cyclooxygenase, activate phagocytes, release free iron and copper ions, or interfere with oxidative phosphorylation's electron transport chain, leading to an overproduction of reactive oxygen species (ROS).

Oxidative stress, resulting from the excessive intracellular accumulation of reactive oxygen species (ROS), reactive nitrogen species (RNS), and other free radical species, contributes to the onset and progression of various diseases, including diabetes, obesity, diabetic nephropathy, diabetic neuropathy, and neurological diseases, such as Alzheimer's disease (AD), amyotrophic lateral sclerosis (ALS), and Parkinson's disease (PD). Oxidative stress is also implicated in cardiovascular disease and cancer[29]. An excess of oxidative stress may oxidize lipids and proteins, altering their structure and function. Antioxidants function as free radical scavengers, hydrogen and electron donors, peroxide decomposers, singlet oxygen quenchers, enzyme inhibitors, synergists, and metal-chelating agents. Both enzymatic and non-enzymatic antioxi-

dants operate in intracellular and extracellular environments to eliminate ROS. Antioxidants work through two primary mechanisms. The first involves breaking the chain reaction by donating electrons to free radicals. The second disrupts chain-initiating catalysts, effectively neutralizing ROS and reactive nitrogen species. Antioxidants also influence biological systems by donating electrons, chelating metal ions, acting as co-antioxidants, or regulating gene expression[30].

CONCLUSION AND RECOMMENDATION

In conclusion, the results highlight soursop leaves as a promising source of natural bioactive compounds, and further investigation into the optimal processing methods for maximizing their therapeutic potential is warranted. The study indicates that drying soursop leaves at 50°C for 3 to 6 hours optimally preserves vitamin C content and enhances antioxidant activity, as evidenced by decreased IC_{50} values. However, extending the drying time to 12 hours may lead to a slight reduction in these beneficial properties. Statistical analyses confirm that drying time significantly affects both vitamin C levels and antioxidant activity in soursop leaf tea powder.

Further research is needed to explore the optimal processing methods for preserving other bioactive compounds and enhancing the therapeutic potential of soursop leaves.

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Caloric restriction mimetics: effects of spermidine and berberine on healthy longevity and prevention of aging-associated diseases

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ABSTRACT

Introduction: Aging is a complex biological process associated with the accumulation of cellular damage, loss of proteostasis, and mitochondrial dysfunction, which contribute to the development of chronic diseases. Spermidine and berberine are natural compounds with complementary properties that promote healthy longevity by targeting key cellular pathways such as autophagy and mitochondrial biogenesis.

The objective of this review is to evaluate the mechanisms of action, benefits, and limitations of spermidine and berberine and to explore their synergistic potential as anti-aging agents in personalized medicine strategies.

Methods: A narrative review of the scientific literature was conducted to analyze the effects of spermidine and berberine in preclinical and clinical models. Relevant studies focusing on molecular mechanisms, therapeutic applications, and practical limitations were examined.

Results: Spermidine stimulates autophagy by inhibiting acetyltransferases, improving protein quality, and reducing toxic aggregates associated with cellular aging. Berberine activates AMPK and SIRT1, enhancing mitochondrial biogenesis and regulating energy metabolism. Both compounds have shown efficacy in animal models in improving cognitive function, reducing oxidative stress, and preventing metabolic diseases. However, their low bioavailability and the lack of longitudinal studies limit their clinical application.

Discussion: The complementary effects of spermidine and berberine address proteostasis and cellular bioenergetics simultaneously. Their combination represents a promising multifactorial approach but requires advances in formulations to optimize absorption and stability. Clinical trials are essential to validate their safety and efficacy in humans.

Conclusions: Spermidine and berberine have significant potential as therapeutic agents in anti-aging medicine. Their integration into personalized therapies could improve quality of life and prevent chronic diseases, although additional studies are needed to overcome current limitations.

KEYWORDS

Proteostasis; autophagy; spermidine; berberine; longevity; anti-aging.

ABBREVIATIONS

AMPK - AMP: activated protein kinase.

CR: Caloric Restriction (Restricción Calórica).

eIF5A: Eukaryotic Initiation Factor 5A.

FOXO: Forkhead Box O.

IL-6: Interleukin 6.

mTORC1: Mechanistic Target of Rapamycin Complex 1.

NAD+: Nicotinamide Adenine Dinucleotide.

NF-κB: Nuclear Factor kappa-light-chain-enhancer of activated B cells.

PGC-1α: Peroxisome Proliferator-Activated Receptor Gamma Coactivator 1-Alpha.

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ROS: Reactive Oxygen Species.

SIRT1: Sirtuin 1.

TFEB: Transcription Factor EB.

TNF-α: Tumor Necrosis Factor Alpha.

ULK1: Unc-51 Like Autophagy Activating Kinase 1.

INTRODUCTION

Aging is a global challenge with profound implications for public health, the economy, and society. This complex biological process is characterized by the progressive decline of cellular functions, increasing organismal vulnerability and contributing to the development of chronic diseases such as cardiovascular diseases, type 2 diabetes, and neurodegenerative disorders[1]. With an aging population on the rise, the search for effective strategies to promote healthy aging has become a scientific priority[2].

Among the cellular mechanisms affected by aging are the loss of proteostasis, accumulation of oxidative damage, and mitochondrial dysfunction. These processes lead to the buildup of misfolded proteins, damaged organelles, and reactive oxygen species (ROS), which are key factors in the functional decline associated with aging[3,4]. In this context, the regulation of autophagy and mitochondrial function has emerged as a promising therapeutic target to slow aging and prevent associated pathologies[5,6].

Caloric restriction (CR) is one of the most studied interventions for extending lifespan and improving health in experimental models. However, its implementation in humans faces practical barriers such as low adherence and potential adverse effects[7,8]. This has spurred interest in CR mimetics, compounds that emulate the beneficial effects of CR without requiring reduced caloric intake[9]. Among these, spermidine and berberine stand out as natural molecules with complementary effects on autophagy regulation, mitochondrial biogenesis, and cellular homeostasis[10,11].

Spermidine, a polyamine found in foods such as wheat germ, stimulates essential processes such as autophagy and proteostasis regulation, contributing to cellular longevity[12]. Berberine, an alkaloid derived from plants of the Berberis genus, promotes mitochondrial biogenesis and energy balance, with significant impacts on the prevention of metabolic diseases[13,14]. These complementary mechanisms position both compounds as key candidates in anti-aging strategies.

This study aims to narratively review the specific molecular mechanisms through which spermidine and berberine contribute to healthy aging. Additionally, their effects are compared, and their potential synergies in combined therapies are explored, discussing current limitations and opportunities for clinical application[15]. This review seeks to provide a solid scientific foundation to advance the development of more effective and personalized anti-aging interventions.

METHODS

A bibliographic search was conducted for documents used in this narrative review using MeSH terms and keywords in the PubMed, Scopus, Web of Science, and Cochrane Library databases to identify relevant articles on caloric restriction mimetics, with a particular focus on spermidine and berberine. The literature search covered the period from 2004 to 2024, as research in this field has primarily developed over the past two decades[16].

To maximize the comprehensiveness of the search and minimize bias, advanced search strategies were applied using Boolean operators and specific keyword combinations related to caloric restriction, autophagy, mitochondrial biogenesis, and the effects of spermidine and berberine in preclinical and clinical models. Additionally, the reference lists of selected articles were manually reviewed to identify additional relevant publications.

Studies were selected based on the following inclusion criteria:

- Original publications, systematic and non-systematic reviews, randomized controlled trials (RCTs), and observational studies.
- Articles analyzing the molecular mechanisms, therapeutic applications, and practical limitations of spermidine and berberine in preclinical and human models.
- Studies in English or Spanish with full-text access.

Studies were excluded if they:

- Focused on compounds other than spermidine and berberine.
- Were not available in English or Spanish.
- Lacked full-text access.
- Did not present appropriate methodologies or relevant data for the review.

To minimize bias in study selection, some elements of the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) methodology were applied in the identification, screening, eligibility, and inclusion of articles, despite this being a narrative review. The process began with retrieving documents from the mentioned databases. After removing duplicates, the titles and abstracts of all retrieved studies were reviewed. Studies that were not related, as well as conference proceedings, letters to the editor, viewpoints, and editorials, were excluded. For potentially relevant studies, full texts were reviewed before making the final selection.

The co-authors discussed and agreed on the final list of reference texts, totaling 15 (see Figure 1). Each article was

critically evaluated for methodological quality and scientific relevance, prioritizing those with the greatest impact and rigor. Studies with replicability and statistical validity were considered to ensure the reliability of the conclusions drawn.

To describe and explain the similarities and differences between the various analyzed elements, the study employed a descriptive comparative approach. This involved selecting elements of interest, analyzing the similarities, and describing the selected elements within their respective contexts.

RESULTS

Aging is a complex biological process that affects all multicellular organisms, involving structural and functional changes that increase vulnerability and reduce the organism's adaptive capacity[1]. One key factor contributing to functional decline is the loss of proteostasis, a critical process for cellular homeostasis and healthy longevity[2,3].

During aging, the ability to maintain protein stability and functionality decreases, leading to the accumulation of misfolded

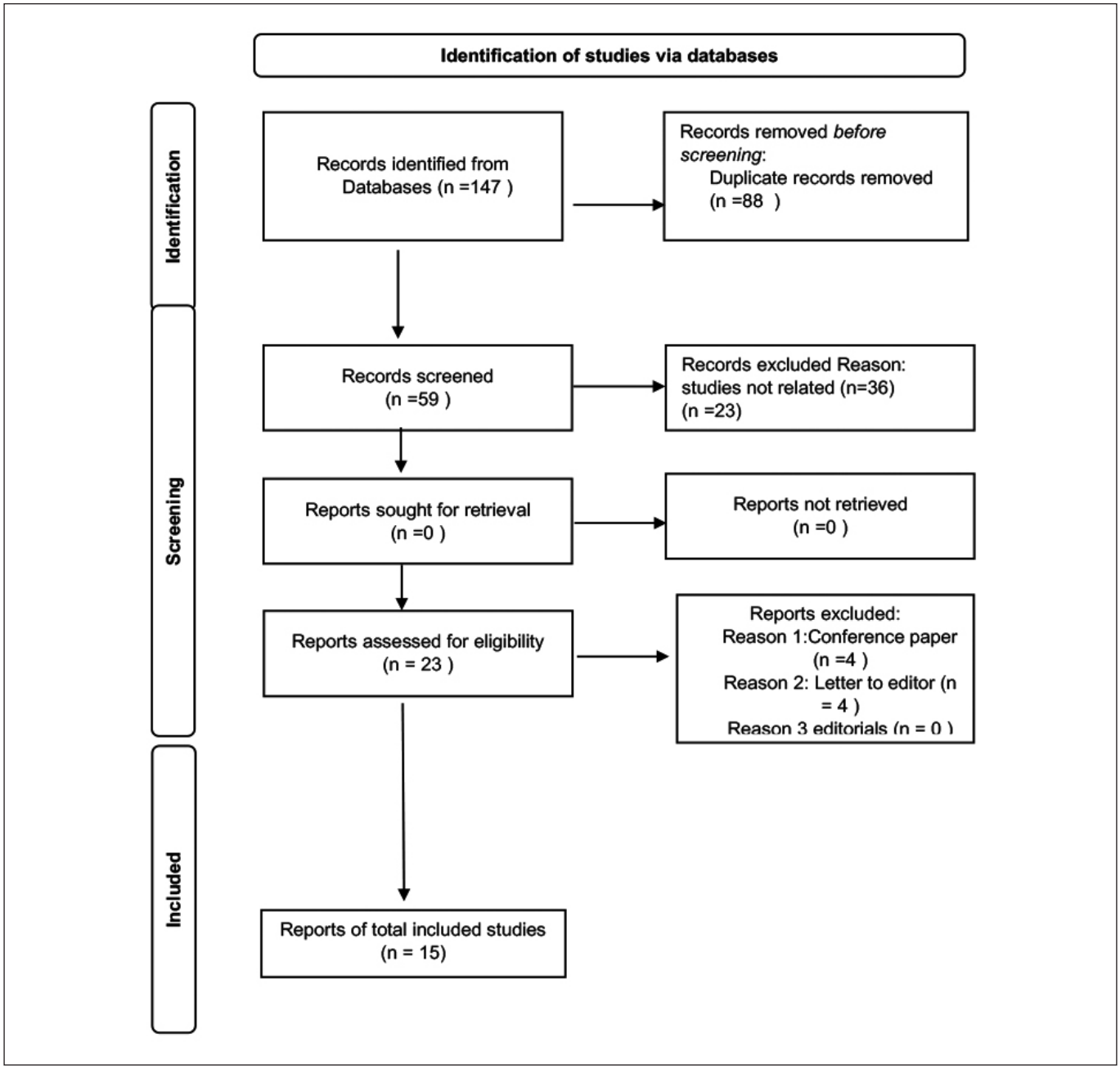

Figure 1. Flowchart to illustrate the process of selecting and filtering articles in this narrative review (PRISMA Model Realignment)

Table 1. Summary table with the works located that deal with the topics studied

Title	Authors	Journal
Meta-analysis of the effect and safety of berberine in the treatment of type 2 diabetes mellitus, hyperlipemia and hypertension	Lan, J., Zhao, Y., Dong F., Yan, Z., Zheng, W., Fan, J., Sun, G.	J. Ethnopharmacol.
Calorie restriction mimetics: can you have your cake and eat it, too?	Ingram DK, Roth GS.	Ageing Res Rev
Higher spermidine intake is linked to lower mortality: a prospective population-based study	Kiechl, S. et al.	Am. J. Clin. Nutr.
The effect of spermidine on memory performance in older adults at risk for dementia: a randomized controlled trial	Wirth, M. et al.	Cortex
Caloric restriction mimetics against age-associated disease: targets, mechanisms, and therapeutic potential	Madeo F., Carmona-Gutierrez D., Hofer S. J., Kroemer G.	Cell Metab.
Polyamines control eIF5A hypusination, TFEB translation, and autophagy to reverse B cell senescence	Zhang, H. et al.	Mol. Cell
Effects of spermidine supplementation on cognition and biomarkers in older adults with subjective cognitive decline (SmartAge)-study protocol for a randomized controlled trial	Wirth, M. et al.	Alzheimers Res Ther.
Berberine in Cardiovascular and Metabolic Diseases: From Mechanisms to Therapeutics	Feng, X., Sureda, A., Jafari, S., Memariani, Z., Tewari, D., Annunziata, G., et al.	Theranostics
Spermidine alleviates cardiac aging by improving mitochondrial biogenesis and function	Wang, J. et al.	Aging
Identification of longevity compounds with minimized probabilities of side effects	Janssens, G. E. & Houtkooper, R. H.	Biogerontology
The quest to slow ageing through drug discovery	Partridge, L., Fuentealba, M. & Kennedy, B. K.	Nat. Rev. Drug Discov.
Spermidine-induced hypusination preserves mitochondrial and cognitive function during aging	Hofer, S. J. et al.	Autophagy
eIF5A hypusination, boosted by dietary spermidine, protects from premature brain aging and mitochondrial dysfunction	Liang, Y. et al.	Cell Rep.
Effects of Berberine on the Gastrointestinal Microbiota	Zhang, L., Wu, X., Yang, R., Chen, F., Liao, Y., Zhu, Z., et al.	Front. Cel. Infect. Microbiol.
Mechanisms of spermidine-induced autophagy and geroprotection	Hofer, S. J. et al.	Nat. Aging

proteins and toxic aggregates characteristic of age-related diseases such as Alzheimer's and Parkinson's disease[1,2]. This progressive deterioration arises from mitochondrial homeostasis disruption, caused by external factors and intracellular triggers such as advanced glycation end products, highly toxic protein aggregates, or excessive ROS production due to abnormal mitochondrial respiration[5,6].

Cells deploy mechanisms to counteract these damages, with proteostasis being one of the most effective. Proteostasis encompasses processes that ensure the proper folding, quality control, and degradation of proteins, including the ubiquitin-proteasome system and autophagy, both of which facilitate the elimination of damaged or unnecessary proteins.

In elderly individuals, these protective systems are also impaired, diminishing cellular defenses, increasing vulnerability, and contributing to pathological effects typical of advanced age[6,7]. Reduced system efficiency leads to the accumulation of defective proteins and generalized cellular deterioration[1,2]. Additionally, macroautophagy, responsible for eliminating dysfunctional organelles and proteins, declines with age, exacerbating proteostatic collapse and accelerating organismal decline[8].

Properly stimulated, macroautophagy can renew proteostasis, making it an excellent target for anti-aging interventions. Research suggests that improving mitochondrial function and proteostasis simultaneously could yield synergistic benefits[9,10,11], necessitating interventions that maximize efficacy.

From a therapeutic perspective, maintaining autophagy is essential for cellular function, with several intervention strategies emerging:

Targeting signaling pathways such as IGF-1/insulin and the AMP/ATP ratio. Autophagy is stimulated by nutrient scarcity or a high AMP/ATP ratio but is inhibited by nutritional abundance. This correlates with energy restriction-based interventions[12]. Additionally, the IGF-1/insulin pathway and FOXO/DAF-16 transcription factors promote autophagy, as does SIRT1 activation via polyphenols, NAD+, or caloric restriction (CR).

Modulating autophagy-related proteins. Autophagy activation depends on the ULK1 kinase, regulated by AMPK and the mTORC1 complex, which stimulates Beclin 1, a key autophagy-promoting protein. Studies on mimicking Beclin 1 activity show promising potential[13].

Enhancing autophagosome activity and lysosomal function. Dietary interventions such as energy restriction show high efficacy in modulating these processes by interacting with key signaling pathways.

Several therapeutic interventions have been proposed to delay aging and associated diseases[14,15], focusing on mechanisms that sustain cellular survival and proteome stability (proteostasis). This is crucial in preventing chronic and degenerative age-related diseases[16].

Proteostasis dysfunction is linked to various pathologies, particularly in tissues with low cellular turnover (nervous system, myocardium), which are especially susceptible to cumulative damage. Disruptions in proteostasis contribute to the development of neurodegenerative diseases like Alzheimer's and Parkinson's, which are prevalent among older populations[1]. Maintaining the cellular proteome is vital not only for health and longevity but also for reducing degenerative disease incidence and achieving healthy aging[2,16].

Dietary interventions involving energy restriction[17] have shown promise but face challenges such as low adherence and adverse effects like sarcopenia risk[18]. Alternatives include compounds capable of mimicking CR benefits while limiting its adverse effects, known as CR mimetics[12,13,19].

Natural compounds such as spermidine and berberine have been identified as active promoters of proteostasis. These two agents, with well-documented anti-aging properties, stand out for their potential roles in maintaining cellular health and longevity.

SPERMIDINE

Spermidine is a naturally occurring substance found in various foods and endogenously in the human metabolism. Recent studies have highlighted its ability to stimulate autophagy[20-22]. It acts by inhibiting acetyltransferases and activating key signaling pathways such as AMPK, SIRT1, and FOXO3a, in addition to modulating autophagic factors related to lysosomal biogenesis, thereby contributing to cellular longevity and maintaining proteostasis[1,23].

Chemically, spermidine is a natural polyamine that plays a crucial role in cellular metabolism, particularly in the context of aging. It is synthesized endogenously and can also be obtained from dietary sources, including wheat germ, soybeans, nuts, and fermented vegetables, as well as whole-grain-derived products. Its anti-aging properties and effects on essential cellular processes, such as autophagy, cellular repair, and metabolic regulation, have gradually been revealed[1,2].

Polyamines, such as spermidine, are organic compounds containing multiple amino groups, enabling them to interact with nucleic acids and proteins. This molecular interaction makes spermidine vital for maintaining cellular homeostasis and modulating metabolic pathways, which are particularly vulnerable during aging[2,4]. Spermidine, along with other polyamines, stabilizes nucleic acid and protein structures, key factors in preserving cellular integrity. Moreover, it regulates gene expression and protects against oxidative stress, which are crucial in preventing age-related diseases and promoting longevity[2-4].

Molecular Mechanisms

One of spermidine's primary mechanisms of action in aging is its induction of autophagy, a catabolic process that enables cells to degrade and recycle damaged or unnecessary components. Autophagy is essential for removing misfolded proteins and dysfunctional organelles, processes that decline with age and contribute to the accumulation of toxic cellular waste.

Spermidine promotes autophagy by inhibiting acetyltransferases, enzymes that acetylate certain proteins, thereby suppressing autophagy. By inhibiting these enzymes, spermidine maintains the activity of key autophagic proteins, facilitating the removal of damaged components and supporting proteostasis and cellular protection throughout aging[2,4].

Autophagy regulation by spermidine is well-documented and central to its therapeutic potential in anti-aging. Experimental models have demonstrated its ability to improve protein quality and reduce the burden of toxic aggregates in critical organs such as the nervous system and liver, which are particularly affected by aging-related waste accumulation[3,4].

Another significant mechanism is spermidine's activation of AMPK and regulation of mTORC1 activity, two key players in

longevity signaling and cellular metabolism. AMPK acts as a metabolic sensor under low-energy conditions, regulating anabolic and catabolic pathways to preserve cellular energy. By activating AMPK, spermidine enhances autophagy and mitochondrial biogenesis, critical processes for maintaining cellular efficiency and reducing oxidative damage[1,4].

mTORC1, which regulates cell growth and proliferation in response to nutrient levels, is overactivated during aging, leading to autophagy inhibition and increased accumulation of misfolded proteins. Spermidine inhibits mTORC1 activity, facilitating autophagy activation and reducing protein damage and cellular inflammation. These effects on AMPK and mTORC1 pathways not only enhance cellular quality but are also associated with increased longevity and improved function in animal models[2,4].

Telomere length is a key indicator of cellular aging, as telomeres shorten with each cell division until the cell loses its ability to divide. Spermidine may contribute to telomere protection by activating telomerase, helping to maintain their length and preventing premature shortening, particularly in highly proliferative tissues such as the immune and epithelial systems, where this protection is essential for proper functioning[2,5]. This positions spermidine as a potential anti-aging compound, as it may delay cellular aging and reduce aging-related diseases in these tissues[5].

A key mechanism related to proteostasis is the post-translational hypusination of eIF5A, a protein essential for protein translation that is activated through this highly conserved process[21,24-26]. Hypusination occurs in two steps: DHS (deoxyhypusine synthase) transfers a 4-aminobutyl group from spermidine to a lysine residue on eIF5A, requiring NAD+. Subsequently, DOHH (deoxyhypusine hydroxylase) converts deoxyhypusine into hypusine by adding an OH group, enabling eIF5A activation 21.

eIF5A activation regulates protein synthesis during initiation, elongation, and termination phases, overcoming ribosomal stalling[27]. It also facilitates the translation of mitochondrial proteins, improving mitochondrial functionality and stimulating autophagy[28-31]. This process further activates TFEB, a transcription factor that regulates lysosomal biogenesis and autophagy by inducing pro-autophagic genes. TFEB is inhibited by mTORC1, which has anti-autophagic activity[30,31].

Spermidine plays a crucial role in autophagy stimulation through the activation of eIF5A and TFEB. Reduced spermidine levels may impair the functionality of mitochondria-dependent cells, such as immune cells[21,29]. TFEB activation via eIF5A could also enhance mitophagy, optimizing energy production and mitochondrial biogenesis[20,32].

These mechanisms are particularly significant in the context of neurodegenerative diseases such as Alzheimer's and Parkinson's, where the accumulation of defective proteins has devastating effects. By promoting eIF5A and TFEB activation, spermidine offers therapeutic potential to improve protein quality and cellular homeostasis, reducing the impact of these disorders[8,16].

Evidence in Animal and Human Models

Experimental evidence supporting spermidine's effects on health and longevity is robust in both animal models and observational human studies. In murine models, spermidine supplementation extended lifespan and improved cardiac health, memory, and immune function. These benefits are attributed to its ability to activate autophagy, enhance mitochondrial function, and reduce defective protein accumulation in critical tissues essential for survival and quality of life[8,16].

Preclinical studies have demonstrated its potential to delay aging and improve health in animal models. Given its low likelihood of adverse effects[33], spermidine is considered a promising candidate for clinical trials in humans[34].

In humans, controlled clinical trials are needed to confirm its effects suggested by animal research. Current findings support its use as an anti-aging agent that could be integrated into dietary and therapeutic strategies to enhance health during aging. Epidemiological studies suggest that regular consumption of spermidine-rich foods correlates with a lower incidence of cardiovascular diseases and increased healthy longevity. A high-spermidine diet has been linked to improved longevity, reduced mortality, and a lower prevalence of age-associated diseases such as cardiovascular diseases and cancer. Furthermore, it has shown potential to mitigate cognitive decline, correlating with greater hippocampal volume and cortical thickness, both associated with preserved cognitive function in older individuals[20,35-37].

Limited clinical studies with spermidine have reported positive effects in aging-related contexts. For example, a study using wheat germ extract, rich in spermidine, evaluated cognitive aspects in individuals over 60. An initial three-month phase observed slight memory improvement[38]. However, an extended 12-month follow-up showed no significant improvement except in high-adherence subgroups, where evident benefits emerged[39].

While spermidine appears safe[33], caution is advised with high doses in individuals with neoplastic conditions, as polyamines have been linked to cancer development. Nevertheless, spermidine's potential to reduce cancer risk through autophagy stimulation and immune surveillance offers a counterpoint, making it a promising candidate for further investigation.

BERBERINE

Berberine is a plant-derived compound with numerous beneficial properties. It has been shown to activate the AMPK pathway, which supports mitochondrial biogenesis and cellu-

lar energy metabolism, improving ATP production in striated muscle. These activities are essential for preserving mitochondrial function and protein balance, both of which are key in preventing metabolic and neurodegenerative diseases associated with aging[1,19].

Berberine is an isoquinoline alkaloid extracted from various plants in the Rutaceae, Ranunculaceae, and Berberidaceae families. In the latter, the Berberis genus is particularly notable, with species such as B. vulgaris (barberry) and B. aristata. This compound has a long history in traditional Chinese medicine and other ancient medical practices for its antimicrobial, anti-inflammatory, antidiabetic, anticancer, and cardiovascular therapeutic properties[40-42].

Despite its low bioavailability, berberine has garnered significant scientific interest due to its ability to improve glycemic control and lipid metabolism, making it a promising option for managing metabolic diseases[43]. Advances in formulations to enhance its bioavailability have further positioned berberine as an anti-aging agent.

With its unique chemical structure, berberine exhibits high affinity for key enzymes and molecular pathways critical in metabolic regulation. It influences processes related to inflammation, mitochondrial dysfunction, and oxidative stress, providing therapeutic benefits not only in managing chronic diseases like diabetes and dyslipidemia but also in improving quality of life and longevity in aging populations[44].

Molecular Mechanisms

Berberine regulates two crucial proteins involved in cellular energy control and metabolic homeostasis: SIRT1 (sirtuin 1) and AMPK. SIRT1 activation is critical for mitochondrial biogenesis, allowing cells to replace dysfunctional mitochondria. This process reduces aging-associated cellular damage and enhances energy production efficiency[43,45].

AMPK activation, on the other hand, stimulates autophagy and regulates lipid and glucose metabolism. It plays a key role in maintaining ATP levels and clearing damaged proteins and organelles through autophagy. These effects improve mitochondrial function and eliminate dysfunctional components, preserving cellular integrity and functionality during aging[43,45].

Mitochondrial dysfunction, a hallmark of cellular aging, is characterized by inefficient energy production and increased ROS generation, which damage proteins, lipids, and DNA. Berberine mitigates mitochondrial dysfunction by activating AMPK and SIRT1, promoting mitochondrial biogenesis and ATP production in energy-demanding tissues like skeletal muscle. This function is especially relevant in aging, as it helps preserve muscle mass and functional capacity[44,45].

Berberine also reduces oxidative stress by lowering ROS levels, protecting cells from damage and improving metabolic efficiency. This mechanism is vital for combating aging-associated diseases such as cardiovascular and neuromuscular pathologies[45].

Furthermore, berberine exhibits anti-inflammatory and antioxidant properties, essential for its anti-aging potential. It modulates the expression of pro-inflammatory and antioxidant genes, targeting signaling pathways involving NF-κB and PGC-1α. NF-κB inhibition reduces pro-inflammatory cytokines such as IL-6 and TNF-α, key contributors to chronic low-grade inflammation that accelerates aging and age-related diseases like diabetes and cardiovascular disorders[46].

Berberine also enhances PGC-1α activity, a regulator of mitochondrial biogenesis and antioxidant mechanisms, which protects cells from oxidative damage. This activity is particularly beneficial for metabolic health and cognitive function, mitigating the impact of inflammatory and oxidative processes that intensify with aging[46].

Evidence in Animal and Human Models

Berberine has demonstrated positive effects in several animal models and human clinical studies, supporting its potential as an anti-aging agent. In aged rodents, berberine administration improved cognitive and muscular function, reduced mitochondrial dysfunction, and decreased oxidative stress in muscle tissue. These effects are attributed to the activation of the AMPK/SIRT1/PGC-1α pathway, which regulates mitochondrial function and cellular turnover, reversing certain aspects of functional decline associated with aging[45,46].

Preliminary human clinical trials have shown benefits in glucose and lipid control, suggesting its potential to improve metabolic health in middle-aged and older individuals. Additionally, berberine consumption has been associated with reduced inflammatory markers in patients with metabolic diseases, indicating its role in preventing age-related conditions like diabetes and cardiovascular diseases[43,44].

DISCUSSION

Spermidine and berberine share fundamental mechanisms in their anti-aging effects, particularly AMPK activation and autophagy regulation. This activation improves cellular metabolism, mitochondrial function, and the removal of waste products, directly contributing to cellular longevity and metabolic health during aging[12,43].

Both compounds stimulate autophagy through specific mechanisms. Spermidine inhibits acetyltransferases, promoting the deacetylation of key proteins involved in autophagy. Berberine, via AMPK activation, similarly stimulates cellular recycling, maintaining homeostasis and reducing oxidative stress caused by damaged proteins[1,2,45]. These shared effects are critical in protecting against neurodegenerative and metabolic diseases, such as cardiovascular conditions, that are common in aging[46].

Despite these similarities, spermidine and berberine exhibit key differences in their mechanisms of action, suggesting complementary benefits when combined in anti-aging therapies. Spermidine uniquely modulates signaling pathways that directly impact protein quality, such as its interaction with transcription factors like FOXO3a and its ability to activate eIF5A. This supports lysosomal biogenesis and proteostasis, enhancing cellular function and reducing toxic protein aggregates associated with aging-related diseases[2,16].

In contrast, berberine's additional effects on lipid and glucose metabolism, mediated through SIRT1 activation and mitochondrial biogenesis, make it especially effective in mitigating mitochondrial dysfunction and protecting against metabolic diseases like type 2 diabetes and cardiovascular disorders[43,44].

The combination of these effects offers a multifactorial approach, optimizing various aspects of cellular aging, from the removal of damaged proteins to supporting healthy mitochondrial function[46]. A combined intervention could yield synergistic effects, enhancing the efficacy of anti-aging therapies by addressing both proteostasis and bioenergetics, two critical factors in aging.

Current Limitations in Research

Despite the growing interest in spermidine and berberine as anti-aging compounds, their practical implementation faces significant limitations. One of the most notable barriers is their low bioavailability. Spermidine has limited bioavailability, reducing its effectiveness in human contexts. Similarly, berberine demonstrates poor bioavailability due to its low intestinal absorption and rapid hepatic elimination. These factors limit the concentration of these compounds in target tissues, impacting their clinical efficacy[43,44].

In addition to pharmacokinetic limitations, there are few longitudinal human studies evaluating their long-term effects. Although animal models have shown positive results in lifespan extension and improvements in metabolic and cognitive function, extrapolating these findings to humans remains challenging. Anti-aging interventions require extended follow-up periods to adequately evaluate their benefits and risks, but current studies are limited in observation time, complicating the understanding of cumulative effects and the long-term safety of these compounds[45,46].

Future Potential in Anti-Aging Therapies

To enhance the efficacy of spermidine and berberine, research focusing on improving their bioavailability is essential. One possibility is the development of advanced formulations to improve absorption, such as nanoparticle delivery systems or liposomal encapsulation, strategies that have been shown to increase the availability of other bioactive compounds.

Another approach could involve designing structural analogs of spermidine and berberine specifically engineered to resist metabolic degradation and improve absorption in the digestive system[43].

Table 2. Comparative summary of similarities and differences in the mechanisms of action of spermidine and berberine in anti-aging interventions targeting proteostasis

Characteristic	Spermidine	Berberine	Similarities
AMPK Activation	Indirectly activates AMPK, improving energy balance.	Directly activates AMPK, supporting autophagy and mitochondrial function.	Both activate AMPK, promoting cellular longevity.
Autophagy Stimulation	Inhibits acetyltransferases, facilitating autophagy.	Stimulates autophagy via AMPK, reducing oxidative stress.	Both eliminate damaged proteins and organelles.
Mitochondrial Function	Indirectly improves mitochondrial function.	Directly facilitates mitochondrial biogenesis via SIRT1.	Both support mitochondrial health.
Proteostasis	Maintains protein quality and reduces harmful aggregates.	Does not directly affect proteostasis but reduces oxidative damage.	Spermidine focuses on protein quality, while berberine reduces oxidative damage.
Additional Effects	Protects against neurodegenerative diseases.	Assists in metabolic diseases (type 2 diabetes, cardiovascular issues).	Both protect against aging-related diseases.
Combined Applications	Optimizes cellular quality when used with berberine.	Enhances mitochondrial function when combined with spermidine.	Potential combination for a comprehensive anti-aging therapy.
Precautions	High doses may alter protein balance.	Excess AMPK or SIRT1 may disrupt cellular signaling.	Both require dose control to avoid side effects.

Additionally, it is crucial to determine the optimal dosage and potential side effects of these compounds when administered over long periods. The interaction of spermidine and berberine with various molecular pathways could have unintended effects in certain contexts, potentially disrupting cellular balance in healthy individuals. Future clinical trials should focus on defining safe and effective doses of these compounds and understanding their combined effects with other anti-aging agents, such as metformin and resveratrol, paving the way for more personalized and effective therapies[44,46].

Clinical Implications

The integration of spermidine and berberine into clinical practice holds significant potential for preventing and treating aging-related diseases. By promoting proteostasis and enhancing autophagy, spermidine emerges as a promising option for managing neurodegenerative diseases where the accumulation of misfolded proteins plays a key pathogenic role. Preclinical studies suggest that it can improve neuronal health and protect against cognitive decline, although more human research is needed to confirm its effectiveness in these specific contexts[43,45].

On the other hand, berberine, with its ability to improve glucose and lipid metabolism alongside its positive effects on mitochondrial biogenesis, offers potential applications in treating metabolic diseases such as type 2 diabetes and dyslipidemia, as well as improving cardiovascular function in aging populations. The regulation of SIRT1 and AMPK by berberine supports mitochondrial health and energy homeostasis, key factors in preventing metabolic and cardiovascular diseases. As a complementary therapy, berberine could help manage metabolic risk factors and enhance the quality of life in older adults[43,45].

The combination of these two substances in personalized medicine strategies represents an innovative approach to addressing aging and its associated diseases. These molecules could be incorporated into individualized protocols based on patients' genetic, metabolic, and lifestyle characteristics. For example, genetic profiling to identify variations in genes related to autophagy, such as ATG5 and FOXO3, or mitochondrial function, such as PGC-1α, could guide the dosing and formulation of combined therapies. Additionally, the use of specific biomarkers, such as ROS or proteostasis indicators, could further optimize their clinical application.

In practice, these molecules could be administered as supplements within dietary regimens tailored to individual needs or integrated into combination treatments with other geroprotective agents. Advanced technologies, such as wearable devices that measure oxidative stress or metabolic activity, could enable real-time intervention adjustments, maximizing therapeutic responses. This approach could not only enhance healthy longevity but also prevent the progression of chronic diseases, paving the way for more effective and targeted therapies in anti-aging medicine.

CONCLUSIONS

Spermidine and berberine demonstrate significant potential in modulating key cellular processes related to longevity, such as autophagy and mitochondrial biogenesis. Their complementary action could offer a promising therapeutic approach to prevent aging-related diseases.

Despite the demonstrated benefits, their clinical application remains limited due to poor bioavailability and the need for long-term clinical trials.

Future research should focus on developing advanced formulations that optimize the absorption and stability of these compounds, as well as determining optimal dosages and interactions with other anti-aging agents. Long-term clinical trials will be essential to confirm the safety and efficacy of these therapies in aging human populations.

Exploring synergistic combinations of spermidine and berberine, aimed at improving proteostasis and mitochondrial function, could address multiple aspects of cellular aging, thereby promoting healthy and high-quality longevity.

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Estimación de la edad gestacional mediante antropometría neonatal en una población residente a gran altitud

Estimation of gestational age by neonatal anthropometry in a high altitude resident population

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RESUMEN

Antecedentes: La edad gestacional suele predecir el pronóstico de los recién nacidos y en determinados casos orienta a brindar atenciones específicas. Sin embargo, en poblaciones con un abordaje prenatal subóptimo el uso de métodos convencionales no siempre es posible. Por otro lado, el principal indicador antropométrico, el peso, es menor debido a la hipoxia crónica; surgiendo la necesidad de evaluar la capacidad de otras medidas antropométricas para estimar la edad gestacional y así mejorar la calidad de atención en esta población.

Objetivos: Explorar la capacidad de predecir la edad gestacional, usando medidas antropométricas no habituales en un hospital situado a 3250 metros sobre el nivel del mar (msnm) en los andes peruanos.

Métodos: Se realizó un estudio transversal prospectivo durante el periodo de Junio a Setiembre de 2024 incluyendo a 242 recién nacidos, usando como medidas antropométricas la circunferencia de brazo (CB), circunferencia de muslo (CM) y circunferencia de pantorrilla (CP), mediante técnicas estandarizadas. Se adoptó métodos estadísticos estándar para determinar el límite crítico, coeficiente de correlación y estimación mediante análisis de regresión. El indicador de desenlace fue el mejor modelo de regresión.

Resultados: Las medidas antropométricas mostraron una correlación positiva con la edad gestacional hasta las 37 semanas, luego del cual fue menor. Se halló una correlación positiva entre la suma de las circunferencias con la edad gestacional para mujeres y varones de: CB+CM+CP (r=0,840), CB+CM+CP (r=0,868); y, la estimación de edad gestacional en semanas mediante las fórmulas: EG= 18,022+ (CM*0,885) + (CP*0902) o EG= 16,79 + (CM*0,894) + (CP*1,008) respectivamente.

Conclusión: La edad gestacional de neonatos nacidos de madres residentes en altura, puede estimarse usando medidas antropométricas como CB, CM, CP; siendo la combinación de CM y CP la de mejor eficacia. Por lo que, se sugiere hacer uso de ellos cuando los métodos estándar no sean posibles de realizar.

PALABRAS CLAVE

Altitud, neonatología, antropometría, longitud, gestación, edad gestacional (DeCS).

ABSTRACT

Background: Gestational age often predicts the prognosis of newborns and in certain cases guides the provision of specific care. However, in populations with a suboptimal prenatal approach, the use of conventional methods is not always pos-

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sible. On the other hand, the main anthropometric indicator, weight, is lower due to chronic hypoxia; there is a need to evaluate the capacity of other anthropometric measures to estimate gestational age and thus improve the quality of care in this population.

Objectives: To explore the ability to predict gestational age, using non-standard anthropometric measurements in a hospital located at 3250 meters above sea level (masl) in the Peruvian Andes.

Methods: A prospective cross-sectional study was conducted from June to September 2024, including 242 newborns, using arm circumference (AC), thigh circumference (TC), and calf circumference (CC) as anthropometric measurements, using standardized techniques. Standard statistical methods were adopted to determine the critical limit, correlation coefficient, and estimation by regression analysis. The outcome indicator was the best regression model.

Results: Anthropometric measurements showed a positive correlation with gestational age up to 37 weeks, after which it was lower. A positive correlation was found between the sum of the circumferences and gestational age for women and men of: AC+TC+CC (r=0.840), AC+TC+CC (r=0.868); and, the estimation of gestational age in weeks using the formulas: EG= 18.022 + (CM*0.885) + (CP*0902) or EG= 16.79 + (CM*0.894) + (CP*1.008) respectively.

Conclusion: The gestational age of newborns born to mothers living at high altitude can be estimated using anthropometric measurements such as BC, CM, CP; the combination of CM and CP being the most effective. Therefore, it is suggested to use them when standard methods are not possible.

KEYS WORDS

High altitude, neonate, antropometry, pregnancy, gestational age. (MeSH terms).

INTRODUCCIÓN

A nivel mundial, según UNICEF se ha observado que 2, 3 millones de niños mueren en el primer mes de vida, con una media aproximada de 6400 muertes neonatales por día, lo cual resulta alarmante[1]. Mientras que en la tasa de mortalidad neonatal en el Perú es variable según regiones, y oscilan entre 7,54 – 15,67 muertes por 1000 nacidos vivos, con una media de 11 aproximadamente[2,3]..

La problemática es multifactorial y dos aspectos importantes son la condición de bajo peso al nacer y prematuridad, ya que éstos tienen un mayor riesgo de complicaciones no sólo en el periodo neonatal, sino también de morir durante el primer año de vida; del mismo modo que predicen la salud global durante los primeros años de vida, el crecimiento, desarrollo psicosocial y posibilidades de supervivencia futura[4-6].

Por lo mismo, aquellos neonatos considerados de alto riesgo para morbilidad y mortalidad, como los prematuros, y que en ocasiones suelen asociarse a un desarrollo fetal anormal deben ser identificados y monitoreados regularmente. En general se suele realizar medidas antropométricas como el peso, perímetro cefálico, toráxico, abdominal y talla; pero no es usual usar otras como la medición de las extremidades. Los parámetros antropométricos alternativos, como la circunferencia del brazo (CB), del muslo (CM) y de la pantorrilla (CP), se pueden usar para evaluar el crecimiento del recién nacido e identificar a los bebés en riesgo. De esta manera, al menos en poblaciones a nivel del mar, algunos de estos estudios ya han encontrado una relación sustancial entre la circunferencia de la parte media del brazo y el muslo con la edad gestacional[7-9].

Sin embargo, existen condiciones multifactoriales que hacen que una sociedad no tenga una totalidad de gestantes con controles adecuados y de ese modo la estimación de la edad gestacional no es posible por los métodos estándar, pero si lo es la evaluación antropométrica del recién nacido.

Respecto al comportamiento de estas variables, se ha descrito un crecimiento diferente en poblaciones de elevada altitud; los primeros datan de la década de los 70´s hallando una mayor incidencia de retraso de crecimiento intrauterino. Por otro lado, estudios más recientes mostraron una disminución de peso de entre 54,7 gr a 96,9 gr por cada 1000 metros que se asciende sobre el nivel del mar y en otros casos una mayor proporción de bajo peso al nacer 11,7% frente a 8,8% [10-12]. En ese sentido, esta investigación pretende explorar la capacidad de utilizar las medidas antropométricas no frecuentes para predecir la edad gestacional en neonatos que son producto de gestaciones a elevada altitud (3270 msnm).

MATERIAL Y MÉTODOS

Estudio analítico de corte transversal con los recién nacidos en el Hospital Regional Docente Materno Infantil "El Carmen", Huancayo, Perú. Se determinó el tamaño de la muestra de 385 neonatos para un reporte anual estadístico de 3917 nacimientos durante el último año, con un límite de confianza del 95% y 5% de error alfa. El muestreo consecutivo fue empleado como técnica de muestreo para seleccionar la recién nacidos que cumplieron los criterios de inclusión.

Los criterios de inclusión fueron: recién nacidos entre junio y setiembre del 2024, contar con una historia completa y parto sin complicaciones.

Los criterios de exclusión fueron: anomalías congénitas de las extremidades, gestación múltiple, restricción del crecimiento intrauterino, diabetes mellitus gestacional y complicaciones del embarazo, como anemia y trastornos hipertensivos del embarazo. Recién nacidos con una diferencia de más de 2 semanas entre la fecha de última menstruación y la puntuación obtenida por examen físico ya sea por

Capurro B o de Ballard. La muestra final estuvo compuesta por 242 recién nacidos.

La edad gestacional se determinó considerando el siguiente orden de prioridad: ecografías del primer trimestre, examen físico por Capurro B y método Ballard a las 12 horas del post natal en prematuros[13,14].

Dentro de 48 horas del parto, los recién nacidos seleccionados fueron examinados utilizando procedimientos estandarizados para medir las variables antropométricas de las extremidades[15,16].

La circunferencia media del brazo, se midió en el punto equidistante entre el proceso del acromion y el proceso del olécranon del brazo izquierdo. La circunferencia del muslo se midió en posición supina al nivel del surco más bajo de la región glútea izquierda; la cinta se colocó perpendicular al eje longitudinal del miembro inferior. La circunferencia de la pantorrilla se midió en el punto más prominente de la pierna izquierda en posición semiflexionada.

Análisis estadístico

Para el análisis estadístico, se evaluó la distribución de los datos mediante la prueba de Shapiro-Wilk. Se utilizaron medidas de tendencia central y dispersión para describir las variables continuas, reportando medianas y rangos intercuartílicos debido a la naturaleza no paramétrica de los datos. La comparación de medidas antropométricas entre sexos se realizó mediante la prueba U de Mann-Whitney.

Para evaluar la relación entre la edad gestacional y las medidas antropométricas neonatales, se empleó la prueba de correlación de Spearman. Posteriormente, se llevó a cabo un análisis de regresión lineal múltiple para identificar los mejores predictores de la edad gestacional, utilizando como variables independientes las circunferencias de brazo, muslo y pantorrilla. La validez del modelo se evaluó mediante el coeficiente de determinación ajustado (R^2) y la inspección de los residuos.

Además, se construyó un modelo de regresión logística para predecir la prematuridad (<37 semanas de gestación) en función de las medidas antropométricas. La capacidad discriminativa del modelo se evaluó mediante la construcción de curvas ROC individuales para cada variable (circunferencia de brazo, muslo y pantorrilla) y una curva ROC combinada utilizando las tres medidas. Se calculó el área bajo la curva (AUC) para cada modelo, encontrándose que la circunferencia de muslo tuvo la mayor capacidad discriminativa de manera individual, mientras que el modelo combinado mostró el mejor desempeño global con un AUC de 0.98.

Todos los análisis se realizaron utilizando los paquetes estadísticos Python (pandas, scipy, statsmodels y scikit-learn), considerando un nivel de significancia de $p < 0.05$.

Aspectos éticos

El estudio fue aprobado por el comité de ética del Hospital Regional Docente Materno Infantil "El Carmen", la recolección de datos resguardó los datos sensibles y la base de datos registró solo las variables estudiadas, sin contener datos de identificación.

RESULTADOS

Las características generales de la muestra estudiada se presentan en la **Tabla 1**. Se observó una media de edad materna de 28,5 años, en su mayoría con grado de instrucción secundaria 76% y culminación de embarazo por parto vaginal frente al de cesárea (78,9% vs 21,1%). Asimismo, en su mayoría provenían de una zona urbana (88,4%), respecto a la zona rural (11,6%). En cuanto a los neonatos, se observó la

Tabla 1. Características generales de los participantes

Características maternas	
Edad (años)	
Media +/- D.S.	28,45 +/- 4,6
Mínimo	19
Máximo	43
Grado de Instrucción	
Sin instrucción	2
Primaria	1
Secundaria	184
Superior	55
Tipo de parto	
Vaginal	191
Cesárea	51
Paridad	
1	58
2-3	117
> 3	67
Procedencia	
Rural	28
Urbano	214
Total	242

Tabla 1 cont. Características generales de los participantes

Características maternas	
Características de los neonatos	
Edad (semanas)	
Media +/- D.S.	38,84 +/- 1,49
Mínimo	34
Máximo	41
Pretérmino	20
A término	222
Peso al nacer (gramos)	
Media +/- D.S.	3117,04 +/- 253,1
Mínimo	2530
Máximo	3975
Sexo	
Masculino	108
Femenino	134
Total	242

predominancia del sexo femenino 55,1% frente al masculino 44,9% con una media de edad gestacional de 38,8 semanas, siendo a término un 86,7% y prematuros un 13,3%; el peso al nacer promedio se halló en 3117,04.

Asimismo, en cuanto a la distribución poblacional, se encontró ligera tendencia hacia los de sexo masculino Figura 1.

Mientras que en el análisis segregado por sexos y edad gestacional (pretérmino y a término) **Tabla 2**; se encontró un ligero mayor peso y talla en el sexo femenino frente al masculino indistintamente de la condición de prematuridad; pero no en las otras medidas antropométricas CB, CM y CP.

Respecto a la correlación entre las medidas antropométricas con la edad gestacional, según condición de nacido prematuro o a término, estos se muestran en la **Tabla 3**. En prematuros, la CB tuvo la menor correlación (r=0,418), mientras que la CM tuvo la mayor correlación (r=0,557); en los neonatos a término se halló que la CP mostró la menor correlación (r=0,235) y la CM la mayor (r=0,668). Para ambos grupos (pretérmino y a término), la combinación de las tres mediciones antropométricas obtuvo correlaciones de r=0,630 y r=0,703 respectivamente. Del mismo modo, las correlaciones de las medidas antropométricas según sexo se muestran en la **Tabla 4**.

En cuanto al análisis global, sin disgregar en prematuro y a término, las medidas antropométricas frente a la edad gestacional, mostraron las siguientes correlaciones:

- CB: r_s = 0,728, p< 0.001
- CM: r_s = 0,812, p< 0.001
- CP: r_s = 0.356, p<0.001

Todas, fuertes y significativas las cuáles se muestran también a través de la Figura 2.; destacando que, en análisis indistinto de prematuridad o condición de neonato a término, la CM guarda mayor correlación con la edad gestacional.

Para garantizar la validez del modelo, se procedió a realizar un análisis de diagnóstico de regresión, el cuál muestra que los errores están distribuidos aleatoriamente en torno a cero, lo que indica que el modelo de regresión es adecuado y no presenta patrones de error sistemáticos; ello se presenta en la Figura 3.

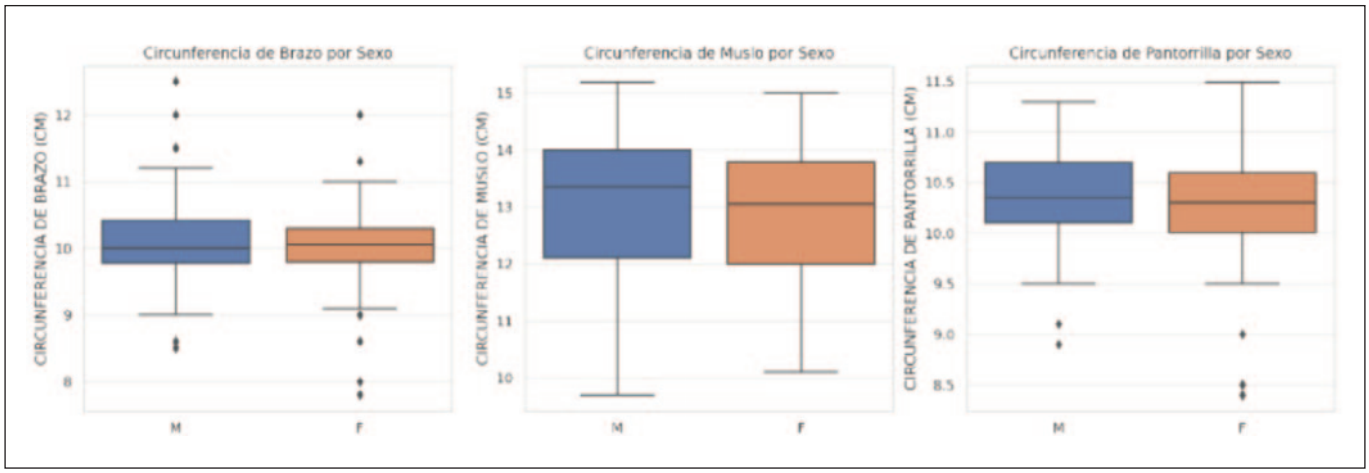

Figura 1. Boxplots de medidas antropométricas (CB, CM y CP), sin diferencias significativas entre sexos

Tabla 2. Descripción de las variables por sexo y edad gestacional

	Masculino		Femenino	
	Pretérmino (N=21)	**Término (N=87)**	**Pretérmino (N=34)**	**Término (N=100)**
Edad materna	26,73	28,84	28,04	29,06
Peso	2776,77	3183,74 *	2796,67	3250,68 * #
Talla	48,39	50,22 *	48,58	50,5 * #
CB	9,53	10,34 *	9,41	10,17 * #
CM	11,7	13,43 *	11,5	13,39 *
CP	9,94	10,56 *	9,84	10,39 * #
CB+CM+CP	31,18	34,34 *	30,74	33,94 *

*p<0,05 Pretérmino vs Término, # p<0,05 masculino vs femenino.

Tabla 3. Correlación entre medidas antropométricas y edad gestacional; según condición de parto y sexo

Parámetros antropométricos	Prematuro	A término	Femenino	Masculino
	Coef. Correlación	**Coef. Correlación**	**Coef. Correlación**	**Coef. Correlación**
Peso	0,888***	0,854***	0,888***	0,854***
Talla	0,626***	0,603***	0,626***	0,603***
CB	0,418***	0,587***	0,418***	0,587***
CM	0,557***	0,668***	0,557***	0,668***
CP	0,508***	0,235***	0,508***	0,235***
CB+CM+CP	0,630***	0,703***	0,630***	0,703***

*** p<0,0001

Posteriormente, se realizó una estimación de la edad gestacional mediante regresión lineal y usando los parámetros antropométricos de uso no habitual (CB, CM y CP), se realizaron los análisis y el modelo con mayor R^2 fue el que solo consideraba CM y CB. La **Tabla 4**, muestra la estimación de la edad gestacional utilizando dichas medidas antropométricas para ambos sexos. En ese sentido, para el sexo femenino se obtuvo un R^2 = 0,72 y para el sexo masculino un R^2 = 0,75.

Tabla 4. Análisis de regresión por circunferencias y sexo

	Femenino	Masculino
	EG =18,022 + (CM * 0,885) + (CP * 0,902)	EG =16,79 + (CM * 0,894) + (CP * 1,008)
Prob F	0,00	0,00
R2	0,72	0,75

Finalmente, se buscó evaluar la capacidad del modelo para discriminar si el neonato era prematuro o a término, mediante las medidas antropométricas estudiadas; el modelo mostró un área bajo la curva ROC: 0,98 con alta sensibilidad y especificidad, la misma que se muestra en la Figura 4.

DISCUSIÓN

La residencia a elevada altitud, definida habitualmente como mayor a 2500 msnm cubre a más de 140 millones de personas, en dichos lugares la disponibilidad de oxígeno es reducido del mismo modo que las temperaturas son más bajas, representando ello desafíos fisiológicos tanto para sus residentes como transeúntes; dichos retos han impulsado cam-

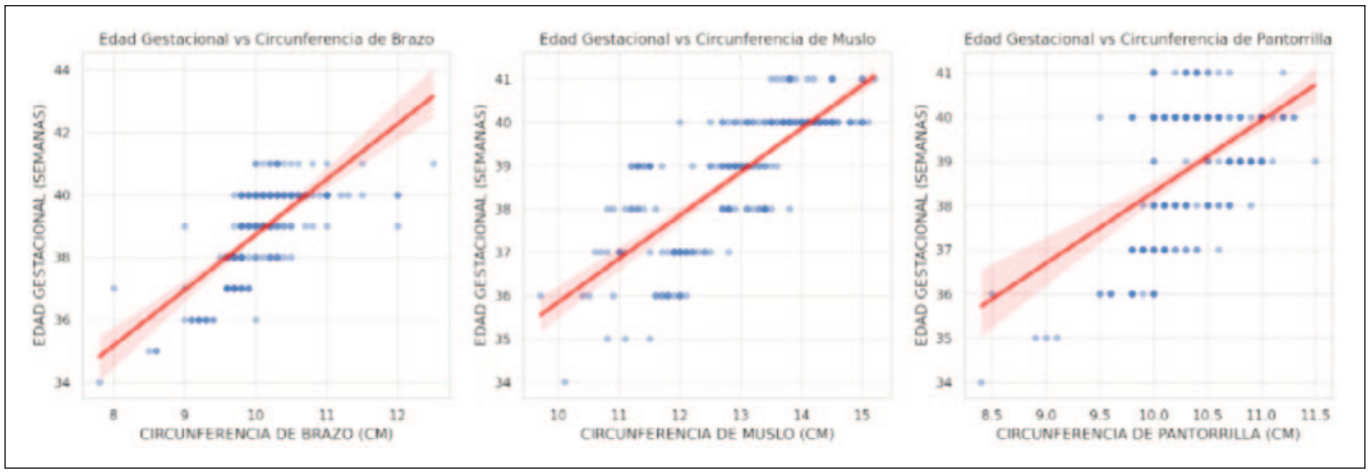

Figura 2. Correlación entre edad gestacional y las medidas antropométricas estudiadas, en un análisis global de edades gestacionales

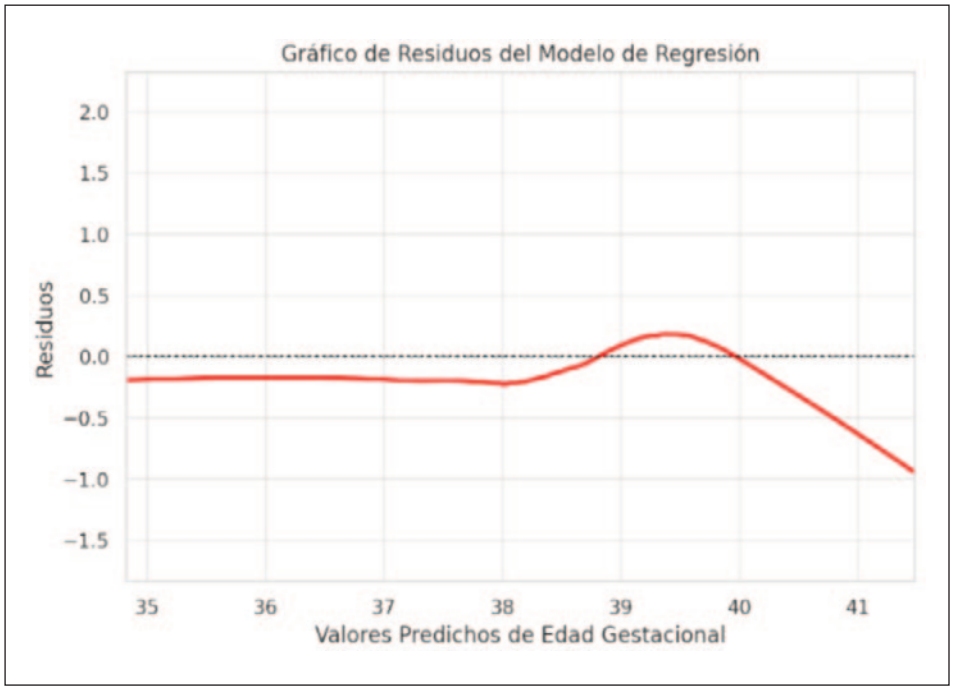

Figura 3. Gráfico de residuos del modelo de regresión para los valores de EG predichos

bios evolutivos destinados a mejorar la aptitud del ser humano, para su supervivencia y reproducción[17].

En ese sentido un estudio observó que el peso al nacer es dosis dependiente de la exposición a niveles bajos de oxígeno, y ésta es más evidente en poblaciones transeúntes como la etnia Han frente a las residentes o adaptadas durante mucho tiempo atrás como los tibetanos; los bebés tibetanos pesaban más que los Han, con un promedio de 310 g más en altitudes de 2700 a 3000 m (IC del 95% = 126,494 g; p<0,01) y 530 g más a 3000-3800 m (210,750 g; p<0,01); y no sólo eso, sino que también se halló una mayor mortalidad prenatal y postnatal tres veces mayor en la etnia Han[18].

Hallazgos similares respecto al crecimiento fetal y peso al nacer, fueron observados, en modelos animales; tal es así, que, los pesos al nacer de gestaciones ovinas en grandes alturas residentes durante varias generaciones son mayores al de las ovejas que fueron sometidas a gran altura sólo durante el periodo de gestación, esto puede explicarse por los cambios morfológicos placentarios encontrados en ellas, como una mayor presencia de superficie total de cotiledones y superficie ocupada por vasculatura, representando así un mecanismo de adaptación heredado de la hipoxia hipobárica[19].

Por otro lado, se ha demostrado también la presencia de alteraciones de la capacidad de difusión placentaria, del trofismo de la arteria uterina y arterias mesometriales a lo largo de la gestación y un aumento de volumen de espacios sanguíneos a nivel placentario y presencia de flujo compensatorio. Del mismo modo, cabe destacar que existió diferencias del crecimiento placentario según sexo, tal es así que, los de sexo masculino presentaron mayor peso placentario, ello probablemente por tener mayor demanda de nutrientes respecto a sus pares, pero a su vez también resultaron ser más susceptibles ante entornos adversos como la hipoxia[20-23].

Sin bien existen mecanismos adaptativos en población nativa, éstos no los hacen invulnerables a ser afectados por la hipoxia hipobárica, y existe, aunque en menor medida algunas consecuencias de dicha exposición, por ejemplo, se ha

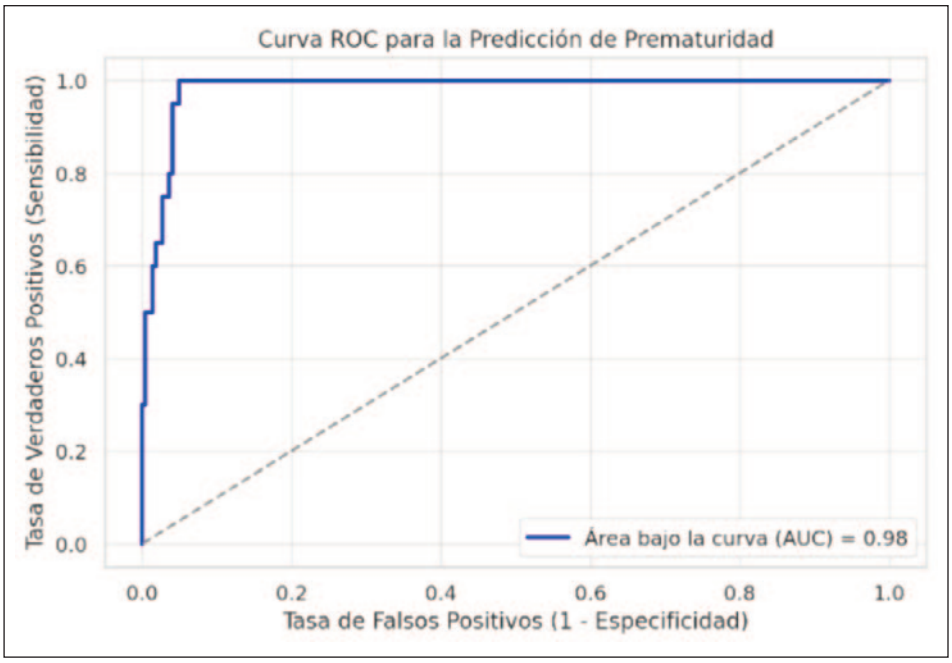

Figura 4. Curva ROC para discriminar la condición de prematuridad y a término, usando medidas antropométricas inusuales (CM, CB, CP), en población residente a gran altitud

descrito mayores casos de restricción de crecimiento intrauterino y bajo peso al nacer; los cuales, sin duda revisten importancia en la morbimortalidad neonatal.

Ahora bien, en relación al peso respecto a la edad gestacional resulta lógico que las consideraciones clásicas establecidas por Lubchenco no apliquen a poblaciones de gran altura, donde la clasificación percentilar de: adecuado, bajo y grande para edad gestacional, son diferentes como se demostró en un estudio[24]. De ese modo, al existir evidencia de que el peso es afectado por la hipoxia hipobárica, resulta más usual su variación en dichos contextos, ello nos lleva a pensar que, si de algún modo el peso al nacer es una buena herramienta para estimar la edad gestacional, en estos casos podría no ser tan válido, y por ello se requieren otras herramientas antropométricas para precisar mejor la edad gestacional del recién nacido en altura.

La estimación de la edad gestacional suele ser sencilla en las zonas urbanas; sin embargo, esto recobra ciertas limitaciones y dificultades, específicamente en zonas de la población altoandina peruana que residen a gran altura; además, pese a los enormes esfuerzos del estado, aún existen retos no resueltos como el embarazo adolescente, captación tardía de gestantes, falta de confianza en la medicina occidental, carencia de ecógrafos o médicos especialistas, entre otros, los cuales derivan en una estimación de edad gestacional no muy precisa por las herramientas habituales[25-27].

Y si no consideramos los métodos de evaluación somática en el postnatal inmediato - mediato; se observa que no se ha desarrollado estudios en población nativa a gran altura, sobre la estimación de la edad gestacional mediante otras herramientas como las medidas antropométricas, que para nuestro caso fueron la circunferencia de brazo, circunferencia de muslo y circunferencia de pantorrilla. Del mismo modo, este estudio resulta una oportunidad para brindar pautas sobre los valores promedio de estas medidas antropométricas para población de altura.

Ante la dificultad de data disponible de investigaciones en poblaciones similares; se tratará de hacer un análisis respecto a neonatos nacidos a nivel del mar, en ese sentido, un estudio realizado en 202 recién nacidos, subclasificó a su muestra según peso al nacer en: menor a 2 Kg, de 2 a 2,5 Kg y mayores a 2,5 Kg., indistintamente del sexo, de los cuáles la CB mostró valores medios de 6,96, 8,18 y 9,82 cm., en tanto la CM fue de 12,89, 14,2 y 15,9 cm y la CP fue de 7,83, 9,13 y 9,99 cm para cada subgrupo respectivamente. Mientras que los coeficientes de correlación de Pearson con un $p<0.001$ para menores de 2 Kg para la CB, CM y CP fueron de 0,63, 0,59 y 0,81; en aquellos entre los 2 Kg y 2,5 Kg fue 0,84, 0,70 y 0,98, y finalmente para aquellos mayores de 2,5 Kg fue de 0,855, 0,84 y 0,86[28]. Para el caso nuestros dichos valores promedios variaron a primera impresión, ya que en nuestro caso los clasificamos por condición de prematuridad o a término, aun así, existen diferencias al respecto.

Otra investigación realizada en neonatos de bajo peso al nacer, tuvo como hallazgo un peso medio de 1,94±0,38 Kg con 2,39 Kg como peso máximo y 1,035 Kg como peso mínimo; la CB osciló entre 6 a 11 cm con una media de 8,66 ± 1,25 cm; la CM media fue de 11,7 cm y la CP osciló entre 6 a 10 cm con un valor medio de 8,7±1,24 (29). Mientras que, en otra revisión de 1270 neonatos en su gran mayoría neonatos a término, se obtuvo una media para el sexo femenino y masculino de la CB de 10,9 cm y 11,0 cm, CM de 15,49 cm y 15,3 cm, CP de 11,2 cm en ambos sexos[30].

Hasta el momento una comparación de nuestra investigación con las tres previas y considerando las diferencias metodológicas, muestran una diferencia de hasta -1.6 cm en la CB, -2.5 cm en la CM y -0.57 cm en la CP en los a término, pero con valores similares en el grupo que investigó a los de bajo peso al nacer; lo cual resulta esperable, considerando los cambios adaptativos en las gestaciones a gran altura descritos anteriormente.

En ese sentido, se encontró otro estudio que buscaba encontrar algún parámetro antropométrico que sea eficaz para identificar neonatos con bajo peso al nacer; es así que esta investigación arrojó para este grupo y para los de sexo femenino y masculino una CB de 9.48+/-1.56 cm y 9.88 +/-2.29 cm; una CM de 12.26+/-1.39 y 12.60+/-1.41 cm y una CP de 8.75+/-1.34 cm y 90.1+/-2.45 cm respectivamente[31]. Reiterando la similitud de hallazgos de nuestra investigación en la población prematura.

Consideramos que nuestro estudio, es el primero en analizar medidas antropométricas de las extremidades en población neonatal nacida a gran altura y por ello se requiere otras investigaciones a fin de poder tener mayor claridad sobre su relación con la edad gestacional y subsecuente estimación por estos métodos.

CONCLUSIÓN

La edad gestacional de neonatos nacidos de madres residentes en altura, no siempre puede ser estimado mediante los métodos tradicionales y las diferencias fisiológicas respecto a sus pares a nivel del mar, hacen que el peso al nacer no guarde necesariamente la clásica relación frente a la edad gestacional. Por ello, herramientas adicionales como la toma de medidas antropométricas pueden ayudar a tener una mejor idea de la edad gestacional en los bebés que nacen a grandes alturas. Sin embargo, dada la escasa información al respecto, se requiere más estudios sobre el tema.

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Contenido de nutrientes críticos en sucedáneos de leche materna comercializada en Perú

Content of critical nutrients in commercially available breast milk substitutes in Peru

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RESUMEN

Introducción: La lactancia materna exclusiva (LME) es vital para el desarrollo infantil, pero su práctica ha disminuido. En Perú, aunque se promueve la LME, los sucedáneos de leche materna (SLM) han ganado terreno. La normativa sobre advertencias de nutrientes críticos sigue siendo debatida, impactando la salud infantil.

Objetivo: Analizar el contenido de nutrientes críticos en SLM dirigidos a niños menores de 2 años, expendidos en Lima Metropolitana.

Materiales y Métodos: Estudio transversal en 27 SLM. La recolección de datos se realizó de enero a junio del 2023 en establecimientos farmacéuticos, centros de abasto, hospitales y centros comerciales, a fin de verificar mediante un registro fotográfico la coincidencia entre la lista de cotejo y el etiquetado nutricional. Los datos fueron exportados al software estadístico JASP versión 0.17.2.1. Se presentó el contenido de sodio, azúcar total, grasas saturadas y grasas trans en 100 g del producto en polvo, en 100 ml del producto bebible y en 100 ml del producto reconstituido, y se comparó con los parámetros de nutrientes críticos establecidos para Perú.

Resultados: En el total de SLM evaluados, el valor de azúcar es el que resalta, con una mediana de 7,50 g/100 ml de producto reconstituido. El SLM con la mediana más elevada de azúcar total (7,8 g/100 ml) fue procedente de Estados Unidos. En el año 2021 se registró el pico más alto de entrega de registros sanitarios (40,74%).

Conclusiones: Los SLM superaron los niveles permitidos de azúcar en la totalidad de los productos en 2019, y en la gran mayoría de los de 2020 y 2021.

PALABRAS CLAVE

Sustitutos de la leche humana; Fórmulas Infantiles; Etiquetado de Alimentos; Azúcares; Sodio; Grasas; Ácidos Grasos trans (fuente: DeCS-BIREME)

ABSTRACT

Introduction: Exclusive breastfeeding (EBF) is vital for child development, but its practice has declined. In Peru, although EBF is promoted, breast milk substitutes (BMS) have gained ground. The regulations on critical nutrient warnings remain debated, impacting child health.

Objective: To analyze the content of critical nutrients in BMS targeted at children under 2 years old, sold in Metropolitan Lima. Materials and

Methods: A cross-sectional study was conducted on 27 BMS. Data collection took place from January to June 2023 in pharmacies, markets, hospitals, and shopping centers to verify, through photographic records, the consistency between the checklist and nutritional labeling. Data were exported to the statistical software JASP version 0.17.2.1. The content of sodium,

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total sugar, saturated fats, and trans fats in 100 g of powdered product, 100 ml of drinkable product, and 100 ml of reconstituted product was presented and compared with the critical nutrient parameters established for Peru.

Results: Among all BMS evaluated, the sugar content stood out, with a median of 7.50 g/100 ml of reconstituted product. The BMS with the highest median total sugar content (7.8 g/100 ml) was from the United States. The highest peak in sanitary registrations was recorded in 2021 (40.74%).

Conclusions: BMS exceeded the permitted sugar levels in all products in 2019 and in the vast majority of products in 2020 and 2021.

KEYWORDS

Breast-Milk Substitutes; Infant Formula; Food Labeling; Sugars; Sodium; Fats; Trans Fatty Acids (source: DECS-BIREME)

INTRODUCCIÓN

La lactancia materna exclusiva (LME) recibida desde el nacimiento hasta los 6 meses, asegura el adecuado crecimiento y desarrollo del lactante. Además, la leche materna contiene alrededor de 7% de lactosa y 4% de grasa, la cual presenta numerosos beneficios y es considerada la mejor fuente de nutrición durante los primeros meses de vida[1]. Sin embargo, su práctica en la actualidad ha disminuido, debido a varios factores, entre los principales la comercialización de fórmulas infantiles o sucedáneos de leche materna (SLM) de origen lácteo y no lácteo, destinados a sustituir parcial o totalmente a la leche materna[2], estos productos deben de seguir parámetros establecidos para proporcionar preparados inocuos que satisfagan las necesidades nutricionales de los lactantes[3]. Cabe resaltar que dichos productos han ido ganando terreno y aumentado sus ventas en las dos últimas décadas, afectando directamente al consumo y duración de la lactancia materna. A nivel mundial en el año 2021, solo el 44% de los niños menores de 6 meses tuvo LME[4], mientras que, en el Perú para el año 2022, solo el 65,9% recibió lactancia materna[5].

Nuestro país promueve la LME desde el año 2006[2] y en los años recientes se promulgó la ley de promoción de alimentación saludable para niños y adolescentes, donde se señala que los productos alimentarios que excedan los parámetros establecidos deberán llevar una advertencia publicitaria (octógonos) que señale un alto contenido de nutrientes críticos que son perjudiciales para la salud[6]. Luego, previo a la implementación de dicha ley, se publicó un decreto supremo que exceptuaba a ciertos alimentos y bebidas de llevar dichas advertencias, dentro de los cuales se encuentran los SLM[7], que son definidos como alimentos preenvasados elaborados para satisfacer necesidades específicas de alimentación en determinadas condiciones o trastornos[8]. Posteriormente, en el año 2021, una Corte de Justicia del Perú declaró nula la disposición final, donde se exime a los SLM de no tener advertencias de nutrientes críticos en la etiqueta y/o envase del producto y exhortando al Poder Ejecutivo que los adecúe de acuerdo con los parámetros técnicos, lo cual no ha ocurrido hasta ahora[9]. Además, en el año 2022, se publicó un predictamen de la Ley 1941 que supuestamente garantizaría la protección de la salud de las poblaciones vulnerables demandantes de fórmulas especiales para su alimentación, no siendo aplicable las normas que regulen el etiquetado y publicidad de alimentos industrializados. Por lo que, de ser publicado, esto eximiría a los SLM de llevar advertencias publicitarias de nutrientes críticos[10].

Sobre este contexto que ocurre en Perú, consideramos que el aporte de nutrientes críticos en los SLM debe ser tipificado, debido a la exposición a la que son sometidos los lactantes inclusive desde su nacimiento. El consumo de cantidades elevadas de azúcar a una edad temprana influye en el incremento inadecuado de peso, pudiendo desencadenar sobrepeso y obesidad, así como el posterior desarrollo de enfermedades crónicas no transmisibles (ECNT)[11]. Del mismo modo el consumo de sodio está asociado a la elevación de la presión arterial, condicionando el desarrollo de ataques cardíacos y accidentes cerebrovasculares en la vida adulta[12]. Las grasas saturadas administradas de manera ilimitada desde la infancia tienen una estrecha relación con el riesgo de padecer enfermedades coronarias y circulatorias a largo plazo[13]. El consumo de grasas trans se considera un factor de riesgo para el adecuado desarrollo cerebral de los recién nacidos y estaría implicado en el desarrollo de afecciones inflamatorias como la diabetes y el cáncer[14]. Como se mencionó, estos nutrientes críticos podrían influir significativamente en el crecimiento y en la salud de un individuo, que están determinados por la genética y el entorno desde la etapa embrionaria. Los primeros 1000 días son cruciales para prevenir enfermedades a largo plazo, que son complejas de tratar y multifactoriales en su aparición, por lo que garantizar una nutrición adecuada y una microbiota saludable durante este período es una prioridad esencial[15].

Por lo tanto, la presente investigación buscó analizar el contenido de nutrientes críticos en SLM dirigidos a niños menores de 2 años, expendidos en diferentes puntos de venta de Lima Metropolitana.

MÉTODOS

Diseño

Estudio observacional, descriptivo y transversal.

Población y muestra

67 SLM proporcionados por la Ventanilla Única de Comercio Exterior (VUCE) y constatados en la página de la Dirección General de Salud Ambiental (DIGESA) durante los años 2019, 2020 y 2021. Dicha información pertenece a la fuente oficial de DIGESA[16,17]. Finalmente, se obtuvo como muestra 27 SLM.

Variables

Se analizaron los SLM según su presentación (en polvo o bebible), marcas comerciales, periodo de vida útil, país, continente y laboratorios de fabricación, empresa importadora, entre otras. Se analizó la energía en kilocalorías, sodio en miligramos, azúcar, grasas saturadas y grasas trans en gramos de cada SLM, a fin de establecer si superan los valores establecidos en Perú. Sodio en alimentos sólidos ≥400 mg/100 g, sodio en bebidas ≥100 mg/100 ml. Azúcar total en alimentos sólidos ≥10 g/100 g, azúcar total en bebidas 5 g/100 ml. Grasas saturadas en alimentos sólidos ≥4 g/100 g, grasas saturadas en bebidas ≥3 g/100 ml. En el caso de las grasas trans deben ser eliminadas de los alimentos y bebidas[18].

Procedimientos del estudio

Proceso de selección de sucedáneos

Por motivos de transparencia y acceso a la información pública, los investigadores en coordinación con la carrera de Nutrición y Dietética de la Universidad Científica del Sur (UCSUR) solicitaron en abril del 2022, a la VUCE del Ministerio de Comercio Exterior y Turismo, la lista de los SLM registrados en la VUCE durante los años 2019, 2020 y 2021[16]. Una vez proporcionada dicha información, el listado fue cotejado por los investigadores en la página web de DIGESA, autoridad sanitaria encargada de otorgar registros sanitarios de alimentos en el Perú. En esta página se verificaron las marcas comerciales, periodo de vida útil, nombre de la empresa, país de fabricación, entre otros[17]. Luego, se procedió a la recolección de datos en primera instancia apersonándose a establecimientos farmacéuticos, centros de abastos, hospitales, centros comerciales donde se expendían los SLM, a fin de verificar mediante un registro fotográfico la coincidencia con la lista de cotejo. Esta recolección se realizó durante los meses de enero a junio del año 2023. Como resultado de este proceso, de la lista de los 67 SLM, se descartaron 12 porque se encontraban duplicados en el listado. Del mismo modo, se identificaron 17 productos que dejaron de expenderse en el mercado peruano, información que fue proporcionada al preguntar en los puntos de venta y con algunos representantes de las empresas distribuidoras en Perú. Finalmente, del listado no se pudieron encontrar 11 sucedáneos; de los cuales, 5 fueron presentaciones líquidas que no se encontraron disponibles a la venta para el público en general, ya que ingresaron como donación a algunos hospitales según refirieron especialistas de los establecimientos de salud que utilizaron dichos SLM y al agotarse no se hizo el petitorio para su adquisición. Asimismo, 4 no fueron hallados luego de una exhaustiva búsqueda en los establecimientos ya mencionados, a pesar de contar con registro sanitario vigente para su venta. Además, 2 fueron fortificadores de leche materna, los cuales no ingresan en la categoría de SLM[19]. Esta selección se realizó durante los meses de julio y agosto del 2023. Finalmente, se obtuvo como muestra final para el análisis 27 SLM.

Registro fotográfico

Luego del proceso de selección, los investigadores nos encargamos de armar un registro fotográfico de los 27 SLM, los cuales fueron registrados en una base de datos indicando los datos indicados en el etiquetado nutricional. Enseguida se calculó el contenido de cada nutriente crítico en su presentación en 100 g o 100 ml de producto, según el tipo de alimento, tomando en cuenta los parámetros de nutrientes críticos del etiquetado frontal en Perú[18].

Revisión y control de calidad de la base de datos

Una vez obtenida la base de datos, los 4 investigadores (2 bachilleres en nutrición y dietética, 1 licenciada en nutrición y 1 magíster en ciencias) nos reunimos para revisar y verificar los datos registrados. Para el análisis se utilizaron los datos mencionados en la tabla de información nutricional del SLM. No hubo variaciones en relación con los valores de sodio, grasas saturadas y grasas trans; sin embargo, en la variable azúcar se incluyó a todos los monosacáridos y disacáridos[20,21], debido a que hubo ausencia de información sobre las cantidades de azúcar en el etiquetado. Para el caso del valor reconstituido, se tomó el dato mencionado en la fórmula (g/100 ml) y en caso de no presentar el valor declarado en el etiquetado nutricional de nutrientes críticos en 100 ml, se realizó un cálculo de proporcionalidad con el fin de estandarizar los resultados. El control de calidad fue realizado en el mes de septiembre del 2023.

Análisis estadístico

Una vez realizada la recolección de datos, estos fueron exportados al software estadístico JASP versión 0.17.2.1. Se calculó la normalidad de los datos con el estadístico Shapiro-Wilk ($p<0,05$), al no obtenerse una distribución normal, se utilizaron pruebas no paramétricas. Se presentó el contenido de sodio, azúcar total, grasas saturadas y grasas trans en 100 g del producto en polvo, 100 ml del producto bebible y 100 ml del producto reconstituido. Se utilizó estadística descriptiva, para las variables cuantitativas (mediana e intervalos de confianza), y cualitativas (frecuencias absolutas y relativas). Para poder conocer las diferencias se utilizó la Prueba U de Mann-Whitney, Kruskall-Wallis y Tau-b de Kendall, según correspondió, con una significancia de 95% de confiabilidad.

Aspectos éticos

Siendo el presente un estudio que no trabaja directamente con seres humanos; sino con los SLM, no requiere consentimiento; sin embargo, para reafirmar nuestro compromiso ético y de integridad científica nuestro proyecto ha sido evaluado y aprobado por el Comité Institucional de Ética de Investigación de la UCSUR (PRE-17-2022-00360). Además, los investigadores declaramos no tener asociación con alguna empresa distribuidora o fabricadora de SLM expendidos en el Perú.

RESULTADOS

En la Tabla 1 se presentan los valores de energía y nutrientes críticos contenidos en los SLM evaluado en sus tres formas: polvo, bebible y reconstituido. Para el total de productos (n=27), producto en polvo (n=25), producto bebible (n=2), total de producto reconstituido (n=27, producto en polvo y producto bebible) y producto en polvo reconstituido (n=25). Del total de productos evaluados, al considerar el producto reconstituido (n=27), el valor energético total fue de 68,00 kcal (IC 95%: 67,00-73,00 kcal). En cuanto al sodio, el contenido total en el producto reconstituido, la mediana de sodio fue de 28,00 mg (IC 95%: 24,00-31,15 mg). El nutriente crítico que resalta es el azúcar total, considerando el total de productos reconstituidos (n=27), la mediana del valor de azúcar es 7,50 g/100 ml. El contenido de grasas saturadas fue de 0,00 g en el producto reconstituido, aunque en la forma reconstituida del polvo alcanzaron un valor máximo de 1,30 g (IC 95%: 0,00-1,30 g). Finalmente, no se detectó contenido de grasas trans en ninguna de las formas del producto evaluadas.

En la tabla 2, se muestra los valores de energía y nutrientes críticos presentes en SLM según continente de fabricación (América y Europa). De los cuales, el 51,9% son de procedencia americana, aunque sin diferencias significativas (p>0,05). Para el SLM reconstituido, el contenido energético fue similar entre ambos orígenes: 68,50 kcal (IC 95%: 67,25-73,00 kcal) para América y 68,00 kcal (IC 95%: 67,00-73,00 kcal) para Europa (p=0,410). El sodio presentó una mediana de 29,50 mg (IC 95%: 27,00-31,23 mg) en América y 26,00 mg (IC 95%: 23,00-31,00 mg) en Europa (p=0,450). El contenido de azúcar total fue ligeramente mayor en productos americanos, con 7,70 g (IC 95%: 7,25-8,20 g), frente a 7,40 g (IC 95%: 6,50-7,70 g) en productos europeos, con un valor p cercano a la significancia (p=0,061). Respecto a las grasas saturadas, los productos reconstituidos de América no mostraron contenido significativo (mediana 0,00 g, IC 95%: 0,00-0,75 g), mientras que los europeos alcanzaron hasta 1,00 g (IC 95%: 0,00-1,30 g) (p=0,130). No se observaron diferencias en las grasas trans, con valores de 0,00 g en ambos casos.

En la tabla 3, se realizó la comparación entre los valores de energía y nutrientes críticos presentados en SLM y su país de fabricación. En el caso del SLM reconstituido, la energía osciló entre 67,50 kcal (Países Bajos) y 70,00 kcal (Alemania), sin diferencias significativas (p=0,790). El sodio varió de 25,00 mg (España) a 31,00 mg (Estados Unidos), con un valor p de 0,630. El contenido de azúcar total fue significativamente mayor en Alemania (7,75 g) respecto a otros países (p=0,025), mientras que las grasas saturadas no presentaron diferencias relevantes (p=0,490). No se detectaron grasas trans en ninguna muestra reconstituida. Los resultados sugieren variaciones específicas en el contenido de azúcar y grasas trans según el país de fabricación, mientras que otros nutrientes no mostraron diferencias estadísticamente significativas.

Tabla 1. Energía y nutrientes críticos presentes en polvo, bebible y producto reconstituido de SLM. Lima, Perú. 2019-2021

Nutrientes	Mediana	IC 95%	
Total (n=27)			
Energía (kcal)	509,00	492,50	513,50
Sodio (mg)	193,00	165,50	222,50
Azúcar total (g)	53,60	52,00	57,10
Grasas saturadas (g)	0,00	0,00	8,40
Grasas trans (g)	0,00	0,00	0,00
Producto en polvo (n=25)			
Energía (kcal)	510,00	495,00	514,00
Sodio (mg)	200,00	170,00	225,00
Azúcar total (g)	54,30	52,07	58,00
Grasas saturadas (g)	0,00	0,00	9,00
Grasas trans (g)	0,00	0,00	0,00
Producto bebible (n=2)			
Energía (kcal)	91,50	86,75	96,25
Sodio (mg)	50,50	47,25	53,75
Azúcar total (g)	8,30	8,05	8,55
Grasas saturadas (g)	0,00	0,00	0,00
Grasas trans (g)	0,00	0,00	0,00
Total producto reconstituido (n=27)*			
Energía (kcal)	68,00	67,00	73,00
Sodio (mg)	28,00	24,00	31,15
Azúcar total (g)	7,50	7,15	7,80
Grasas saturadas (g)	0,00	0,00	1,25
Grasas trans (g)	0,00	0,00	0,00
Producto en polvo reconstituido (n=25)			
Energía (kcal)	68,00	67,00	73,00
Sodio (mg)	27,00	23,00	31,00
Azúcar total (g)	7,50	7,10	7,80
Grasas saturadas (g)	1,00	0,00	1,30
Grasas trans (g)	0,00	0,00	0,00

* Incluye el cálculo de los SLM en polvo reconstituidos (n=25) y bebible (n=2).

Tabla 2. Energía y nutrientes críticos presentes en polvo, bebible y producto reconstituido de SLM, según continente de fabricación. Lima, Perú. 2019-2021

Nutrientes	n	Continente de fabricación	Mediana	IC 95%		Valor p*
Total (n=27)						
Energía (kcal)	14	América	499,00	468,25	520,00	0,604
	13	Europa	511,00	507,00	513,00	
Sodio (mg)	14	América	184,00	166,38	221,25	0,512
	13	Europa	200,00	169,00	220,00	
Azúcar total (g)	14	América	53,30	52,02	56,00	0,808
	13	Europa	54,30	46,30	58,00	
Grasas saturadas (g)	14	América	0,00	0,00	4,43	0,191
	13	Europa	7,40	0,00	9,00	
Grasas trans (g)	14	América	0,00	0,00	0,00	0,403
	13	Europa	0,00	0,00	0,10	
Total producto reconstituido (n=27)**						
Energía (kcal)	14	América	68,50	67,25	73,00	0,410
	13	Europa	68,00	67,00	73,00	
Sodio (mg)	14	América	29,50	27,00	31,23	0,450
	13	Europa	26,00	23,00	31,00	
Azúcar total (g)	14	América	7,70	7,25	8,20	0,061
	13	Europa	7,40	6,50	7,70	
Grasas saturadas (g)	14	América	0,00	0,00	0,75	0,130
	13	Europa	1,00	0,00	1,30	
Grasas trans (g)	14	América	0,00	0,00	0,00	NaN***
	13	Europa	0,00	0,00	0,00	

* Prueba U de Mann-Whitney.
** Incluye el cálculo de los SLM en polvo reconstituidos (n=25) y bebible (n=2).
*** NaN (no aplica). La varianza es igual a 0 después de agruparlos.

En la tabla 4, se observa el otorgamiento de registros sanitarios de SLM por país de fabricación para los años 2019-2021. El total de registros sanitarios otorgados se da de manera ascendente, observándose el pico más alto el año 2021, con el 40,74% de registros sanitarios otorgados para comercialización en el periodo de estudio. En 2019, los productos fabricados en España y México presentaron las proporciones más altas de registros ese año, con 42,86 % (n=3) y 28,57 % (n=2), respectivamente. En 2020, los productos fabricados en Estados Unidos tuvieron la mayor proporción, con 57,14 % (n=4). En 2021, México mostró el mayor porcentaje de registros (57,14 %, n=4). Los resultados evidencian una variabilidad en la obtención de registros sanitarios por país y año, aunque sin una tendencia significativa estadísticamente hablando.

Tabla 3. Energía y nutrientes críticos presentes en polvo, bebible y producto reconstituido de SLM, según país de fabricación. Lima, Perú. 2019-2021

Países de fabricación	n	Energía (kcal)	Valor p*	Sodio (mg)	Valor p*	Azúcar total (g)	Valor p*	Grasas saturadas (g)	Valor p*	Grasas trans (g)	Valor p*
		Mediana		Mediana		Mediana		Mediana		Mediana	
Total (n=27)											
Alemania	4	512,00	0,609	200,00	0,665	58,45	0,012 **	7,40	0,519	0,15	0,031 **
España	7	509,00		169,00		46,30		0,00		0,00	
Estados Unidos	7	498,00		184,00		52,00		0,00		0,00	
México	7	520,00		184,00		56,00		0,00		0,00	
Países Bajos	2	510,00		206,50		55,70		4,95		0,05	
Total producto reconstituido (n=27)* **											
Alemania	4	70,00	0,790	26,00	0,630	7,75	0,025 *	1,00	0,490	0,00	NaN* ***
España	7	68,00		25,00		6,50		1,20		0,00	
Estados Unidos	7	69,00		31,00		7,80		0,00		0,00	
México	7	68,00		27,00		7,60		0,00		0,00	
Países Bajos	2	67,50		27,70		7,35		0,65		0,00	

* Prueba Kruskal-Wallis.
** p<0.05 (diferencias significativas).
*** Incluye el cálculo de los SLM en polvo reconstituidos (n=25) y bebible (n=2).
**** NaN (no aplica). La varianza es igual a 0 después de agruparlos.

Tabla 4. SLM por país de fabricación, según registros sanitarios otorgados para comercialización. Lima, Perú. 2019-2021

País de fabricación	n	2019		2020		2021		Valor p*
		n	%	n	%	n	%	
Alemania	4	0	0,00	2	50,00	2	50,00	0,660
España	7	3	42,86	2	28,57	2	28,57	
Estados Unidos	7	1	14,29	4	57,14	2	28,57	
México	7	2	28,57	1	14,29	4	57,14	
Países Bajos	2	0	0,00	1	50,00	1	50,00	
Total	27	6	22,22	10	37,04	11	40,74	

* Tau-b de Kendall.

En la tabla 5, se comparó los registros sanitarios otorgados del 2019- 2021, el laboratorio de fabricación y la empresa importadora de los SLM. Abbott, representado por Abbott Laboratorios S.A., registró un total de cinco productos, con una distribución de registros del 20,00 % (n=1) en 2019, 60,00 % (n=3) en 2020 y 20,00 % (n=1) en 2021. Alter, con Lukoll S.A.C. como importadora, presentó un solo registro sanitario en 2020. Industrias Lácteas de Vallejo, importado por Sanulac Nutrición Perú S.A.C., no tuvo registros en 2019 ni 2020, pero alcanzó 2 registros en 2021. Laboratorios Ordesa,

Tabla 5. SLM por laboratorios de fabricación y empresa importadora, según registros sanitarios otorgados para comercialización. Lima, Perú. 2019-2021

Laboratorios de fabricación	Empresa importadora	n	2019		2020		2021		Valor p*
			n	%	n	%	n	%	
Abbott	Abbott Laboratorios SA	5	1	20,00	3	60,00	1	20,00	0,079
Alter	Lukoll S.A.C.	1	0	0,00	1	100,00	0	0,00	
Industrias Lácteas de Vallejo	Sanulac Nutrición Perú S.A.C.	2	0	0,00	0	0,00	2	100,00	
Laboratorios Ordesa	Distribuidora Continental 6 S.A.	4	2	50,00	0	0,00	2	50,00	
Mead Johnson	Mead Johnson Nutrition (Peru) S.R.L.	3	3	100,00	0	0,00	0	0,00	
Mead Johnson	RB Health Perú S.R.L.	6	0	0,00	4	66,67	2	33,33	
Nestlé	Nestlé Marcas Perú S.A.C.	6	0	0,00	2	33,33	4	66,67	

* Tau-b de Kendall.

distribuido por Distribuidora Continental 6 S.A., obtuvo registros en 2019 (n=2) y 2021 (n=2). Mead Johnson presentó dos importadoras: Mead Johnson Nutrition (Perú) S.R.L., con 3 de sus registros en 2019, y RB Health Perú S.R.L., con 4 y 2 registros en 2020 y 2021 respectivamente. Finalmente, Nestlé Marcas Perú S.A.C. obtuvo 2 registros en 2020 y 4 en 2021. Estos resultados revelan una variabilidad en la obtención de registros sanitarios según la relación entre los laboratorios de fabricación y sus respectivas empresas importadoras, sin una tendencia significativa estadísticamente identificable.

DISCUSIÓN

De acuerdo con los resultados encontrados, podemos evidenciar que existen SLM dirigidos a niños menores de 2 años que superan los parámetros técnicos de nutrientes críticos establecidos para el Perú según el Reglamento de la Ley 30021[22], siendo el azúcar total, el nutriente crítico que excede los parámetros para producto reconstituido.

El nutriente crítico que se encontró en mayores cantidades fue el azúcar, similar a lo encontrado en el estudio de Daga y Weisstaub quienes recolectaron datos de la tabla de información nutricional de ocho SLM en un supermercado de Lima Metropolitana, con el fin de estimar cuáles deberían llevar advertencias nutricionales. Se encontró que la totalidad de SLM excedieron en los niveles permitidos de azúcar. Es importante mencionar que en la mitad de los SLM no se encontraron detallados el contenido de azúcares en la tabla de información nutricional, haciendo referencia a una información más general de carbohidratos totales[23].

De igual manera, en el estudio realizado en el Líbano por Hoteit y colaboradores, analizaron el contenido de azúcares añadidos en fórmulas infantiles encontrando valores entre 0,37 a 4,17 g/100 g. Cabe resaltar que el azúcar añadido más preponderante fue la glucosa, seguida de la fructosa. Además, está información fue extraída mediante pruebas fisicoquímicas en laboratorios[24]. Resultado similar de Awad y colaboradores, donde encontraron fórmulas infantiles que contenían azúcares que superaban más del 5% de la ingesta total de energía (5,68% a 27,06%) y aunque a diferencia de nuestro estudio se utilizó método de cromatografía líquida con detección de índice de refracción, al igual que nuestro estudio solo se mencionaban en las etiquetas los niveles de carbohidratos y muy pocos mencionaban el contenido de azúcar añadido[25].

Según lo mostrado en nuestros resultados, los SLM procedentes de América presentaron los valores más altos de azúcar en g/100 ml, en comparación con lo mostrado por Pries y colaboradores en Indonesia[20], donde analizaron 99 fórmulas para compararlos con la normativa CODEX y la del etiquetado del semáforo nutricional de la Agencia de Normas Alimentarias del Reino Unido, encontrando que el 97% de la muestra estudiada contiene azúcares como sacarosa, fructosa y azúcares añadidos. La mediana del contenido total de azúcar fue de 7,3 g/100 ml. Similar a lo encontrado en nuestro estudio, donde se halló en el producto reconstituido un valor de 7,80 g/100 ml (Estados Unidos), lo que demuestra la excesiva cantidad de azúcar presente en las fórmulas infantiles[20]. Se debe señalar que a pesar de que no existe una recomendación para el consumo de azúcares libres en lactantes, la OMS señala que, para la población general, debe ser menor al 10% de la ingesta calórica total[26].

Alfaris y colaboradores analizaron el contenido nutricional de fórmulas lácteas para bebés expendidas en la ciudad de Riad en Arabia Saudita, encontrando que el contenido de

energía total osciló entre 424,23 - 544,21 kcal/100 g en fórmulas infantiles dirigidas a niños de 0 a 12 meses. En contraste con nuestro estudio, donde la media más alta analizada por país de fabricación de los SLM fue la mexicana donde el contenido fue de 520 kcal. El estudio saudí utilizó para el análisis, pruebas fisicoquímicas, a diferencia de nuestro estudio donde se comparó desde lo declarado en el etiquetado nutricional[27].

Actualmente, en la región de América, sólo 4 países (Brasil, Uruguay, México y Chile) cuentan con las políticas necesarias para combatir y reducir el contenido de sodio en los alimentos[28]. Lo que muestra relación con lo hallado en nuestro estudio, a pesar de que los valores de sodio no exceden los parámetros normados en Perú, se debería recomendar la disminución del consumo de sodio en niños[29]. Si bien es cierto que no existe una recomendación de sodio en lactantes, la OMS señala un consumo máximo de 2 g/día para la población en general[30].

En cuanto a las grasas saturadas, Hoteit y colaboradores en su estudio realizado en el Líbano, observaron que las fórmulas infantiles contenían hasta un valor de 78,85 g por cada 100 g. El ácido graso más sobresaliente fue el ácido palmítico con una proporción de 11,4 - 68,2 g/100 g [24]. En contraste, nuestro estudio presentó menores valores. Los SLM procedentes de Alemania presentaron la mayor mediana en el estudio con un valor de 7,4 g/100 g de grasas saturadas. Sin embargo, si consideramos el producto reconstituido, la mediana con el valor más alto lo tendría España (1,2 g/100 ml). Con relación a grasas trans, los SLM procedentes de Alemania presentaron valores más altos (0,15 g). Sin embargo, si consideramos los productos reconstituidos, en todos los países es 0,00 g/100 ml, siendo menores a los hallados en el estudio libanés, que encontró valor máximo de 0,59 g/100 g [24].

Nuestro estudio reveló que existe un incremento anual del otorgamiento de registros sanitarios, exponiendo a la población a un mayor número de fórmulas infantiles. La industria busca sistemáticamente ser el principal productor, comercializador y expendedor de las fórmulas infantiles. Abarcando principalmente países donde no existen políticas drásticas que protejan a los consumidores y promuevan la lactancia materna por encima de los SLM. Por ello, buscan ingresar con mayor número de fórmulas a los mercados de países en vías de desarrollo, como el Perú[31].

De igual modo, nuestro estudio pone en evidencia que los laboratorios Nestlé, Mead Johnson y Abbott en medio de la pandemia recibieron una mayor cantidad de registros sanitarios. Además, en un estudio realizado en Lima en el año 2020, en establecimientos de salud, se encontró que los SLM que incumplen las recomendaciones internacionales de comercialización de SLM y del Reglamento de Alimentación Infantil del Perú son las mismas encontradas en nuestro estudio. Lo que podría generar canales irregulares de interacción con los profesionales de la salud (incentivos, donaciones, etc.)[32]. En ese mismo sentido, Ching y colaboradores en un estudio realizado en Sudáfrica, identificaron las tácticas de marketing de las empresas a inicios de la pandemia del Covid-19, concluyendo que las mismas empresas citadas en nuestro estudio como Nestlé, Abbott y Mead Johnson tienen tácticas de injerencia grandes en la población e incumplen el Código Internacional de Comercialización de Sucedáneos de la Leche Materna[33], dicho código regula la comercialización de sucedáneos para proteger la lactancia materna, esencial para la salud infantil. En Perú, su vigencia se refuerza mediante normas del Ministerio de Salud[2,29]. Aunque enfrenta desafíos de implementación, es crucial para promover la lactancia materna y evitar la influencia negativa de productos comerciales.

Por todo lo anteriormente expuesto, se evidencia que, aunque los SLM no deberían llevar etiquetado frontal para los nutrientes de sodio, grasas saturadas y grasas trans, se debería recomendar la disminución de su consumo y monitorizar su comercialización[34], ya que, a pesar de ser productos indicados para regímenes especiales, su venta se encuentra disponible para el público en general. La evidencia muestra un consumo de 52,9% de fórmulas infantiles en niños de 0 a 5 meses a nivel nacional para el año 2019, según el informe técnico emitido por el Instituto Nacional de Salud[35].

Limitaciones

Las constantes actualizaciones en los registros sanitarios otorgados por la entidad sanitaria a las fórmulas, dificultaron la recolección y selección de SLM para la investigación. Además, perjudicó el seguimiento y monitoreo de ciertos productos. Asimismo, se observó la falta de precisión en la información nutricional declarada en el etiquetado, encontrando disacáridos declarados como ingredientes, más no como valor en la tabla de información nutricional, todo lo cual dificultó el proceso de revisión y control de calidad de la base de datos. Otra limitación del estudio fue el sesgo de selección, ya que solo trabajamos en base a la lista proporcionada por VUCE - DIGESA. Cabe indicar que, se sabe de la existencia de otros productos que cuentan con registro sanitario vigente, pero no se realizó su análisis por motivos logísticos en la ejecución del estudio. Otra limitación encontrada en nuestro estudio fue que el análisis del contenido nutricional se realizó según el etiquetado nutricional consignado en las fórmulas. Para profundizar en el análisis, se debería someter a pruebas fisicoquímicas a fin de determinar la composición de los SLM, no sólo para corroborar si el contenido proporcionado en el etiquetado es el correcto, sino también, para tener un amplio panorama de los tipos de carbohidratos, azúcares y grasas presentes.

Fortalezas

Nuestro estudio puede servir como antecedente para futuras investigaciones relacionadas a SLM. El listado de los SLM

fue brindado por la autoridad sanitaria (VUCE-DIGESA), haciendo fidedigna la búsqueda y recolección de los productos encontrados. El proceso de recolección, selección y análisis de datos de los SLM expendidos previo y durante a la emergencia sanitaria por Covid-19 (2019-2021), se realizó de manera exhaustiva.

Conclusiones

Los SLM superan los niveles permitidos de azúcar, lo que hubiera requerido la inclusión de una advertencia nutricional (octógonos) en todos los productos. Esta situación se observó en la totalidad de los productos en 2019, en la gran mayoría en 2020, y en una proporción significativa en 2021, independientemente de la etapa de implementación de la ley de alimentación saludable. Por ello, una vez se establezcan los parámetros para los SLM estos deberían ser más exigentes. Así también, nuestro estudio evidencia cómo durante la pandemia (2020 y 2021) la autoridad sanitaria otorgó una mayor cantidad de registros sanitarios con relación al año 2019, permitiendo su comercialización en el mercado peruano.

Recomendaciones

Nuestro estudio puede servir de referencia para fortalecer los sustentos técnicos científicos en el desarrollo de normas y/o políticas de la autoridad sanitaria a fin de mejorar las disposiciones que reglamenten el contenido de nutrientes críticos en los SLM. Además, es fundamental que la comunidad académica y científica realice estudios sobre el consumo de SLM en lactantes menores de 2 años, con un enfoque particular en los primeros 6 meses de vida. Esto es especialmente importante, ya que después de esta etapa, el alto consumo de estos nutrientes críticos en los alimentos proporcionados en el hogar puede representar un mayor riesgo para la salud.

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The association between protein intake and feeding practice with stunting in children aged 24-59 months

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ABSTRACT

Introduction: Stunting is a growth disorder caused by prolonged malnutrition, particularly during the first 1,000 days of life. It is diagnosed by assessing a child's height for age. This study aims to analyze respondent characteristics and examine the association between family income, feeding practices, protein intake, and stunting in toddlers aged 24-59 months.

Method: This cross-sectional study involved 171 toddlers aged 24-59 months in the Koto Mudik IV Health Center area, Pesisir Selatan Regency. Participants were selected using proportional random sampling. Family expenditure data were gathered using the *Home Observation for Measurement of Environment* (HOME) questionnaire, while feeding practices were assessed with the *Semi-Quantitative Food Frequency Questionnaire* (SQ-FFQ). Protein intake was calculated based on daily consumption and compared to Recommended Dietary Allowances (RDA). Stunting was determined using height-for-age Z-scores (HAZ) according to WHO standards, with a HAZ score below -2 Standard Deviations (SD) classified as stunting. Statistical analysis was conducted using the chi-square test, significant ($p < 0.05$).

Results: The study found that 34.5% of toddlers were stunted, 59.1% had families earning below the Provincial Minimum Wage, 56.1% had poor feeding practices, and 31.6% had insufficient protein intake. Additionally, 56.1% of fathers and 53.2% of mothers had completed secondary education, while most fathers (66.7%) were farmers and mothers (79.5%) were homemakers. Significant associations were observed between stunting and family income (p=0.017), feeding practices (p=0.007), and protein intake (p=0.002).

Conclusion: Family income, feeding practices, and protein intake significantly influence stunting. Increasing animal protein consumption may help reduce stunting prevalence.

KEYWORDS

Anthropometric assessment, growth; malnutrition, pediatric nutrition, socioeconomic factors.

INTRODUCTION

Stunting is a condition where children face hindered growth as a result of long-term nutritional deficiencies, especially during the critical first 1,000 days of life, which spans from pregnancy to the age of two. It is assessed by evaluating a child's height to their age[1].

Data from the Indonesian Nutrition Status Study (SSGI) in 2022 reveals that the prevalence of stunting in Indonesia has decreased from 24.4% in 2021 to 21.6% in 2022. However, this decrease remains below the National Medium-Term Development Plan (RPJMN) target of 14%. Furthermore, data from the Ministry of Health in 2023 show that stunting prevalence in 2021 and 2022 in Western Sumatra has increased from 23.3% to 25.2%, while in Bali it has declined from 10.9% to 8% [2]. The West Sumatra report on the accelerated reduction of stunting in 2023 showed SSGI results in 2022 showing that the prevalence of stunting in the Pesisir Selatan Regency was (29.8%), Sawah Lunto City was (13.7%), and Bukit Tinggi City was (16.8%) [3].

According to the causal framework of undernutrition developed by UNICEF, the causes of undernutrition according to UNICEF reports from 2013 and 2019, the causes of malnutrition (including undernutrition) can be categorized into three primary levels: immediate, underlying, and basic causes.

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Immediate causes include insufficient dietary intake and the presence of infectious diseases. Underlying causes encompass factors such as household food insecurity, inadequate caregiving practices, an unhealthy living environment, and limited access to healthcare services. At the most fundamental level, basic causes are driven by poverty, governance systems and policies, as well as access to education[1,4].

The impacts of stunting on children's lives can be in the short and long term. Short-term impacts include increased mortality, morbidity, impaired cognitive, motor, and language development, and health expenditure. Long-term impacts include short stature, increased risk of obesity and related diseases, poor reproductive health, decreased achievement, and learning ability, and lack of ability to engage in physical or cognitive activities at optimal levels and work capacity. The impacts of stunting on children can persist until children become adults. In the absence of effective prevention, management, or intervention strategies, stunting can expose children to numerous long-term health challenges. These include an increased likelihood of developing conditions such as obesity, osteoporosis, diabetes mellitus, and other degenerative illnesses. To address and minimize the effects of stunting, it is crucial to adopt a comprehensive approach that incorporates better dietary practices, improved access to healthcare services, and enhanced nutritional education[5,6].

Various entities, such as government bodies, global organizations, non-governmental organizations, and community groups, have been addressing the issue of stunting with the goal of lowering the stunting rate to below 14% by 2024. Currently, much of the attention given to addressing stunting focuses on increasing the intake of animal protein. This is because animal-based foods are rich in high-quality protein and essential micronutrients such as iron, zinc, and vitamin B12, which are critical for child growth and development. Previous studies have demonstrated that adequate consumption of these nutrients can improve children's growth outcomes and reduce the risk of stunting, particularly during the first 1000 days of life, a critical period for preventing nutritional deficiencies. Headey *et al* indicate that higher consumption of animal-derived foods is strongly associated with lower stunting rates in children. The provision of high-quality protein from animal products, coupled with vital micronutrients like iron and vitamin B12, has been proven to promote children's growth and help mitigate the nutritional deficiencies that lead to stunting[7].

The percentage of total caloric intake from protein in Pesisir Selatan Regency (54.40%) is lower than in Pasaman Barat (67.14%). Solok Selatan (59.44%), and Sijunjung (55.07%). According to the Decree of the Minister of National Development Planning/Head of Bappenas No. KEP.42/M.PPN/HK/04/2020, Pesisir Selatan Regency has been designated as one of the regions for coordinated efforts to reduce the stunting rate in 2021. The Pesisir Selatan Regency government is dedicated to reducing stunting rates in the area by implementing the 'pasan mandeh' innovation, a comprehensive community-based approach with ten actionable steps aimed at preventing stunting. These steps focus on enhancing child nutrition, improving the health of infants and toddlers, promoting the intake of a variety of nutritious and balanced foods, and encouraging family participation in health insurance programs. The 'pasan mandeh' method blends local knowledge with focused interventions across multiple sectors to involve families and communities in combating stunting, making it a distinctive model that meets the region's specific needs. The concept of "pasan mandeh" highlights a community-driven, localized intervention that integrates both health and nutrition aspects[8]. With this in mind, Pesisir Selatan was considered a suitable location for this study to identify the characteristics of respondents as well as the correlation between feeding practice, family income, and protein intake and the nutritional status of toddlers aged 24-59 months in the working area of the Koto Mudik Health Centre IV in Pesisir Selatan Regency.

METHOD

This study, employing a cross-sectional design, was conducted from March 2023 to January 2024 in the working area of the Koto Mudik Health Centre IV, Pesisir Selatan Regency. Concentrating on children aged 24-59 months allows for a clearer and more pertinent understanding of the lasting effects of nutritional problems, while also providing valuable insights into child development during this crucial stage of growth.

The total population amounted to 415 children aged 24-59 months. The technique of proportional random sampling was undertaken by fulfilling the inclusion criteria, i.e., parents were willing to participate in the study, could communicate well, had toddlers aged 24-59 months. The sample size of 171 toddlers was obtained by the following formula:

$$n = \frac{z^2 1 - \alpha/2\ P\ (1-P) N}{d^2 (N-1) + Z^2 - \alpha/2\ P(1-P)}$$

n: Minimum sample size required

N: Total population

$z^2 1 - \alpha/2$: Z value at the significance level (95% = 1.96)

P: Proportion of the subject group with low family income

d: Degree of deviation from the desired population

This study used informed consent. The research data consisted of primary and secondary data. Primary data included data on nutritional status, family income, parental feeding style, and protein intake. Data on Nutritional Status related to Stunting is derived from assessments of toddlers using

the height-for-age z-score, using a Microtoice stature meter, with classifications set at below -2 standard deviations (SD). The categories for nutritional status include Stunting (defined as < -2 SD) and Normal (defined as ≥ -2 SD)[9].

Family Income is defined as the total monetary earnings a family receives each month, which is then compared against the provincial minimum wage standard (UMP) using the HOME questionnaire. Income considered below the UMP is categorized as less than Rp. 2.742.476 per month, while income above this threshold is classified as equal to or greater than Rp. 2.742.476 per month[10].

Feeding Practices encompass the methods that mothers use in nurturing toddlers, particularly regarding the preparation and provision of food. The questionnaire used for this assessment contains 15 questions. Feeding practices are categorized as Poor (when the score is ≤80% of the Total Score) and Good (when the score is >80% of the Total Score)[11].

Protein Intake refers to the daily average of protein-rich foods consumed by toddlers, which is then compared to the recommendations outlined in the Adequate Nutritional Intake (RDA) guidelines. Data collection was done using the Semi-Quantitative Food Frequency Questionnaire (SQ-FFQ). The classification of intake is categorized as Deficient (when <90% of RDA) and Normal (when ≥90% of RDA)[12].

Meanwhile, secondary data included data on the profile of Pesisir Selatan Regency and the total population obtained from the report. The data was subjected to further analysis through the Chi-Square test to examine the relationships among categorical variables, particularly focusing on family income levels, maternal feeding practices, and the nutritional status (stunting vs. normal) of toddlers. The statistical analyses were carried out using SPSS version 25, with significance established at $p < 0.05$.

RESULTS

This study demonstrated that the majority of the children were identified as male. The respondents were mostly at the age of 36-47 months. Most of the respondents' fathers' education was at the high school level, and most of them worked as farmers. Meanwhile, the education of the respondents' mothers was mostly at the senior secondary school level, and most of them were housewives. The number of stunting respondents was smaller than normal. The family income of more than half of the respondents was below UMP. The parental feeding practices of more than half were categorized as poor. In addition, most of the respondents' protein intake was in the normal category (Table 1).

This study presents the ten kinds of food most consumed by respondents, including rice as a source of carbohydrates.

Table 1. Frequency distribution of respondents' characteristics in the working area of the Koto Mudik Health Centre IV in Pesisir Selatan Regency year 2024

Respondent Characteristics	f	%
Characteristics of Toddlers		
Sex		
Male	93	54.4
Female	78	45.6
Age		
24-35 months	56	32.7
36-47 months	58	33.9
48-59 months	57	33.3
Case of Stunting (TB/U)		
Stunting (Z-Score <-2 SD)	59	34.5
Normal (Z-Score ≥-2 SD)	112	65.5
Family Income		
Below UMP (<Rp2,742,476/month)	101	59.1
Above UMP (≥Rp2,742,476/month)	70	40.9
Parental Feeding Style		
Poor (≤80% of total score)	96	56.1
Good (>80% of total score)	75	43.9
Protein Intake		
Deficit (<90% RDA)	54	31.6
Normal (≥90% RDA)	117	68.4
Characteristics of Fathers		
Education		
Dropout from primary school	2	1.2
Primary school	16	9.4
Junior secondary school	36	21.1
Senior secondary school	97	56.7
Higher education	20	11,7

Table 1 continuation. Frequency distribution of respondents' characteristics in the working area of the Koto Mudik Health Centre IV in Pesisir Selatan Regency year 2024

Respondent Characteristics	f	%
Characteristics of Fathers		
Occupation		
Unemployed	114	6.0
Farmer		66.7
Merchant	9	5.3
Peasant	2	1.2
Entrepreneur	10	5.8
Civil servant	7	4.1
Characteristics of Mothers		
Education		
Dropout from primary school	4	2.3
Primary school	15	8.8
Junior secondary school	31	18.1
Senior secondary school	91	53.2
Higher education	30	17.5
Occupation		
Farmer	4	2.3
Merchant	6	3.5
Entrepreneur	4	2.3
Civil servant	5	2.9
Housewife	136	79.5
Others	16	9.4
Total	171	100.0

Meanwhile, the average daily intake of animal protein most consumed by respondents was that of chicken meat.

Table 3 illustrated that 42.7% more stunting was found among the group with income below UMP. The statistical test results depicted that there was a significant association between family income and the case of stunting in respondents ($p < 0.05$).

43,8% stunting was more common among children with poor feeding practice. The statistical test result showed that there was a significant association between parental feeding style and stunting ($p < 0.05$). Stunting was more prevalent among children with protein intake in the deficit category. There was a significant association between protein intake and stunting in toddlers aged 24-59 months in the working area of the Koto Mudik Health Centre IV in Pesisir Selatan Regency Year 2024 ($p < 0.05$).

DISCUSSION

Respondent Characteristics (stunting, family income, feeding Practice, and protein intake)

This research found that 34.5 % were stunted. This is in line with a study conducted by Vasera and Kurniawan showed 20.9% of the proportion of stunted[14]. In the present study, 40.9% of children with family income above UMP. This is in line with a study by Nurmalasari *et al* which found that 41.4 % children from families with high income[15]. UNICEF in 2013 suggested that the economic crisis is one of the root causes of inhibited growth and development of toddlers. Families with high income levels manage to fulfill all primary and secondary needs of children[4].

This research also illustrates that the number of toddlers with good feeding practice amounted to 75 children (43.9%). This is in line with a study by Widyaningsih *et al*., in 2018 which found that 51.2% of stunting exhibit fewer breastfeeding patterns[12]. Feeding habits have an impact on food consumption quality, which eventually raises nutritional adequacy[16].

This study showed that 31.6 % of children with a protein intake deficit. This is in line with a study by Ranti *et al* showed that 11.6 % of children with protein intake deficits[18]. Protein intake plays a role in various metabolic processes of other nutrients, especially contributing to the absorption of micronutrients that support the growth and physical development of toddlers. Protein is a macronutrient and the basic building block of the body's cell structure. The main function of protein is to form new tissues and repair damaged body tissues[19,20].

Association between Family Income and Stunting

This researched showed that stunting is more common in families whose income is below UMP compared to family income above UMP. The result of the statistical test showed that there was a significant association between family income and stunting in toddlers aged 24-59 months in the working area of the Koto Mudik Health Centre IV, Pesisir Selatan Regency. This result is in line with a study by Saadong *et al* which stated that there was a significant association between family income and stunting (p-value = 0.044)[21].

Table 2. Frequency distribution and average intake of food ingredients that are often consumed by toddlers aged 24-59 months of the Koto Mudik Health Centre IV in Pesisir Selatan Regency Year 2024

No.	Food	N	%	Average protein intake per day (g)	Intake per day%
1	White Rice	171	100	4.4	16.0
2	ChickenMeat	161	94.1	2.9	10.6
3	ChickenEggs	160	93.5	3.4	12.4
4	Tofu	157	91.8	0.9	3.2
5	Potatoes	143	83.6	0.2	0.7
6	Tempeh	140	81.8	2.0	7.2
7	Biscuits	128	74.8	0.7	2.7
8	*Bakwan*	117	68.4	0.3	1.3
9	Doughnuts	115	67.2	0.3	1.0
10	Chicken Satay	114	66.6	1.9	7.1

Table 3. Association between family income, feeding practice, and protein intake and stunting in toddlers aged 24-59 months in the working area of the Koto Mudik Health Centre IV in Pesisir Selatan Year 2024

Independent Variable	Stunting in Toddlers						*P-Value
	Stunting		Normal		Total		
	f	%	f	%	f	%	
Family Income							
Below UMP (<Rp2,742,476)	41	42.7	55	57.3	96	100	0.017
Above UMP (≥Rp2,742,476)	18	24	57	76	75	100	
Feeding Practice							
Poor (≤80% of total score)	42	43.8	54	56.3	96	100	0.007
Good (>80% of total score)	17	22.7	58	77.3	75	100	
Protein Intake							
Deficit (<90% RDA)	28	51.9	26	48.1	54	100	0.002
Normal (≥90% RDA)	31	26.5	86	73.5	117	100	

* the chi-square test is significant with $p<0.05$, UMP (provincial minimum wage).

Family income refers to the household's ability to fulfil its needs. Families with low incomes will have limitations in meeting their needs and less variety in food ingredients. They also commonly spend most of their income on food. Family income determines the kind of food that will be consumed. Lack of food consumption and variety can increase the risk of nutrient deficiencies. Although a family spends most of its income to fulfil its consumption, it does not necessarily mean that the food consumed has adequate nutrition. In addition, the family's ability to purchase food is not only influenced by the amount of income but also by the price of food. Some food with high prices are not purchased, causing some families to rarely serve them and further resulting in reduced fulfilment of nutritional needs by Nurmalasari *et al*[15].

Association between Feeding Practice and Stunting

The results of this study indicated that there was a significant association between parental feeding style and stunting in toddlers aged 24- 59 months in the working area of the Koto Mudik Health Centre IV in Pesisir

Selatan Regency. This result is in line with a study by Mastila *et al* which showed that there was an association between child feeding and stunting ($p < 0.05$) [22].

The act of feeding infants and young children directly impacts children's nutritional status and has a significant impact on child survival. One of the indirect variables influencing children's nutritional health, including stunting, is the feeding habits of the parents, according to the United Nations Children's Fund (UNICEF)[4]. Parenting is the mother's ability to provide good care for children through feeding practices, personal hygiene practices, and the environment so as to support the achievement of good nutritional intake for child growth and development. Feeding practices are parents' behavior in providing food intake to meet children's nutritional needs. Good feeding practices include three main meals and two snacks as sources of energy, carbohydrates, protein, fat, vitamins, and minerals[24,25].

Association between Protein Intake and Stunting

The findings in this study show that there was a significant relationship between protein intake and stunting in toddlers aged 24-59 months in the working area of Koto Mudik Health Centre IV in Pesisir Selatan Regency also shows that the source of protein most consumed by respondents was animal protein derived from chicken eggs and chicken meat. The results of this study are in line with Sari and Hidayati indicating that the intake of chicken protein has a beneficial effect on children's growth and helps lower the risk of stunting[26]. Furthermore, Widyastuti and Rahmawati found a notable connection between the consumption of animal protein, such as chicken, and the occurrence of stunting in children. These research findings emphasize the crucial role of sufficient protein intake in supporting the healthy growth and development of children[27]. Likewise, The study by Pratiwi and Setiawan suggests that regularly eating chicken meat is linked to better nutritional health in children and a lower likelihood of stunting[28]. Different from Diana *et al* the result also indicated that the chocolate flavor biscuits prepared with 20 g Bilih fish flour significantly increased the tail lengths, Y-Maze score, and the number of hippocampus neuron cells (CA4, DG) in experimental Rats[29,30]. Another study by Kaimila *et al* also reported a linear correlation between animal protein consumption and increased height in children[31]. Fikri *et al* reviewed and compiled existing knowledge on the role of protein in managing stunting, highlighting the significance of adequate protein intake in supporting optimal growth while minimizing potential risks[32].

The nutritional content of animal protein is higher than that of vegetable protein sources. Animal protein is easier to digest and contains more essential amino acids necessary for growth. Protein (high-protein foods such as meat, fish, eggs, milk, and other dairy products) can stimulate IGF-1 production in the body. Protein is the main fuel for the process of growth and repair of body tissues. IGF-1 is produced naturally in the human body and is influenced by factors such as growth hormone and nutrient intake (protein, omega-3 fatty acids, complex carbohydrates, vitamin D, and zinc). Although some foods can potentially increase IGF-1 production or activity in the body, it is important to note that a balanced diet and a healthy lifestyle are keys to ensuring optimal IGF-1 levels and healthy growth[19,20].

IGF-1 balance is vital because IGF-1 is a hormone that plays a pivotal role in growth, development, bone growth, cartilage growth, and muscle growth, as well as stimulates the production of growth hormone in the pituitary gland, which in turn stimulates the growth of body cells. IGF-1 works in the body by stimulating the growth of cells (including bone and muscle cells). When IGF-1 is present in sufficient amounts, the process of bone growth runs properly, helping children achieve optimal height and then stimulating muscle growth, which can prevent stunting. IGF-1 also affects the body's overall metabolism and ensures the body gets the nutrients it needs for optimal growth. IGF-1 deficiency leads to stunted bone growth, thus contributing to stunting. As such, IGF-1 helps to ensure that a child's growth process runs smoothly and reduces the risk of stunting[19,20].

CONCLUSION AND SUGGESTION

The results show that there is a significant association between family income and stunting, parental feeding style, and protein intake and stunting in toddlers aged 24-59 months in the working area of the Koto Mudik Health

Centre IV in Pesisir Selatan Regency in 2024**.** Mothers of toddlers are encouraged to constantly provide protein-rich foods, especially animal protein, to support the growth and development of toddlers.

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A formative study of weekly iron-folic Acid (WIFA) supplementation for adolescent school girls in West Java Indonesia

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ABSTRACT

Introduction: The weekly iron-folic acid (WIFA) supplementation program for adolescent school girls is mainly allocated in regencies where they are found as locusts of stunting. However, the prevalence of anemia in adolescent school girls in Indonesia remains high and the adherence of supplement consumption remains low. The objective of this study was to assess the performance of WIFA supplementation for adolescent school girls in West Java Indonesia.

Methods: This research is a formative study conducted to 280 adolescent school girls in ten high schools in Tasikmalaya and Ciamis, West Java Province, Indonesia. Systematic random sampling was used to select the adolescent school girls. Data collected using structured questionnaire including adolescent characteristics, knowledge, and history of WIFA tablets received and consumed. Data were analyzed descriptively.

Results: The study examined that while 99.3% participants knew about WIFA supplementation, only 64.1% consumed the tablets, and most (97.3%) took fewer than 24 tablets in six months. Side effects like nausea (70.7%) and dizziness (66.3%) were common. Knowledge gaps persisted, with only 32.4% understanding anemia diagnosis. Distribution at schools varied, often occurring at school events. Despite the program's intent to prevent anemia, low adherence and misinformation about the tablet and the program remains high among the adolescent school girls.

Conclusion: Lack of understanding about anemia and WIFA supplementation among adolescent school girls and less optimal of WIFA management might have been responsible on adherence of consuming WIFA tablets. It indicated that nutrition education for adolescent school girls should be implemented, including the information on how to manage side effects from tablet consumption. In addition, WIFA program implementation should be improved by strengthening distribution mechanisms and increasing teacher's role in the program.

KEYWORDS

Adherence, adolescent school girls, anemia prevention, iron-folic acid, supplement consumption.

INTRODUCTION

Adolescence presents a second window of opportunity for establishing healthy lifelong nutrition. Adolescents are vulnerable to undernutrition because their rapid growth raises their nutritional needs. While prevention of stunting in the first 1,000 days remains a priority, adolescence provides an opportunity for a high return on investment with nutrition interventions. The prevalence of stunted children in Indonesia remains high (27.67%) in 2019 and 24.4% in 2021[1,2]. Meanwhile in 2018, 32% of Indonesian adolescents in Indonesia suffered from anemia[3]. It means that approximately 7.5 million Indonesian adolescents are at risk of experiencing problems in their developmental growth and cognitive abilities. Also, they

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become vulnerable to infectious diseases. The government put the strategy in stunting prevention by empowering sensitive intervention programs to educate adolescence.

Stunting is an intergenerational problem, which means the quality of life is determined by the history of nutritional and health conditions in the previous life cycle[4]. Adolescents who were malnourished during their childhood or had experienced prolonged malnutrition due to inappropriate eating behavior up to marriage and pregnancy will be at risk of giving birth to stunted babies. Parenting and eating patterns that do not support normal growth and development keep on repeating themselves and lead to a low intake of nutrients for the next generation of children, resulting in a decline in the quality of human resources[5]. One point in the life cycle that is the potential to break the chain is the nutritional intervention for adolescents who will take a role as mothers in the future.

Iron-folic acid (IFA) supplementation is an intervention given to pregnant women and adolescent school girls to reduce the prevalence of anemia. It is one of the efforts to accelerate the alleviation of stunting in Indonesia as an integrated stunting reduction intervention. Increasing stunting awareness among adolescent school girls through optimization of the implementation of weekly iron-folic acid (WIFA) supplementation is the potential way to induce behavioral change in improving lifelong nutrition and health to overcome stunting. The objectives of this study were to analyze WIFA program implementation for adolescent school girls in West Java, Indonesia.

METHODS

Design and Participant

A formative study was conducted in five high schools in Tasikmalaya and five high schools in Ciamis, West Java Province, Indonesia. The selection of high schools was made purposively based on the recommendation from education and health district offices. The research was conducted in July-September 2022.

The minimum sample was calculated based on the sample size calculation formula in cross-sectional studies. Where P is the delta proportion of adolescent school girls aged 13-18 years with the knowledge of IFA and anemia in the good category was 20,78%[6], d is the precision (0.05) corresponding to the effect size, Zα/2 is 1.96 as a normal deviate for two-tailed alternative hypothesis at 5% level of significance. Below is the sample size calculation:

$$n = \frac{Z^2 \; x \; p \; (1 - p)}{d^2}$$

$$n = \frac{1.96^2 \text{ x } 0.21 \; (1 - 0.21)}{(0.05)^2}$$

$$n = \frac{3.8416 \text{ x } 0.1659}{0.0025}$$

$$n = \frac{0.6373}{0.0025}$$

$$n = 254.92 \; (+10\% \sim n = 280)$$

The calculated sample size is, therefore, 280. The final sample size of 280 was proportionally allocated to the 10 selected high schools from two districts. Systematic random sampling was used to select the adolescent school girls using random numbers generated for each class using school girl attendance register.

Data Collection

A set of questionnaires was made systematically in either open or closed questions to answer the objectives of this study. Training of enumerator was conducted to verify the same perception and understanding between researcher and enumerator regarding the set of questionnaires, its objectives, and the process how to collect the data. The data collected were adolescent characteristics, history of receiving IFA supplementation, history of WIFA consumption, and knowledge related to anemia and WIFA supplementation.

All the research procedure and questionnaire have been through review by Ethical Committee of Human Research in the institution which the researchers belonged under registration number 699/IT3.KEPMSM-IPB/SK/2022. Prior to data collection all the participants were explained about the research aim, procedure, and side effects and benefits that they may have gained from the procedure. All participants agreed to the procedure and signed the informed consent document.

In-depth interview and focus group discussion were administered to obtain information on the management of WIFA supplementation. Subjects of in-depth interview and focus group discussion were teachers, adolescent school girls and staffs of public health center.

Data Analysis

Estimation of elementary statistics consisting of mean and standard deviation were applied to all the quantitative variables. In addition, estimation of proportion was applied to all the categorical variables or quantitative variables which are categorized. The results of the estimation were presented in the form of tables. All analyses for quantitative data were carried out using Microsoft Excel and SPSS Version 22.0 for windows.

RESULTS

The subjects in this study were high school and vocational high school students (adolescent school girls) in grade 11. The distribution of subject characteristics is presented in Table 1.

Table 1. Characteristics of adolescent school girls

Characteristics of adolescent school girls	n	%
District		
Tasikmalaya	142	50.0
Ciamis	142	50.0
School type		
Public/private high school	141	49.6
Vocational high school	143	50.4

Subjects are adolescent school girls who live in Tasikmalaya and Ciamis Regencies, with the proportion of subjects in each district being 50%. Two types of schools were the targets of the research, namely public/private high school and vocational high school, with the percentage of subjects being 49.6% and 50.4%, respectively.

Table 2 presents the distribution of adolescent school girls according to their history of receiving IFA supplementation. Adolescent school girls were asked to report their history of receiving IFA supplementation, including the duration of time, frequency of receiving, and the number of IFA supplements taken within the last year.

Table 2. Distribution of adolescent school girls based on history of receiving IFA supplementation

History of receiving IFA supplementation	n	%
Duration of time receiving IFA supplement at school		
Less than a year	214	75.4
1 year	28	9.9
>More than 1 year	42	14.8
Mean±SD (month)	9.1 ± 4.7	
Frequency of receiving IFA supplement		
Every week	155	54.6
Others	129	45.4
Numbers of IFA supplement received within the last year		
<24 tablet	143	50.4
≥24 tablet	141	49.6
Mean±SD (tablet)	17.8 ± 7.2	

Table 2 shows that most adolescent school girls (75.4%) have received IFA at school for less than a year, and only a few of them (9.9%) have received IFA in a year. This is due to the pandemic Covid-19 in 2020-2022 although the WIFA supplementation program has been started in 2018. The average duration of time that participants received the IFA supplement was 9.1 months. As many as 54.6% of participants had received it every week. The average number of IFA received within the last six months was 17 tablets, which is less than the recommendation (52 tablets per year or 26 tablets per six months).

Table 3 reported the history of WIFA consumption in adolescent school girls. Adolescent school girls who consumed IFA

Table 3. Distribution of adolescent school girls based on history WIFA consumption

History of WIFA Consumption	n	%
Consume the IFA tablets that have been provided		
Yes	182	64.1
No	102	35.9
The location to consume IFA tablet		
At school	98	53.8
At home	54	29.7
At school and home	30	16.5
The number of IFA tablets that have been consumed during the last six month (n=182)		
<24 tablet	177	97.3
≥24 tablet	5	2.7
Benefit after IFA consumption		
Have no benefit	100	55.6
Feeling fresh and well	72	39.6
Not easy to feel sleepy	34	18.8
Feeling more excited	29	15.9
More focus on learning	20	11.0
Feeling side effect after consumption		
No	97	53.3
Yes	85	46.7
Type of side effect		
Nausea	58	70.7
Dizziness	55	66.3
Iron-likely odor when belching	25	30.1
Vomiting	1	1.2

tablets were only 64.1%. It indicated that the program should be improved. As for the location to take IFA tablets, most adolescent school girls took them at school (53.8%), and some of them took them at home (29.7%), while a few (16.5%) took them both at school and home. Most participants (97.3%) had taken IFA for less than 24 tablets, with the average number of tablets consumed being 5 during the last six months. This result was in line with the previous study which reported that only 21% had consumed at least 27 tablets[7].

Table 4 presented the distribution of adolescent school girls' general knowledge of anemia and WIFA supplementation, where almost all adolescent school girls (98.2%) have heard about the anemia and WIFA supplementation, and only 1.8 % of adolescent school girls did not know or have never heard about anemia and WIFA supplementation. Most of the adolescent school girls received information regarding anemia from their teachers (62.0%), health workers (59.9%), and the media (43.7%).

The knowledge of the adolescent school girls on how to understand anemia status was still below expectation, which was shown by only 32.4 % of adolescent school girls who had a correct answer about how to measure anemia status (checking Hb level in the blood). In comparison, the others still answered wrong (67.6%). Almost all adolescent school girls (99.3%) have heard about the WIFA supplementation program, and only 0.7 % of adolescent school girls have yet to hear of iron tablets supplementation to increase the red blood cells of adolescent school girls.

The knowledge of adolescent school girls related to causes and symptoms of anemia is presented in Table 5. Most adolescent school girls (75%) understood that they must receive iron supplementation weekly. However, some of them (23.6%) said the frequency of iron supplementation needed was once a month, and 1.4 % of adolescent school girls stated that iron supplements were only given during menstruation. Within a year, only 38.7% of adolescent school girls knew that the requirement to consume iron supplementation tablets lasted for 52 weeks.

The general knowledge of adolescent school girls regarding the side effect of taking/consuming iron tablets is presented

Table 4. School adolescent girl knowledge related to anemia and WIFA supplementation

Questions	n	%
Do you know or ever heard about anemia		
Yes	279	98.2
No	5	1.8
If the answer is yes, where do you get information about anemia?		
Teachers	173	62.0
Media (printed or electronic)	122	43.7
Parents or Family	93	33.5
Friends	58	20.8
Extracurricular activities	5	1.8
Way to find out whether school adolescent girl have an anemia or not is by checking the hemoglobin level in the blood.		
False	192	67.6
True	92	32.4
Adolescent school girls have heard about IFA supplementation program		
Yes	282	99.3
No	2	0.7

Table 5. Adolescent school girls' knowledge related to dosage and duration of WIFA supplementation

Questions	n	%
Frequency of IFA supplementation in school to prevent or to overcome anemia		
Once a week	213	75.0
Once a month	67	23.6
During menstruation period	4	1.4
Within a year, for how long (time duration) the student must consume IFA supplement		
52 weeks	110	38.7
12 weeks	98	34.5
4 weeks	76	26.8
Nutrient content in IFA supplement		
Iron and Folic Acid	172	60.6
Iron and Calcium	97	34.2
Iron and Zinc	15	5.3
Iron dosage in IFA supplement		
50 mg of Iron	144	50.7
60 mg of Iron	121	42.6
70 mg of Iron	19	6.7

in Table 6. Most adolescent school girls answered that iron supplementation could provide benefits for preventing anemia (93%), not getting tired easily (59.5%), and increasing concentration (50%). According to these findings, the WIFA supplement tablets help replace lost iron due to the menstruation period and meet the iron necessity, which is insufficient from food. The iron substance in iron tablets is helpful in increasing concentration in learning, maintaining body fitness, and preventing anemia[8].

Table 6. Adolescent school girls' knowledge related to benefit in consuming WIFA supplement

Benefit of Consuming WIFA Supplement	n	%
Prevent anemia	264	93.0
Not easily tired	169	59.5
Increase concentration	142	50.0
Increase work productivity	62	21.8
Increase study capacity	56	19.7
Sleep more soundly	47	16.5
Increase body weight	3	1.1

From the qualitative survey, it was found that the Weekly Iron-Folic Acid (WIFA) supplementation program for adolescent school girls is mainly allocated in regencies where they are found as locusts of stunting. The IFA supplement tablets administration is usually coordinated by Red Cross Youth (RCY) supervisors, teachers of the School Health Clinic, and/or Physical Education Teachers as the person-in-charge (PiC). The PiC responsibilities to IFA administration are receiving and distributing IFA tablets, monitoring-evaluating, and reporting activities regarding IFA distribution. Another duty is to invite Red Youth Cross cadres to distribute IFA tablets to adolescent school girls and record, monitor, and evaluate results. Several schools have some teachers in charge as School Health Clinic teachers. Meanwhile, there is also school that delegates only one person to be in charge of the IFA administration. The IFA supplementation program at the level of Public Health Centre is managed by Nutrition Counsellor, School-aged-children Counsellor, School Health Clinic Counsellor, and Health Promotion Counsellor. From organizational structure, the IFA program is supervised or under the responsibility of a Nutrition Counsellor, with its implementation assisted by other counsellors. However, during school visits, the in-charge IFA team can be selected from any work section since the IFA tablet administration program is usually accompanied by other health programs at the school.

The IFA distribution to adolescent school girls by the affiliated schools is carried out in several ways: (1) once a week, IFA is distributed on a specific day to be consumed together at schools (weekly flag ceremony, students' events, or during first lesson hour); (2) IFA tablets in some amounts are distributed one time (for example a stock for one month or one semester); and (3) only distributed to students who ask or need it. Ways to give IFA tablets in every school are also different. Some tablets are (1) distributed directly by the PHC when they visit schools, (2) given by PiC (IFA tablets are given when PiC visits every class), and (3) some tablets are given by the RCY members or the class leader. For schools that invite RCY members to help, they provide attendance schedules for the RCY members as the schedule for IFA distribution to adolescent school girls in the schools.

IFA socialization is carried out according to a variety of schedules. The socialization of IFA administration is taken within other health activities held at schools that are not limited to the IFA context. A routine health activity the Public Health Centre carries out in schools is health screening activities for school students. In this screening activity, several PHC also distribute the IFA tablets to new students at the same time. Some PHC is also looking for adolescent school girls' events for inserting the IFA socialization or Red Cross Youth activities by inviting the members to become peer groups as counselors for other adolescent school girls.

At the school level, the received IFA from the Public Health Centre will be stored in School Health Clinic room in a special cupboard, but other schools keep the tablets in a cool place and not exposed to direct sunlight or some schools use First Expire First Out (FEFO) system.

DISCUSSION

Environmental differences such as school location and status can reflect differences in students' character between schools[9]. Environmental factors can influence compliance with the consumption of iron supplement tablets in female adolescents. According to social support and social network theory, one factor that affects a person's health is social support and its network. Adolescents are at an age of psychological development that requires support from the environment to grow and have good obedience[10]. Previous research results state that someone with good environmental support is likely to consume iron tablets times many more than someone with poor environmental support[11].

According to the Ministry of Health recommendation, the number of WIFA tablets a person needs to consume in a year is 52 tablets delivered each week[12]. A study in East Nusa Tenggara showed that the proportion of adolescent school girls who received WIFA tablets was 93%[13]. The mean number of WIFA tablets consumed was only ten in the previous six months, which was lower than the number of

tablets received. Awareness of adolescents on WIFA supplementation to prevent anemia remained low, and that was due to the need for more information on anemia and health practice, which was contributed by social and cultural factors and food habits[14].

The low knowledge about anemia and nutrition in adolescent school girls will lead to deviant consumption selection of WIFA supplementation. Their nutritional intake will not fulfill their needs, particularly their daily iron needs[15]. From this explanation, it is necessary to make a follow-up program to increase the knowledge and motivation of adolescent school girls. One form of realization is holding a nutrition education program for high school students. Nutrition education is an effort to change attitudes and behavior to make people understand the importance of nutritional intake for increasing concentration and learning achievement[16]. This study stated that adolescent school girls' knowledge about anemia must be improved to create behavioral changes in anemia prevention and to support a successful anemia prevention program. Therefore, it is necessary to socialize WIFA supplementation to adolescent school girls along with their parents[17].

One causal factor of the low achievement from the WIFA supplementation program is the inadequate or lacking health facilities and infrastructures[18]. The information or general knowledge related to anemia and iron supplementation is crucial for adolescent school girls, and this understanding can be reflected in efforts to prevent and cure anemia. One of many attempts is consuming food as needed, having a healthy diet, and not undergoing extreme diets[19]. Moreover, to increase knowledge about anemia, it is necessary to carry out counseling for adolescent school girls. It is known that the knowledge of adolescent school girls about anemia has increased after counseling when compared to the state before counseling[20]. Thus, counseling is needed to improve the WIFA program with cross-sectoral support.

The regulation about the frequency, duration, dosage, and procedures for administering iron supplementation is listed in Official Circular Letter Number HK.03.03/V/ 0595 /2016 issued by the Directorate General of Public Health, Ministry of Health, Republic of Indonesia, which stated that IFA supplementation must be given for 1 tablet per week throughout the year (52 weeks) for adolescent school girls at school and women of childbearing age at work. The IFA supplementation contains 60 mg of elemental iron (Ferro Sulfate, Ferro Fumarate, or Ferro Gluconate) and 0.4 mg of folic acid[21].

Adolescent school girls' attitudes regarding anemia and WIFA supplementation are influenced by several factors, one of which is knowledge of the benefits of iron supplements. Adolescent school girls' lack of knowledge and awareness regarding anemia and iron supplementation causes nutritional problems[22].

CONCLUSION

There were only 64.1% of adolescent school girls who consumed WIFA tablets. There were still many adolescent school girls (55.6%) who stated that there was no benefit of consuming IFA tablets. In addition, the average number of WIFA tablets received by adolescent school girls was only 18 tablets per year, while it should be 52 tablets. Lack of understanding about anemia among adolescent school girls and less optimal of WIFA management might have been responsible on adherence of consuming WIFA tablets. It indicated that nutrition education for adolescent school girls and the WIFA program implementation should be improved.

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Conocimientos, actitudes y prácticas sobre lactancia materna exclusiva: Perspectivas en gestantes y madres postparto

Knowledge, attitudes and practices on exclusive breastfeeding: Perspectives in pregnant and postpartum mothers

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RESUMEN

Introducción: La lactancia materna exclusiva (LME) es fundamental para el desarrollo infantil, pero su prevalencia en el Ecuador es subóptima, especialmente en áreas urbanas. La LME ofrece beneficios multidimensionales, pero su establecimiento es desafiante debido a factores socioculturales. Es crucial apoyar a las madres a promover la LME.

Objetivo: Evaluar los conocimientos, actitudes y prácticas sobre LME en una población de gestantes y madres postparto.

Metodología: Se realizó un estudio descriptivo transversal con 105 mujeres (gestantes y posparto) en un centro de salud urbano en Riobamba, Ecuador. Se aplicó un cuestionario estructurado en cuatro secciones: sociodemográficos, conocimientos, actitudes y prácticas sobre lactancia materna. Categorizando los puntajes en alto, medio y bajo con percentiles. Se realizaron análisis estadísticos paramétricos ANOVA para identificar asociaciones.

Resultados: La muestra de 105 mujeres, predominantemente mestizas (86,67%) y con estudios secundarios (62,86%), mostró que el 66,7% tenía altos niveles de conocimiento y actitudes favorables hacia la lactancia materna, pero un 19% presentó niveles bajos en ambas áreas. Las prácticas se distribuyeron entre adecuadas (46,7%) y regulares (44,8%), con un 8,6% inadecuadas. El nivel educativo influyó significativamente en el conocimiento sobre lactancia (p=0,018), con mejores puntajes en mujeres con estudios superiores versus primarios. No hubo asociaciones entre ocupación/prácticas, ni etnia/actitudes (p>0,05).

Conclusiones: El nivel educativo influye significativamente en el conocimiento sobre lactancia materna, requiriendo intervenciones en poblaciones con baja escolaridad. Un 19% de las mujeres mostró bajos conocimientos y actitudes, requiriendo apoyo específico. No se encontraron asociaciones entre ocupación y prácticas, ni etnia y actitudes, sugiriendo analizar otros factores del entorno social.

PALABRAS CLAVE

Salud materno infantil, nutrición neonatal, prácticas de alimentación, factores psicosociales, factores culturales.

ABSTRACT

Introduction: Exclusive breastfeeding (EBF) is essential for child development, but its prevalence in Ecuador is suboptimal, especially in urban areas. EBF offers multidimensional benefits, but its establishment is challenging due to sociocultural factors. Supporting mothers to promote EBF is crucial.

Objective: To assess knowledge, attitudes, and practices regarding EBF in a population of pregnant and postpartum mothers.

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Methodology: A descriptive cross-sectional study was conducted with 105 women (pregnant and postpartum) in an urban health center in Riobamba, Ecuador. A structured questionnaire was administered in four sections: sociodemographic, knowledge, attitudes, and practices regarding breastfeeding. Scores were categorized as high, medium, and low using percentiles. Parametric ANOVA statistical analyses were performed to identify associations.

Results: The sample of 105 women, predominantly mixed-race (86,67%) and with secondary education (62,86%), showed that 66,7% had high levels of knowledge and favorable attitudes toward breastfeeding, but 19% had low levels in both areas. Practices ranged from adequate (46,7%) to regular (44,8%), with 8,6% being inadequate. Educational level significantly influenced breastfeeding knowledge (p=0,018), with higher scores in women with higher versus primary education. There were no associations between occupation/practices or ethnicity/attitudes (p>0,05).

Conclusions: Educational level significantly influences breastfeeding knowledge, requiring interventions in populations with low educational attainment. Nineteen percent of women showed low knowledge and attitudes, requiring specific support. No associations were found between occupation and practices, or ethnicity and attitudes, suggesting analyzing other factors in the social environment.

KEYWORDS

Maternal and child health, neonatal nutrition, feeding practices, psychosocial factors, cultural factors.

INTRODUCCIÓN

Según la Encuesta Nacional de Salud y Nutrición (ENSANUT) del año 2018, en Ecuador, el 37,9 % de los menores de 6 meses no recibe lactancia materna exclusiva (LME), en el área urbana la prevalencia de lactancia materna exclusiva es menor (58,4%) que en el área rural (70,1%)[1].

La LME consiste en que el bebé reciba solamente leche materna (LM) durante los primeros 6 meses de vida y ningún otro alimento ya sea sólido o líquido, excepto vitaminas, minerales o medicamentos[2,3].

La LM es la fuente óptima de nutrientes y energía para el crecimiento y desarrollo infantil. Es el alimento de elección para los recién nacidos, su composición rica en macronutrientes como lactosa, grasas y proteínas y micronutrientes como vitaminas, minerales e inmunoglobulinas, la convierte en un alimento vivo y dinámico que se adapta a las necesidades cambiantes del niño. Las inmunoglobulinas, junto con la lactoferrina y los oligosacáridos, fortalecen el sistema inmunológico del infante, protegiéndolo de infecciones y alergias[4,5].

Además, se asocia a una serie de beneficios multidimensionales. En el ámbito de la salud, la LM confiere efectos positivos tanto para el lactante como para la madre. Adicionalmente, se observan ventajas en los planos económico, ambiental y familiar. Dada la amplitud de sus beneficios, la promoción y el cumplimiento de la lactancia materna revisten una importancia crucial para el bienestar integral de la sociedad[4,6]. Proporciona soporte emocional y psicológico a la diada madre-hijo, contribuye a evitar gastos en la compra de fórmulas, biberones y reduce la necesidad de consultas médicas y medicamentos[7,8].

La lactancia materna es la estrategia más eficaz para proporcionar a los bebés una salud óptima y un bienestar completo, tal como lo indica la OMS. Tanto es así que en la primera hora de vida la LM disminuye el riesgo de fallecer en el primer mes en más o menos 20%; entre los 9 y 11 meses los niños no amamantados tienen 30% más de probabilidades de morir[9].

Establecer la lactancia no siempre es sencillo, la madre y su bebé requieren un periodo de adaptación. Los factores socioculturales alrededor de las madres son determinantes para el inicio, la duración y el éxito de la lactancia materna[10]. Si existen dificultades, es probable que la madre necesite el apoyo de profesionales con experiencia en lactancia[11]. Muchas veces estas limitaciones obstaculizan su curso normal e incluso producen su abandono[4]. Por lo mencionado antes, es de vital importancia acompañar de forma activa y permanente a las madres, así como a su red de apoyo[12,13].

METODOLOGÍA

Con el objetivo de determinar los conocimientos, actitudes y prácticas sobre lactancia materna exclusiva, se realizó un estudio descriptivo transversal de enfoque mixto en una muestra por conveniencia conformada por 105 mujeres (85 gestantes y 20 postparto) de edades comprendidas entre 15 y 45 años. Las participantes fueron seleccionadas a partir de la revisión de las tarjetas de monitoreo infantil, registradas durante el periodo comprendido entre diciembre de 2021 y marzo de 2022 del Centro de Salud tipo B Santa Rosa, ubicado en la zona urbana de Riobamba, provincia de Chimborazo, Ecuador.

La población de estudio incluyó a mujeres embarazadas o en período de lactancia que cumplieron con los siguientes criterios de inclusión: residencia en el área de influencia del Centro de Salud tipo B Santa Rosa, recepción de atención prenatal en dicho establecimiento, disposición a participar voluntariamente y firma del consentimiento informado. Se excluyeron mujeres con enfermedades que contraindicaran la lactancia materna, consumo de drogas o alcohol durante el embarazo o la lactancia, y dificultades para comprender el cuestionario.

Se empleó un cuestionario autoadministrado de 29 preguntas cerradas para la recolección de datos cuantitativos. El instrumento, estructurado en cuatro secciones, incluyó preguntas dicotómicas (sí/no) y preguntas con escala de Likert para medir grados de acuerdo o frecuencia. La primera sección recopiló datos socioeconómicos (8 ítems), la segunda evaluó

conocimientos sobre lactancia materna (10 ítems, puntuación máxima 20), la tercera exploró actitudes (6 ítems, puntuación máxima 21), y la cuarta examinó prácticas de alimentación (5 ítems, puntuación máxima 10). El cuestionario detallado se encuentra disponible como anexo.

Para la evaluación de los conocimientos, actitudes y prácticas, se determinaron los valores máximo y mínimo, así como, los percentiles 30 y 70 de cada variable. Estos percentiles se emplearon para clasificar las puntuaciones en tres categorías: nivel bajo (por debajo del percentil 30), nivel medio (entre los percentiles 30 y 70) y nivel alto (por encima del percentil 70). Esta estratificación permitió una interpretación más clara de los resultados y facilitó la identificación de grupos de mujeres con distintos niveles de conocimientos, actitudes y prácticas.

Se aplicó pruebas paramétricas (ANOVA) comparando las estratificaciones, así como las características sociodemográficas, con el objetivo de identificar posibles asociaciones.

Este estudio se realizó conforme a la normativa ética ecuatoriana, garantizando el consentimiento informado, la confidencialidad de los datos y la protección de la información personal de los participantes, respetando los principios de autonomía, beneficencia y no maleficencia.

RESULTADOS

La muestra estuvo compuesta por 105 mujeres, cuyas características sociodemográficas se detallan en la tabla 1. La mayoría de las participantes se encontraban en el rango de edad de 25 a 29 años (38,10%), que corresponden a la etapa de adultos jóvenes. La etnia predominante fue la mestiza (86,67%). En cuanto al nivel de estudios, gran parte de las participantes tenían estudios secundarios (62,86%). El 28,57% de las embarazadas y madres eran solteras. La mayor parte de las mujeres residían en zonas urbanas (82,86%), y se desempeñaban como amas de casa (52,38%).

Se analizaron los puntajes totales de conocimientos, actitudes y prácticas sobre lactancia materna de 105 participantes. Los puntajes de conocimiento oscilaron entre 14 y 20, con un percentil 30 (P30) de 17 y un percentil 70 (P70) de 18. Los puntajes de actitudes variaron entre 8 a 21, con un percentil P30 de 20 y un P70 de 21. Las prácticas, los puntajes fluctuaron de 5 a 10, con percentiles P30 y P70 de 8 y 10 respectivamente. Estos valores, mínimos, máximos y percentiles sirvieron como punto de corte para la categorización de las variables conocimientos, actitudes y prácticas en tres niveles que se detallan a continuación en la tabla 2.

La distribución de los niveles de conocimientos, actitudes y prácticas en lactancia materna exclusiva reveló los siguientes datos (Tabla 3). Se observó que un 66,7% de las participantes demostraron altos niveles de conocimiento y actitudes favorables. Sin embargo, un 19% presentó niveles bajos en ambas áreas, lo que sugiere una disparidad significativa. En

Tabla 1. Perfil sociodemográfico de las mujeres encuestadas

Características sociodemográficas	n	%
Grupos de edad		
15 a 19 años	7	6,67
20 a 24 años	36	34,29
25 a 29 años	40	38,10
30 a 34 años	20	19,05
35 a 39 años	1	0,95
40 a 45 años	1	0,95
Etnia		
Mestizo	91	86,67
Blanco	1	0,95
Indígena	13	12,38
Nivel de estudios		
Primaria	5	4,76
Secundaria	66	62,86
Superior		34
Estado civil		
Soltera	30	28,57
Casada	42	40,00
Divorciada	1	0,95
Unión de hecho	32	30,48
Zona de residencia		
Urbana	87	82,86
Rural	18	17,14
Ocupación de la madre		
Ama de casa	55	52,38
Empleada a tiempo completo	10	9,52
Empleada a tiempo parcial	3	2,86
Estudiante	22	20,95
Trabajadora autónoma/independiente	15	14,29

Tabla 2. Estadísticos descriptivos: Conocimientos, actitudes y prácticas

Estadísticos	Total Conocimientos	Total Actitudes	Total Prácticas
N (Válido)	105	105	105
Mínimo	14	8	5
Máximo	20	21	10
Percentil 30	17	20	8
Percentil 70	18	21	10

Tabla 3. Niveles de Conocimientos, Actitudes y Prácticas

Nivel/ Condición	Categoría	Frecuencia (N=105)	Porcentaje (%)
Conocimientos	Alto	70	66,7
	Medio	15	14,3
	Bajo	20	19,0
Actitudes	Favorable	70	66,7
	Regular	15	14,3
	Desfavorable	20	19,0
Prácticas	Adecuada	49	46,7
	Regular	47	44,8
	Inadecuada	9	8,6

cuanto a las prácticas se encontró una distribución más equilibrada, con un 46,7% en prácticas adecuadas y un 44,8% en prácticas regulares, aunque un 8,6% mostró prácticas inadecuadas. Para comprender mejor estos datos, es crucial verificar si existen patrones de asociaciones entre niveles evaluados y variables sociodemográficas.

Se realizó un ANOVA para evaluar la influencia del nivel educativo en el conocimiento sobre lactancia materna (Tabla 4), como parte del análisis de asociaciones con variables sociodemográficas. Los resultados mostraron que el nivel educativo influye significativamente en el conocimiento sobre lactancia materna ($p = 0,008$), con puntajes más altos en personas con estudios superiores (18,18) y más bajos en estudios primarios (16,40). La diferencia significativa entre los dos grupos fue ($p = 0,018$). Esto sugiere que un mayor nivel educativo se asocia con un mejor conocimiento sobre lactancia materna. Adicionalmente, se analizó mediante ANOVA la influencia de la ocupación en los niveles de prácticas, y la influencia de la etnia en los niveles de actitudes, sin encontrase diferencias estadísticamente significativas en estos análisis ($p>0,05$).

Tabla 4. Análisis ANOVA de conocimientos por nivel de educación

Estadístico	Valor
Variable Dependiente	Puntaje Conocimientos
Variable Independiente (Factor)	Nivel de Educación (Superior, Secundaria, Primaria)
Estadístico F	5,041
Grados de Libertad (gl) Entre Grupos	2
Grados de Libertad (gl) Dentro de Grupos	102
Valor p (Sig.)	0,008
Prueba de Homogeneidad de Varianzas (Levene) Sig.	0,467
Estadísticos Descriptivos (Media ± Desviación Estándar)	
Superior	18,18 ± 1,242
Secundaria	17,53 ± 1.361
Primaria	16,40 ± 1,673
Pruebas Post Hoc (Diferencias Significativas)	
Superior vs. Primaria	1,776* ($p = 0,018$)

* La diferencia de medias es significativa ($p < 0,05$).

DISCUSIÓN

El presente estudio exploró los conocimientos, actitudes y prácticas (CAP) sobre lactancia materna exclusiva en gestantes y madres postparto, revelando una distribución heterogénea entre las participantes. Si bien un porcentaje significativo (66,7%) demostró altos niveles de conocimiento y actitudes favorables hacia la lactancia materna exclusiva, una proporción considerable (19%) presentó niveles bajos en ambas áreas, lo que sugiere una disparidad importante en la comprensión y valoración de esta práctica.

En cuanto a las prácticas de lactancia materna exclusiva, se observó una distribución más equilibrada, con un 46,7% de las participantes reportando prácticas adecuadas y un 44,8% reportando prácticas regulares. Sin embargo, la presencia de un 8,6% de participantes con prácticas inadecuadas indica que es fundamental implementar acciones precisas para perfeccionar la ejecución de la lactancia materna exclusiva.

Al comparar los datos revelados con el estudio de Bautista y colaboradores[14], se observan diferencias significativas en

los niveles de CAP. Específicamente, mientras que su investigación, que incluyó una intervención educativa, reportó un 98,6% de madres con un nivel de conocimientos adecuado, el presente estudio transversal reveló que solo el 66,7% de las participantes demostraron altos niveles de conocimiento. Esta disparidad sugiere que la ausencia de una intervención educativa en la población estudiada podría ser un factor determinante, lo que resalta la necesidad de implementar estrategias similares en el ámbito de esta investigación.

Además, al analizar la relación entre actitudes y prácticas, se encuentra que, a pesar de que el 66,7% del grupo de estudio mostraron actitudes favorables hacia la lactancia materna, solo el 46,7% reportaron prácticas adecuadas. Esta discrepancia entre actitudes y prácticas también se observó en el estudio de Bautista y colaboradores, aunque en menor medida. A pesar del incremento en actitudes favorables tras la intervención, no todas las madres alcanzaron prácticas óptimas. Esto indica que, tanto en la presente investigación como en el de Bautista y su equipo, las actitudes favorables no siempre se traducen directamente en prácticas adecuadas, esto pone en evidencia que se debe de considerar otros factores que influyen en la práctica de la lactancia materna exclusiva.

A diferencia del trabajo actual cuantitativo, que evaluó los niveles de CAP en una población urbana, el estudio de Pico Fonseca et al.[15] en Jamundí adoptó un enfoque cualitativo para explorar las experiencias de madres afrodescendientes e indígenas. Mientras que los resultados de este estudio proporcionan datos numéricos sobre la prevalencia de conocimientos y prácticas, el estudio de Jamundí ofrece una comprensión profunda de cómo los factores culturales y sociales influyen en las decisiones de lactancia materna. La influencia de familiares y personas cercanas, destacada en el estudio de Jamundí, se señala que es imprescindible considerar el sostén social como un factor primordial para el impulso de la lactancia materna en la población estudiada.

Como parte del análisis de asociaciones sociodemográficas, en el estudio llevado a cabo se realizó un ANOVA para evaluar la influencia del nivel educativo en el conocimiento sobre lactancia materna, así como la influencia de la ocupación en las prácticas y la etnia en las actitudes.

Los resultados revelaron que el nivel educativo influye significativamente en el conocimiento sobre lactancia materna ($p = 0,008$). Este hallazgo sugiere que las participantes con niveles educativos más altos (estudios superiores) demostraron un mayor conocimiento en comparación con aquellas con niveles educativos más bajos (estudios primarios).

La diferencia significativa encontrada entre estos dos grupos ($p = 0,018$) subraya la importancia de la educación como un factor determinante en la adquisición de conocimientos sobre lactancia materna.

Este hallazgo es consistente con estudios previos que han demostrado una relación positiva entre el nivel educativo y el conocimiento sobre salud materna e infantil[16–18]. La educación puede proporcionar a las mujeres un mayor acceso a información, habilidades de búsqueda y comprensión de conceptos de salud[19,20].

Sin embargo, es importante considerar que otros factores, como el acceso a servicios de salud y el apoyo comunitario, también pueden influir en el conocimiento sobre lactancia materna[21–23].

En este estudio, se observa que, a diferencia del nivel educativo, la ocupación y la etnia no mostraron una influencia directa en las prácticas y actitudes de lactancia materna ($p > 0,05$). Este hallazgo nos llevó a considerar que factores no evaluados, como el apoyo social, las creencias culturales y las experiencias personales, podrían tener un impacto significativo. Esta idea se ve reforzada al comparar los resultados de la investigación con el estudio de la Amazonía ecuatoriana[24], donde factores externos como la presencia de empresas petroleras y políticas gubernamentales crean un entorno complejo que afecta la salud de las comunidades indígenas.

La comparación entre ambos estudios sugiere que, en contextos con fuertes influencias externas, las características individuales pueden perder relevancia frente a fuerzas mayores. En la población de estudio, la falta de asociaciones significativas nos indica que factores más sutiles y personales, como el apoyo social, podrían ser determinantes. Esto se alinea con la investigación de Kamenetzky et al.[25], quienes encontraron que el apoyo social percibido tiene un impacto significativo en el estrés materno y, por ende, en la lactancia. Su estudio destaca que la disminución del apoyo social postparto aumenta el estrés y reduce la oxitocina, perjudicando la lactancia.

Por lo tanto, en el estudio a consideración como en los de la Amazonía y Kamenetzky et al., se resalta la importancia de mirar más allá de las variables demográficas y socioeconómicas evidentes. Debemos considerar el contexto social y cultural más amplio, explorando las redes de apoyo, las creencias arraigadas y las experiencias que dan forma a las decisiones de las madres[25]. En la Amazonía, esto implica abordar las influencias externas que alteran los modos de vida y el acceso a alimentos. En este trabajo, implica fortalecer las redes de apoyo familiar y comunitario, así como implementar políticas y programas que fomenten un entorno favorable para la lactancia, especialmente en contextos vulnerables.

CONCLUSIONES

El estudio en 105 mujeres reveló que el nivel educativo influye significativamente en el conocimiento sobre lactancia materna ($p=0,018$), por tal motivo las intervenciones educativas deben enfocarse en poblaciones con escolaridad nula o deficiente. Un 19% de las mujeres demostró bajos conocimientos y actitudes desfavorables, lo que podría traducirse

en prácticas subóptimas en lactancia. No se encontraron asociaciones significativas entre ocupación y prácticas, ni etnia y actitudes (p>0,05), sugiriendo explorar otros factores influyentes. Se recomienda fortalecer las redes de apoyo y políticas que fomenten la lactancia, especialmente en contextos de vulnerabilidades.

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ANEXOS

Cuestionario sobre conocimientos, actitudes y prácticas sobre lactancia materna: bit.ly/3DCDdXZ.

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Consumo de frutas y verduras asociado a las características de las heces según escala de Bristol en universitarios de Lima-Perú

Consumption of fruits and vegetables associated with stool characteristics according to the Bristol scale in university students from Lima-Peru

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RESUMEN

Introducción: El tipo de alimentación es uno de los factores que puede contribuir a la aparición del estreñimiento, una dieta baja en fibra, alta en harinas y azúcares constituye un factor de riesgo para dar origen al estreñimiento, lo cual es frecuente en los universitarios.

Objetivo: Identificar el consumo de frutas, verduras y su asociación con las características de las heces según la escala de Bristol en universitarios de Lima-Perú.

Métodos: Se trata de un estudio transversal y correlacional efectuado en 1.144 estudiantes universitarios peruanos de las facultades de Ciencias de la Salud de Lima. La edad de los estudiantes fue de 18 a 42 años. El cuestionario sobre frecuencia de consumo de frutas y verduras fue validado por juicio de expertos e incluye 23 frutas, 18 verduras, las cuales se encuentran disponibles en los mercados de Lima y para identificar las características de las heces se empleó la escala de Bristol. Se analizó la asociación entre la frecuencia de consumo de las diferentes frutas y verduras con la escala de Bristol con las características de las heces, mediante la prueba estadística de Chi-cuadrado y la prueba exacta de Fisher por ser variables ordinales y nominales.

Resultados: Las frutas y verduras más consumidas fueron el plátano (27,4%), manzana (26,7%), zanahoria (27,4%), tomate (27,3%), cebolla (27%) y lechuga (25,2%). Más del 50% de estudiantes presentaron deposiciones de tipo 4 (lisas y blandas) y consumieron dos o más porciones de verduras por día y tres o más porciones de frutas. Existe asociación directa moderada entre las variables, es decir a mayor consumo de de frutas y verduras las características de las heces son más blandas ($p<0,05$).

Conclusión: Consumir frutas y verduras diariamente está asociado con deposiciones de características lisas y blandas. Sin embargo, es necesario fomentar el consumo de agua, frutas, verduras variadas (fibra soluble e insoluble) y realizar actividad física.

PALABRAS CLAVE

Tránsito intestinal; Microbiota; Fibra dietética; Alimentación saludable; Patrones dietéticos.

LISTA DE ABREVIATURAS

OMS: Organización Mundial de la Salud.

IBM-SPSS: Statistical Package for the Social Sciences.

INEI: Instituto Nacional de Estadística e Informática.

ABSTRACT

Introduction: The type of diet is one of the factors that can contribute to the onset of constipation, a diet low in fiber,

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high in flour and sugars constitutes a risk factor to give rise to constipation, which is frequent in university students.

Objective: To identify the consumption of fruits and vegetables and their association with stool characteristics according to the Bristol scale in university students in Lima-Peru.

Methods: This was a cross-sectional and correlational study carried out in 1,144 Peruvian university students from the faculties of Health Sciences in Lima. The age of the students was 18 to 42 years. The questionnaire on frequency of fruit and vegetable consumption was validated by expert judgment and includes 23 fruits, 18 vegetables, which are available in Lima markets, and the Bristol scale was used to identify stool characteristics. The association between the frequency of consumption of the different fruits and vegetables with the Bristol scale and stool characteristics was analyzed using the Chi-square statistical test and Fisher's exact test because they are ordinal and nominal variables.

Results: The most consumed fruits and vegetables were banana (27.4%), apple (26.7%), carrot (27.4%), tomato (27.3%), onion (27%) and lettuce (25.2%). More than 50% of the students presented type 4 stools (smooth and soft) and consumed two or more servings of vegetables per day and three or more servings of fruits. There is a moderate direct association between the variables, that is, the higher the consumption of fruits and vegetables, the softer the stool characteristics ($p<0.05$).

Conclusion: Daily consumption of fruits and vegetables is associated with smooth and soft stools. However, it is necessary to promote the consumption of water, fruits, varied vegetables (soluble and insoluble fiber) and physical activity.

KEYWORDS

Intestinal transit; Microbiota; Dietary fiber; Healthy eating; Dietary patterns.

INTRODUCCIÓN

La Organización Mundial de la Salud (OMS) recomienda consumir por lo menos 400 g diarios o cinco porciones de 80 g cada una para obtener beneficios nutricionales y bienestar de la salud[1]. En 2017, 3,9 millones de muertes en todo el mundo se atribuyeron a la falta de consumo de frutas y verduras en cantidades suficientes[2].

Se estima que la ingesta insuficiente de frutas y verduras es la causa de alrededor del 14% de las muertes por cáncer gastrointestinal en todo el mundo. En promedio, consumimos sólo alrededor de dos tercios de las cantidades mínimas recomendadas de frutas y verduras[3]. En Perú, el año 2023, el Instituto Nacional de Estadística e Informática (INEI) manifestó que, el promedio diario de consumo de porciones de frutas en la semana por personas de 15 y más años de edad fue 2 porciones y de las ensaladas de verduras fue 1 porción, asimismo, el promedio de días a la semana de consumo de frutas fue de 4 días, y de las ensaladas de verduras fue 3 días[4].

Por otro lado, la prevalencia de estreñimiento reportada en los estudios revisados es variable, el Consenso latinoamericano de estreñimiento crónico reportó cifras para población general de 5-21%[5]. En adolescentes o jóvenes las frecuencias encontradas están entre 22,3% y 26,0%[6]. Es un trastorno prevalente que afecta la calidad de vida de los pacientes y genera gastos de recursos en los sistemas de atención médica en todo el mundo[7], en la práctica clínica, todavía se considera un desafío, ya que los médicos con frecuencia no están seguros de qué tratamientos usar y cuándo[8].

El estreñimiento comprende un conjunto de síntomas que incluye esfuerzo excesivo, heces duras, sensación de evacuación incompleta, uso de maniobras digitales o defecación poco frecuente, las causas pueden ser problemas metabólicos, deficiencia de fibra, problemas anorrectales y medicamentos[9]. Para mejorar estas complicaciones, se debe ingerir líquidos, fibra dietética, hacer ejercicio regularmente y modificar la dieta. Los laxantes son la base del tratamiento farmacológico para una posible terapia a largo plazo en pacientes que no responden a la modificación del estilo de vida o la dieta[10].

La escala de Bristol es una herramienta muy útil para determinar la consistencia y que a través de las imágenes las personas pueden identificar el tipo de deposiciones que evacuan con frecuencia. Así mismo, en la actualidad es la única escala que recoge la forma de las heces y es recomendada por los grupos de consenso para la recogida de datos en patología funcional intestinal[11-13].

La alimentación también tiene un peso significativo en la aparición del estreñimiento, pues se sabe que una dieta baja en fibra y alta en harinas y azúcares constituye un factor de riesgo, lo cual es frecuente entre los adolescentes y universitarios[14]. Este componente dietario es un factor determinante porque aumenta el volumen del bolo fecal y el tránsito por el colon; además, debe tenerse en cuenta que los movimientos peristálticos se estimulan por la distensión del colon y se afectan cuando el bolo fecal es insuficiente[8].

Una dieta rica en frutas, verduras y otros alimentos de origen vegetal y con alto contenido en fibra mejora la flora intestinal y tiende a aumentar las bacterias asociadas a los compuestos antiinflamatorios vinculados a un buen metabolismo[15]. También se ha demostrado que un mayor consumo de frutas y verduras reduce la prevalencia de la diverticulosis, así como de otros problemas digestivos como los gases, el estreñimiento y la diarrea[16].

Existen muchos factores que limitan el consumo de frutas y verduras como son los ingresos económicos, las personas

con mayor nivel de educación tienden a consumir menos frutas y verduras que las que tienen menos educación, esto se debe a que los de mayor nivel educativo tienden a trabajar fuera de casa; prefieren los alimentos procesados que son fáciles de transportar o adquirir y no contienen frutas y verduras[17].

Actualmente no existen estudios sobre la asociación de las variables, por ello, el objetivo de la investigación fue identificar el consumo de frutas, verduras y su asociación con las características de las heces según la escala de Bristol en universitarios de Lima-Perú.

MÉTODOS

Se desarrolló un estudio transversal, correlacional y no experimental. La investigación se desarrolló durante el año 2024. Se incluyó estudiantes matriculados con asistencia regular en el ciclo académico 2024-2 (julio a diciembre), mayores de 18 años, quienes firmaron el consentimiento informado. Se excluyeron estudiantes que siguen regímenes dietéticos especiales, embarazadas, deportistas y aquellos con diagnóstico de estreñimiento o diarrea.

La población de estudio estuvo conformada por estudiantes universitarios de ciencias de la salud de universidades públicas y privadas de Lima Metropolitana. La muestra fue de 1.144 estudiantes de ambos sexos, con un rango de edad de 18 a 42 años. El muestreo fue no probabilístico por conveniencia.

Recopilación de los datos

La participación de los universitarios se gestionó través de sus docentes, a quienes se les explicó el objetivo de la investigación y se les envió el enlace del cuestionario - elaborado en Google Forms - a sus correos electrónicos. El llenado del cuestionario fue voluntario, aceptaron y firmaron el consentimiento informado.

Instrumentos

Se diseñó un instrumento de frecuencia de consumo de frutas y verduras que se comercializan y consumen en Lima. Este instrumento consta de una lista de 23 frutas y 18 verduras, con opciones de respuestas que incluyen: nunca, 1 vez a la semana, 3 veces a la semana, 4 veces a la semana, 5 veces a la semana, 6 veces a la semana y diariamente, como se observa en la Tabla 2 y 3**.**

La validación del instrumento fue realizada por 10 jueces nutricionistas, quienes evaluaron (claridad, coherencia, objetividad, pertinencia y relevancia). El promedio del coeficiente V Aiken fue de 0,95, lo que indica una validez excelente. Además se realizó una prueba piloto con 40 estudiantes para hallar la confiabilidad del instrumento siendo este 0,91 el alfa de Cronbach, considerando una confiabilidad excelente.

Otro instrumento utilizado fue la escala de Bristol, empleada para recoger información sobre la forma de las heces, según las recomendaciones de grupos de consenso en patología funcional intestinal[11-13]. La escala de Bristol clasifica las heces en 7 tipos; el tipo 1: Grumos duros separados, como nueces (difíciles de pasar); tipo 2: Con forma de salchicha, pero grumosa; tipo 3: Como una salchicha, pero con grietas en su superficie; tipo 4: Como una salchicha italiana o una serpiente, lisa y blanda; tipo 5: Bultos blandos con bordes claramente cortados (se pasan fácilmente); tipo 6: Trozos esponjosos con bordes irregulares, un excremento blando y tipo 7: Acuosas, en trozos sólidos, totalmente líquidas[18]. En el cuestionario, se incluyó la descripción e imágenes de cada tipo de heces según la escala de Bristol.

Análisis estadístico

Se utilizó el software IBM-SPSS, v.29. Las variables se describieron mediante frecuencias y porcentajes. Se realizó la prueba Chi-cuadrado y Prueba exacta de Fisher para asociar el consumo de frutas y verduras con las características de las heces según la escala de Bristol, ambas variables ordinales. El nivel de significancia utilizado fue α= 0,05.

Cuestiones éticas

La investigación aplicó las normas bioéticas establecidas por la Declaración de Helsinki[19], el Código Nacional de Integridad Científica, emitido por el Consejo Nacional de Ciencia y Tecnología (CONCYTEC)[20]. Los participantes tomaron conocimiento sobre los objetivos de la investigación antes de iniciar el cuestionario y mediante el consentimiento informado aceptaron participar voluntariamente no existiendo riesgo alguno.

RESULTADOS

La edad promedio de los estudiantes fue 23 años (DE=4,81). En la tabla 1 se muestra que el 70,5% fueron mujeres, el 43,4% fueron de la escuela de nutrición, seguido de la escuela de enfermería (18%), obstetricia (15,7%), medicina humana (12,4%) y terapia física y rehabilitación (10,4%).

El 68,62% fueron de universidades privadas (n=4), el 31,38% de universidades públicas (n=3). El 81,5% vive con sus padres o familiares, el 53,2% realiza actividad física, asimismo, el 76% son universitarios que no tienen antecedentes de familiares con estreñimiento crónico (Tabla 1).

En la tabla 2, se observa que el 53,8% de los universitarios, consumen menos de tres porciones de frutas y el 59,4% consume de dos o más porciones de verduras.

También se halló, que el 51,2% de los universitarios indicaron que sus deposiciones diarias según la escala de Bristol fue de tipo 4, seguido del tipo 3 (35,5%), ambos tipos son considerados deposiciones fáciles de evacuar.

Tabla 1. Características generales de los estudiantes universitarios

Variables	n	%
Sexo		
Femenino	806	70,5
Masculino	338	29,5
Escuela profesional		
Nutrición	497	43,4
Enfermería	206	18,0
Terapia física y rehabilitación	119	10,4
Obstetricia	180	15,7
Medicina humana	142	12,4
Tipo de universidad		
Privada (n=4)	785	68,62
Pública (n=3)	359	31,38
Vive con sus padres o familiares		
Si	932	81,5
No	212	18,5
Realiza actividad física		
Si	609	53,2
No	535	46,8
Algún familiar papá, mamá o hermanos sufre de estreñimiento crónico		
Si	274	24,0
No	870	76,0
Total	**1144**	**100,0**

Por otro lado, el consumo de agua en promedio fue de 5 vasos por día (DE=1,99).

En la tabla 3 se observa que la mayoría de los universitarios consumen frutas de una a tres veces a la semana. La mayoría de estudiantes nunca consumieron algunas frutas como: el tumbo 64,2%, un 48,7% cocona, 34,3% ciruela, 38% tuna y el 39,3% membrillo. Los alimentos más consumidos una vez a la semana fueron la granadilla (37,3%), piña (31,4%) y pera (30,4%). Las frutas más consumidas tres veces por semana fueron el plátano (27,4%) y la manzana (26,7%) principalmente.

Tabla 2. Consumo de frutas y verduras de los estudiantes universitarios

Consumo de frutas y verduras	n	%
Porción de frutas por día		
3 o más porciones	528	46,2
Menos de 3 porciones	616	53,8
Porción de verduras por día		
Menos de 2 porciones	465	40,6
2 o más porciones	679	59,4
Características de las heces diarias según la escala de Bristol		
Tipo 1	9	0,8
Tipo 2	63	5,5
Tipo 3	406	35,5
Tipo 4	586	51,2
Tipo 5	40	3,5
Tipo 6	33	2,9
Tipo 7	7	0,6
Total	**1144**	**100,0**

Se evidenció asociación significativa entre cada una de las frutas con las características de las heces según escala de Bristol de los universitarios ($p<0.05$).

En la tabla 4 se observa que la mayoría de los universitarios consumen verduras de una a tres veces a la semana. Las verduras que nunca consumieron los estudiantes fueron la berenjena (44,8%), acelga (46,7%), nabo (39,7%), poro (37,4%). Asimismo, los alimentos más consumidos una vez por semana, el 34,9% caigua, 31,4% col, 32,6% el zapallo, 31,6% coliflor y espinaca respectivamente. Las verduras más consumidas tres veces por semana fueron la zanahoria (27,4%), tomate (27,3%), cebolla (27%) y lechuga (25,2%).

Se evidenció asociación significativa entre cada una de las verduras con las características de las heces según escala de Bristol de los universitarios ($p<0.05$).

Tabla 3. Consumo de frutas de los universitarios de ciencias de la salud

Frutas		Nunca	1 v/s	2 v/s	3 v/s	4 v/s	5 v/s	6 v/s	Diario	Características de las heces p-valor
		n (%) = 1144 (100)								
Arándanos	n	301	287	225	143	73	68	16	31	0,001
	%	26,3	25,1	19,7	12,5	6,4	5,9	1,4	2,7	
Carambola	n	409	305	162	146	78	27	12	5	0,043
	%	35,8	26,7	14,2	12,8	6,8	2,4	1,0	0,4	
Chirimoya	n	333	368	185	156	64	24	8	6	0,001
	%	29,1	32,2	16,2	13,6	5,6	2,1	0,7	0,5	
Ciruela	n	392	329	171	152	48	32	11	9	0,042
	%	34,3	28,8	14,9	13,3	4,2	2,8	1,0	0,8	
Cocona	n	557	245	141	117	57	16	6	5	0,001
	%	48,7	21,4	12,3	10,2	5,0	1,4	0,5	0,4	
Durazno	n	141	357	266	208	78	44	17	33	0,001
	%	12,3	31,2	23,3	18,2	6,8	3,8	1,5	2,9	
Fresa	n	38	326	252	239	129	62	30	68	0,001
	%	3,3	28,5	22,0	20,9	11,3	5,4	2,6	5,9	
Granadilla	n	136	420	228	176	77	37	24	46	0,001
	%	11,9	36,7	19,9	15,4	6,7	3,2	2,1	4,0	
Limón	n	15	146	221	256	140	111	59	196	0,001
	%	1,3	12,8	19,3	22,4	12,2	9,7	5,2	17,1	
Naranja	n	40	292	232	272	154	61	24	69	0,001
	%	3,5	25,5	20,3	23,8	13,5	5,3	2,1	6,0	
Mandarina	n	32	253	261	260	150	64	40	84	0,001
	%	2,8	22,1	22,8	22,7	13,1	5,6	3,5	7,3	
Mango	n	69	353	238	228	116	48	31	61	0,001
	%	6,0	30,9	20,8	19,9	10,1	4,2	2,7	5,3	
Manzana	n	41	283	245	306	124	52	27	66	0,001
	%	3,6	24,7	21,4	26,7	10,8	4,5	2,4	5,8	
Melocotón	n	240	292	265	190	76	46	20	15	0,001
	%	21,0	25,5	23,2	16,6	6,6	4,0	1,7	1,3	
Membrillo	n	450	232	178	154	68	42	8	12	0,001
	%	39,3	20,3	15,6	13,5	5,9	3,7	0,7	1,0	

*Chi cuadrado p<0,005.

Tabla 3 continuación. Consumo de frutas de los universitarios de ciencias de la salud

Frutas		Nunca	1 v/s	2 v/s	3 v/s	4 v/s	5 v/s	6 v/s	Diario	Características de las heces p-valor
		n (%) = 1144 (100)								
Papaya	n	63	288	242	271	136	51	31	62	0,001
	%	5,5	25,2	21,2	23,7	11,9	4,5	2,7	5,4	
Pera	n	125	348	289	201	91	33	20	37	0,001
	%	10,9	30,4	25,3	17,6	8,0	2,9	1,7	3,2	
Piña	n	92	359	272	205	78	48	28	62	0,001
	%	8,0	31,4	23,8	17,9	6,8	4,2	2,4	5,4	
Plátano	n	26	250	245	314	122	62	35	90	0,001
	%	2,3	21,9	21,4	27,4	10,7	5,4	3,1	7,9	
Sandía	n	113	349	254	237	97	43	18	33	0,001
	%	9,9	30,5	22,2	20,7	8,5	3,8	1,6	2,9	
Tumbo	n	734	132	96	98	47	23	9	5	0,001
	%	64,2	11,5	8,4	8,6	4,1	2,0	0,8	0,4	
Tuna	n	435	315	176	123	45	31	12	7	0,001
	%	38,0	27,5	15,4	10,8	3,9	2,7	1,0	0,6	
Uva	n	159	352	258	190	92	44	17	32	0,001
	%	13,9	30,8	22,6	16,6	8,0	3,8	1,5	2,8	

*Chi cuadrado p<0,005.

En la tabla 5, se evidenció que existe una asociación moderada entre las porciones de frutas por día y las características de las heces según escala de Bristol. El 63,8% reportaron deposiciones de tipo 3 y consumen menos de tres porciones de frutas, asimismo, el 52,2% de los universitarios presentaron deposiciones de tipo 4 y consumieron de tres o más porciones. La mayoría presentaron deposiciones del tipo 3 y 4.

En la tabla 6, se evidenció que existe una asociación moderada entre las porciones de verduras por día y las características de las heces según escala de Bristol (p<0,05).

El 51,2% de los universitarios reportaron deposiciones de tipo 3 y consumieron dos o más porciones de verduras por día, mientras que el 66% presentaron deposiciones de tipo 4 y consumieron dos o más porciones de verduras por día.

DISCUSIÓN

La mayoría de los universitarios consumen frutas de una a tres veces a la semana. Y un porcentaje alto de estudiantes nunca consumieron algunas frutas como: el tumbo 64,2%, 48,7% la cocona, 34,3% ciruela, 38% tuna y el 39,3% membrillo. Un estudio realizado en universitarios, reportó valores similares a los alimentos que nunca consumieron como el tumbo 72%, un 67,5% cocona, 39,8% chirimoya, 71,8% ciruela y el 52,4% membrillo[21].

Los alimentos más consumidos una vez a la semana fueron la granadilla (37,3%), piña (31,4%) y pera (30,4%). Las frutas con un porcentaje alto de consumo de 3 veces por semana fueron el plátano (27,4%) y la manzana (26,7%) principalmente. Estos resultados fueron similares al estudio de Gomez et al.[21], quienes reportaron que, los alimentos más consumidos por los estudiantes fueron la pera y la granadilla (37,3%) respectivamente, el limón (28,2%), el plátano (13,5%) y la mandarina (10,2%). Otro estudio de Torres y De la Cruz reportó valores similares al estudio, mostraron que las frutas más consumidas son el plátano, la naranja y la piña[22].

Por su parte, el estudio de Huamancayo et al.[23], evidenció una prevalencia de bajo consumo de frutas y verduras que

Tabla 4. Consumo de verduras de los universitarios de ciencias de la salud

Verduras		Nunca	1 v/s	2 v/s	3 v/s	4 v/s	5 v/s	6 v/s	Diario	Características de las heces p-valor
		n (%) = 1144 (100)								
Apio	n	206	328	253	223	81	31	5	17	0,001
	%	18,0	28,7	22,1	19,5	7,1	2,7	0,4	1,5	
Acelga	n	534	313	118	141	29	7	1	1	0,002
	%	46,7	27,4	10,3	12,3	2,5	0,6	0,1	0,1	
Berenjena	n	512	258	145	156	44	20	4	5	0,001
	%	44,8	22,6	12,7	13,6	3,8	1,7	0,3	0,4	
Brócoli	n	137	342	266	236	119	26	14	4	0,001
	%	12,0	29,9	23,3	20,6	10,4	2,3	1,2	0,3	
Caigua	n	296	399	195	171	58	15	9	1	0,001
	%	25,9	34,9	17,0	14,9	5,1	1,3	0,8	0,1	
Cebolla	n	32	191	209	309	154	58	45	146	0,001
	%	2,8	16,7	18,3	27,0	13,5	5,1	3,9	12,8	
Col	n	340	359	174	169	62	27	8	5	0,001
	%	29,7	31,4	15,2	14,8	5,4	2,4	0,7	0,4	
Coliflor	n	332	361	169	186	64	24	5	3	0,001
	%	29,0	31,6	14,8	16,3	5,6	2,1	0,4	0,3	
Espinaca	n	80	361	281	247	93	37	21	24	0,001
	%	7,0	31,6	24,6	21,6	8,1	3,2	1,8	2,1	
Lechuga	n	26	191	300	288	133	89	42	75	0,001
	%	2,3	16,7	26,2	25,2	11,6	7,8	3,7	6,6	
Nabo	n	454	296	163	139	59	21	9	3	0,001
	%	39,7	25,9	14,2	12,2	5,2	1,8	0,8	0,3	
Pepinillo	n	138	245	282	235	143	50	28	23	0,001
	%	12,1	21,4	24,7	20,5	12,5	4,4	2,4	2,0	
Poro	n	428	306	174	145	42	38	6	5	0,001
	%	37,4	26,7	15,2	12,7	3,7	3,3	0,5	0,4	
Rabanito	n	298	317	226	177	75	34	10	7	0,001
	%	26,0	27,7	19,8	15,5	6,6	3,0	0,9	0,6	
Tomate	n	52	207	223	312	154	44	47	105	0,001
	%	4,5	18,1	19,5	27,3	13,5	3,8	4,1	9,2	
Vainita	n	98	308	246	259	135	43	18	37	0,001
	%	8,6	26,9	21,5	22,6	11,8	3,8	1,6	3,2	
Zanahoria	n	22	211	218	314	174	71	33	101	0,001
	%	1,9	18,4	19,1	27,4	15,2	6,2	2,9	8,8	
Zapallo	n	122	373	241	200	103	60	15	30	0,001
	%	10,7	32,6	21,1	17,5	9,0	5,2	1,3	2,6	

*Prueba exacta de Fisher, p<0,005.

Tabla 5. Asociación entre las porciones de frutas por día y las características de las heces según escala de Bristol de los universitarios

			Porción de frutas por día		Total	p-valor
			3 o más porciones	Menos de 3 porciones		
Características de las heces según escala de Bristol	Tipo 1 	n	5	4	9	0,001
		%	55,6	44,4	100,0	
	Tipo 2 	n	32	31	63	
		%	50,8	49,2	100,0	
	Tipo 3 	n	147	259	406	
		%	36,2	63,8	100,0	
	Tipo 4 	n	306	280	586	
		%	52,2	47,8	100,0	
	Tipo 5 	n	12	28	40	
		%	30,0	70,0	100,0	
	Tipo 6 	n	22	11	33	
		%	66,7	33,3	100,0	
	Tipo 7 	n	4	3	7	
		%	57,1	42,9	100,0	
Total		n	528	616	1144	
		%	46,2	53,8	100,0	

*Prueba exacta de Fisher, p<0,005. V-Cramer =0,5.07.

fue de 60,1%, mencionaron que, las principales razones para no consumir frutas y verduras fueron el considerar que es poco frecuente conseguirlas en los cafetines de la universidad (78,7%), el tiempo insuficiente para su selección, compra y preparación (73,6%) y el vivir con alguno de los padres que se encargaban de su alimentación (55,3%).

En el estudio la mayoría de los universitarios consumen verduras de una a tres veces a la semana. Las principales verduras que nunca consumieron los estudiantes fueron la berenjena (44,8%), acelga (46,7%), nabo (39,7%), poro (37,4%). Asimismo, los alimentos más consumidos una vez por semana, el 34,9% caigua, 31,4% col, 32,6% el zapallo, 31,6% coliflor y espinaca respectivamente. Las verduras más consumidas 3 veces por semana fueron la zanahoria (27,4%), tomate (27,3%), cebolla (27%) y lechuga (25,2%). El estudio de Gomez et al.[21], hallaron prevalencias similares en las verduras principales que nunca consumieron los estudiantes fueron la berenjena (61,4%) acelga (55,5%), nabo (50,6%), poro (48%). Las verduras de mayor consumo 2 veces por semana fueron: 27,3% la espinaca, 26,9% brócoli, 23,7% apio, 22,5% zapallo, 20,2% col y un 17,6% la zanahoria. Por otro lado, la investigación de Torres y De la Cruz mostraron valores similares al estudio, mostraron que las verduras más consumidas fueron el jitomate, la zanahoria y la calabacita[22].

Los universitarios tienen un consumo bajo de frutas y verduras, el factor asociado a ello fue por las horas de clase y las horas de estudio[24], además el tiempo insuficiente para la selección, compra y preparación de raciones con frutas y verduras; mientras que, vivir con alguno de los padres, consti-

Tabla 6. Asociación entre las porciones de verduras por día y las características de las heces según escala de Bristol de los universitarios

			Porción de verduras por día		Total	p-valor
			Menos de 2 porciones	2 o más porciones		
Características de las heces según escala de Bristol	Tipo 1 	n	3	6	9	0,001
		%	33,3	66,7	100,0	
	Tipo 2 	n	32	31	63	
		%	50,8	49,2	100,0	
	Tipo 3 	n	198	208	406	
		%	48,8	51,2	100,0	
	Tipo 4 	n	199	387	586	
		%	34,0	66,0	100,0	
	Tipo 5 	n	26	14	40	
		%	65,0	35,0	100,0	
	Tipo 6 	n	3	30	33	
		%	9,1	90,9	100,0	
	Tipo 7 	n	4	3	7	
		%	57,1	42,9	100,0	
Total		n	465	679	1144	
		%	40,6	59,4	100,0	

*Prueba exacta de Fisher, p<0,005. V-Cramer =0,577.

tuye un factor protector para el estudiante debido a que son responsables de la alimentación en el hogar[23].

El estreñimiento es un problema molesto para las personas, que no es tratado muchas veces adecuadamente y que genera además consecuencias importantes, es necesario desarrollar estrategias preventivas diversas orientadas a diferentes grupos poblacionales, entre ellos el de los jóvenes[14].

Además, el estudio evidenció que existe una asociación moderada entre la frecuencia de frutas y verduras con las características de las heces según escala de Bristol de los universitarios (p<0,05). El 50% de los universitarios manifestaron realizar deposiciones de tipo 3 (como una salchicha, pero con grietas en su superficie) y consumen menos de tres porciones de frutas y consumieron dos o más porciones de verduras por día, asimismo, el 52,2% de los universitarios presentaron deposiciones de tipo 4 (blanda y lisa) y consumieron de tres o más porciones de frutas y consumieron de dos o más porciones de verduras por día.

Esta asociación de las variables puede ser explicado porque las frutas y verduras que más consumieron fueron el plátano, manzana, zanahoria, tomate, cebolla y la lechuga y el consumo de agua en promedio fue de 5 vasos por día. Esto puede ser explicado porque las frutas y verduras presentan fibra soluble, este tipo de fibra absorbe el agua formando un gel viscoso, que ablanda las heces y facilita su tránsito[25], también tienen fibra insoluble, que aumenta el volumen de las heces y estimula los movimientos intestinales[26], lo que favorece la evacuación. Además de la fibra, las frutas y verduras contienen otros elementos que contribuyen a combatir el estre-

ñimiento, como el agua, muchas frutas y verduras tienen un alto contenido de agua, lo que ayuda a mantener las heces hidratadas y blandas[27].

Por ello es importante incentivar la ingesta de una dieta equilibrada que no esté centrada solo en carbohidratos simples y es importante promover el consumo de frutas y verduras[14] como fuente de fibra, desde edades tempranas y que en la etapa de la juventud practiquen un hábito alimentario permanente del consumo de la diversidad de frutas y verduras que posee nuestro país. Los malos hábitos alimentarios, una disminución de la ingesta de líquidos, un cambio en la dieta como la disminución de la ingesta de fibra, o poca actividad física, pueden dar lugar a estreñimiento o acentuar un estreñimiento previo[28].

Respecto a las limitaciones, no se realizó un recordatorio de 24 horas para cuantificar la cantidad en gramos del consumo de frutas, verduras y determinar así la cantidad diaria de fibra ingerida o tipo de fibra y no se identificó el tipo de actividad física. Los resultados no pueden extrapolarse a otros contextos.

CONCLUSIÓN

Consumir frutas y verduras diariamente está asociado con deposiciones de características lisas y blandas. Sin embargo, es necesario fomentar el consumo de agua, frutas, verduras variadas (fibra soluble e insoluble) y realizar actividad física. Sin embargo, es necesario promover la ingesta de agua y el consumo de otros alimentos con fibras como cereales, menestras, semillas oleaginosas y realizar actividad física para evitar el estreñimiento.

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Relación entre edad de menarquia, grasa corporal y condición nutricional en escolares de 12 años de la Comunidad de Madrid

Relationship between age at menarche, body fat and nutritional status in 12-year-old schoolgirls in the Madrid Community

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RESUMEN

Introducción: La edad de menarquia supone la maduración ovárica y se circunscribe en las etapas finales de crecimiento femenino. Es un rasgo fisiológico con base genética que modifica sustancialmente las características somáticas y de composición corporal, muy sensible a las condiciones del entorno socioambiental.

Objetivos: Conocer la asociación entre la edad de menarquia, la cantidad y distribución de la grasa corporal y la condición nutricional en una muestra de niñas madrileñas con la misma edad cronológica.

Material y Métodos: Se analizaron 126 niñas de 12 años, que se clasificaron en función de la aparición de la menarquia. De acuerdo a la normativa del Internacional Biological Programme, se midieron estatura, peso, perímetro de la cintura umbilical y cinco pliegues subcutáneos, estimado el índice de masa corporal, índice cintura-talla, sumatorio de pliegues subcutáneos y porcentaje de grasa. Se establecieron comparaciones de medias para las distintas variables mediante test de contraste como la T de Student o el test de U-Man-Whitney.

Resultados: Se reportaron diferencias entre las niñas con y sin menarquia. Las primeras presentaron mayor índice de masa corporal (20,4 ± 3,7 vs 18,1 ± 3,1), sumatorio de pliegues (60 ± 18 vs 50± 17) y porcentaje de grasa (26,6 ± 3,6 vs 24,0 ±3,7) que las segundas. La condición nutricional se asoció, a esta característica madurativa ya que el exceso de peso (sobrepeso + obesidad) afectó al 9,6 % de las premenárquicas frente al 22,2 de las postmenárquicas.

Conclusiones: El presente estudio pone de manifiesto una asociación positiva entre la edad de menarquia, la cantidad y distribución de la grasa corporal y la condición nutricional femenina. Para la misma edad cronológica, las niñas postmenárquicas presentaron promedios superiores para todas las variables antropométricas de tamaño y composición corporal, excepto el ICT. Asimismo, la presencia de menarquia duplica la prevalencia de exceso ponderal.

PALABRAS CLAVE

Menarquia, antropometría, índice de masa corporal composición corporal.

ABSTRACT

Introduction: The age of menarche is the age of ovarian maturation and is defined by the final stages of female growth. It is a genetically determined physiological trait that significantly modifies somatic and body composition characteristics and is highly sensitive to socio-environmental conditions.

Objectives: To determine the association between age at menarche, amount and distribution of body fat and nutritional

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status in a sample of girls from Madrid of the same chronological age.

Material and methods: We analysed 126 12-year-old girls classified according to the age at menarche. Height, weight, umbilical circumference and five subcutaneous skinfolds were measured according to the standards of the International Biological Programme, and body mass index, waist-to-height ratio, sum of subcutaneous skinfolds and fat percentage were estimated. Comparisons of means for the different variables were made using Student's t-test or U-Man-Whitney test.

Results: There were notable differences observed between girls with and without menarche. The former exhibited a higher body mass index (20.4 ± 3.7 vs. 18.1 ± 3.1), fold sum (60 ± 18 vs. 50 ± 17) and fat percentage (26.6 ± 3.6 vs. 24.0 ± 3.7) compared to the latter. Nutritional status was found to be associated with this maturational characteristic, with excess weight (overweight + obesity) affecting 9.6% of premenarchal girls compared to 22.2% of postmenarchal girls.

Conclusions: The present study shows a positive association between age at menarche, the amount and distribution of body fat and female nutritional status. For the same chronological age, post-menarchal girls had higher averages for all anthropometric variables of body size and composition, except for waist to height ratio. Also, the presence of menarche doubles the prevalence of excess weight.

KEYWORDS

Menarche, anthropometry, body mass index, body composition.

ABREVIATURAS

ICT: Índice de Cintura-Talla.

IMC: Índice de Masa Corporal.

SNPS: Polimorfismos de un solo nucleótido (SNPs).

(∑ 5P): Suma de 5 pliegues adiposos (bíceps, triceps, subescapular, suprailíaco y pantorrilla).

%GC: Porcentaje de grasa corporal.

INTRODUCCIÓN

La menarquia, término con él que se denomina la primera menstruación, es un hito significativo en el desarrollo y maduración de las mujeres. Marca el final de la niñez y determina el inicio de su capacidad reproductiva. La edad en la que se produce presenta una gran variabilidad poblacional y es un buen indicador del nivel social, económico y de calidad de vida[1]. De hecho, los estudios con carácter secular demuestran que la edad de primera menstruación ha descendido históricamente asociándose a las mejoras socioeconómicas, higiénicas y sanitarias de los países desarrollados[2]. Por otra parte, la edad de primera regla presenta variaciones en función de la ubicación geográfica, clima o alimentación entre otros factores relacionados con el ambiente[3,4]. Pero no hay que olvidar que la edad de menarquia tiene un condicionamiento genético, como han demostrado los estudios familiares entre hermanas o madres/hijas[5,6]. Así mismo, los análisis de genoma completo han demostrado la asociación de diversos polimorfismos de un solo nucleótido (SNPs) a esta característica[7,8].

Durante la fase puberal se modifica la composición corporal de las niñas lo que se traduce fundamentalmente en un aumento del tejido graso y su distribución troncal, como apuntan diversas investigaciones. Así, por ejemplo, el estudio de Kim *et al*[9] en el año 2010, en niñas y jóvenes coreanas, puso de relieve que el cambio asociado a la madurez puberal definido por la menarquia llevaba asociado un aumento del peso, la estatura, el índice de masa corporal (IMC) y la redistribución de la grasa corporal. También Rebacz-Maron *et al.*[10] en población tanzana observaron que el porcentaje de grasa corporal (%GC) aumentaba significativamente desde la etapa pre-menarquica a la post-menarquica aunque no se modificaban marcadores de distribución adiposa como el índice cintura talla (ICT) o el de cintura cadera. En la misma línea, Gemelli *et al.*[11], analizando una muestra de niñas brasileñas entre 11 y 17 años, comprobaron que la aparición de la menarquia se asociaba con cambios en la composición corporal. En concreto, las mayores diferencias en el perfil antropométrico se encontraron para el intervalo de edad entre los 11 y 12 años entre las niñas que habían o no menstruado, teniendo las primeras mayor estatura, peso, masa grasa y muscular que las segundas.

El objetivo del presente estudio es aportar nuevos datos sobre este importante rasgo madurativo estableciendo la asociación entre la edad de menarquia, la cantidad y distribución de la grasa corporal y la condición nutricional en una muestra de adolescentes madrileñas.

MATERIAL Y MÉTODOS

Este estudio forma parte de un proyecto de investigación denominado "variación somática puberal y edad de menarquia de las niñas españolas del siglo XXI" que se desarrolla en el grupo de investigación EPINUT (https://www.ucm.es/epinut/) y que tiene la aprobación del comité de bioética de la Universidad Complutense de Madrid. La muestra consta de 126 niñas de 12 años asistentes a colegios e institutos de enseñanza secundaria públicos de la comunidad de Madrid. Todas ellas dieron su conformidad para participar y se cuenta con el consentimiento informado de sus padres, madres o tutores. Para comparar el perfil antropométrico de tamaño, composición corporal y distribución de la grasa, se clasificaron las niñas en dos grupos: con o sin menarquia.

Las entrevistas se realizaron de modo personal respetando la privacidad de las jóvenes. Cada participante contesto sobre si había empezado a menstruar o no, para establecer las dos

categorías de pre-menarquia y post-menarquia. En aquellos casos en los que la respuesta fue positiva se solicitó la edad del evento. La caracterización antropométrica se realizó con material homologado (tallímetro SECA, báscula Soehnle, cinta y adipómetro Holtain) y siguiendo la normativa del *International Biological Program* (IBP Weiner y Lourie, 1981)[12]. Las variables consideradas han sido: estatura, peso, perímetro de la cintura umbilical (PUC) y los pliegues subcutáneos del bíceps, tríceps, subescapular, supra umbilical ilíaco y pantorrilla. A partir de estas medidas se calcularon las variables derivadas: IMC (peso kg/estatura m^2), índice cintura-talla (PUC/estatura), la suma de los cinco pliegues (∑ 5P) y el %GC a través de la fórmula de Siri (1961)[13] (%GC = [(4,95/D)- 4,50] x 100) con el previo cálculo de la densidad utilizando las expresiones Durnin y Rahaman, 1967[14] (D= 1,1369-0,0598 log (∑ 4P bíceps, tríceps, subescapular y suprailíaco).

La condición nutricional se evaluó aplicando los puntos de corte del IMC propuestos por Cole *et al.*[15,16] estableciendo las categorías de insuficiencia ponderal (IP), normopeso (NP), sobrepeso (SP) y obesidad (OB).

El análisis estadístico, comenzó comprobado la normalidad de las distribuciones utilizando la prueba de Kolmogórov-Smirnov (k-s), y en función de dicha normalidad se contrastaron los promedios de las variables cuantitativas utilizando pruebas paramétricas (T- Student) o no paramétricas (U de Mann-Whitney). Se ha considerado un nivel de significación p <0,05.

RESULTADOS

De las 126 niñas de la muestra, 53 de ellas no habían tenido la menstruación y 76 sí. Como se advierte en la Tabla 1 las niñas con menarquia presentan promedios superiores en todas las variables antropométricas directas analizadas. Lo mismo sucede con el IMC, el %CG y el ∑ 5P como se reporta en la Figura 1.

Cabe señalar que, aunque la medida de los pliegues se incrementa en las niñas postmenárquicas, el perfil de distribución de la grasa subcutánea se mantiene, tal como se aprecia en la Figura 2.

Por otra parte, la condición nutricional cambia de manera importante de manera que, entre las niñas que han tenido la regla, se incrementa significativamente la prevalencia normopeso y del exceso ponderal (Tabla 2). Al analizar la situación

Tabla 1. Perfil antropométrico de niñas de 12 años con y sin menarquia

	Premenarquicas N= 53 Media ± DE	Postmenarquicas N=76 Media ± DE	p
Estatura (cm)	152,81 ± 8,25	157,99 ± 5,38	<0,001
Peso (kg)	42,61 ± 9,83	50,93 ± 8,53	<0,001
PUC (cm)	65,04 ± 8,20	69,10 ± 7,57	< 0,05
ICT	0,42 ± 0,04	0,43 ± 0,04	0,191
Pliegue bicipital (mm)	7,67 ± 2,72	8,83 ± 2,64	<0,05
Pliegue tricipital (mm)	12,05 ± 3,95	14,68 ± 4,71	<0,001
Pliegue subescapular (mm)	8,99 ± 4,39	11,94 ± 4,65	<0,001
Pliegue suprailíaco (mm)	8,51 ± 3,99	10,49 ±3,89	<0,001
Pliegue pantorrilla (mm)	12,49 ± 5,25	14,36 ± 5,16	<0,05

PUC: perímetro de cintura umbilical; ICT: índice cintura-talla.

Tabla 2. Condición nutricional según el IMC en niñas pre y postmenárquicas

	IP	NP	SP	OB
IMC	<15,93	15,93 - 22,139	22,14 - 27,24	<27,24
Premenárquicas	25,0%	65,4%	7,7%	1,9%
Postmenárquicas	2,8%	75,0%	19,4%	2,8%
p	<0,001			

IP: insuficiencia ponderal; NP: normopeso; SP: sobrepeso; OB:obesidad.

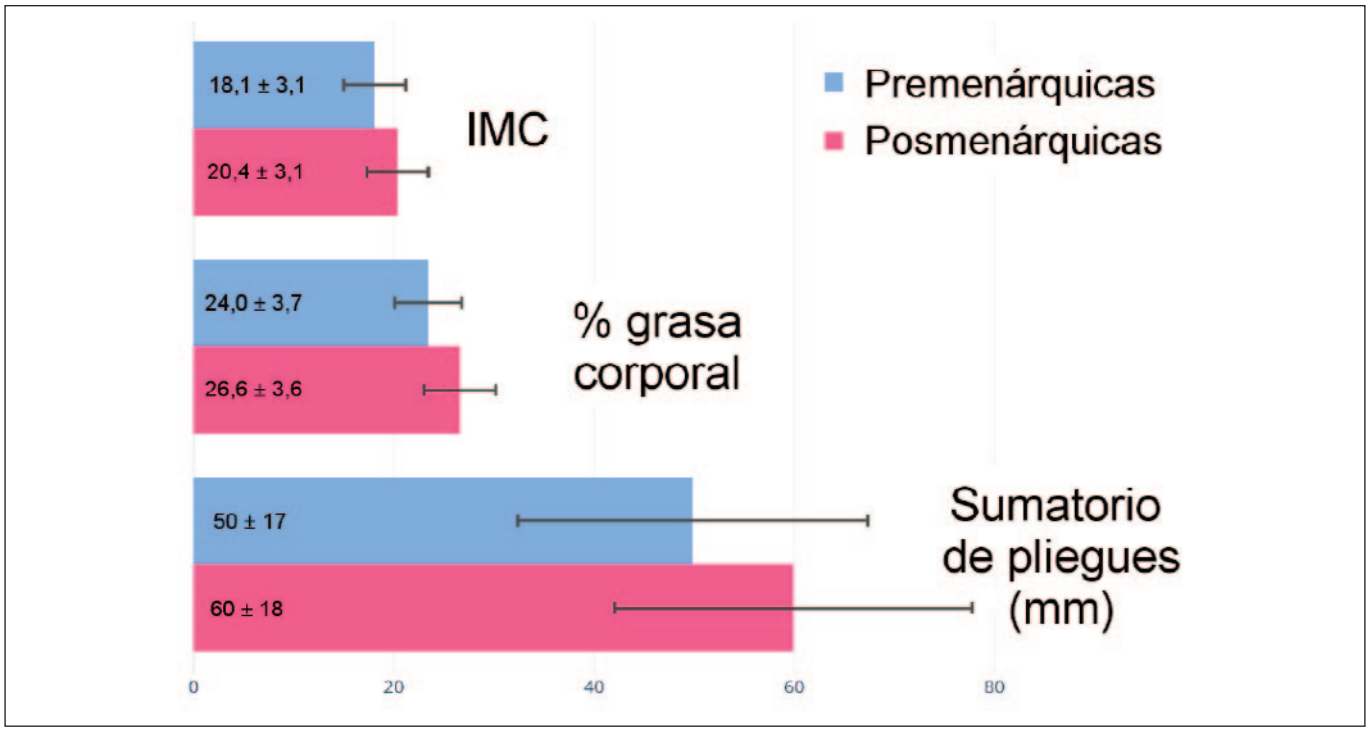

Figura 1. Diferencias para el IMC y el componente adiposo en niñas con y sin menarquia

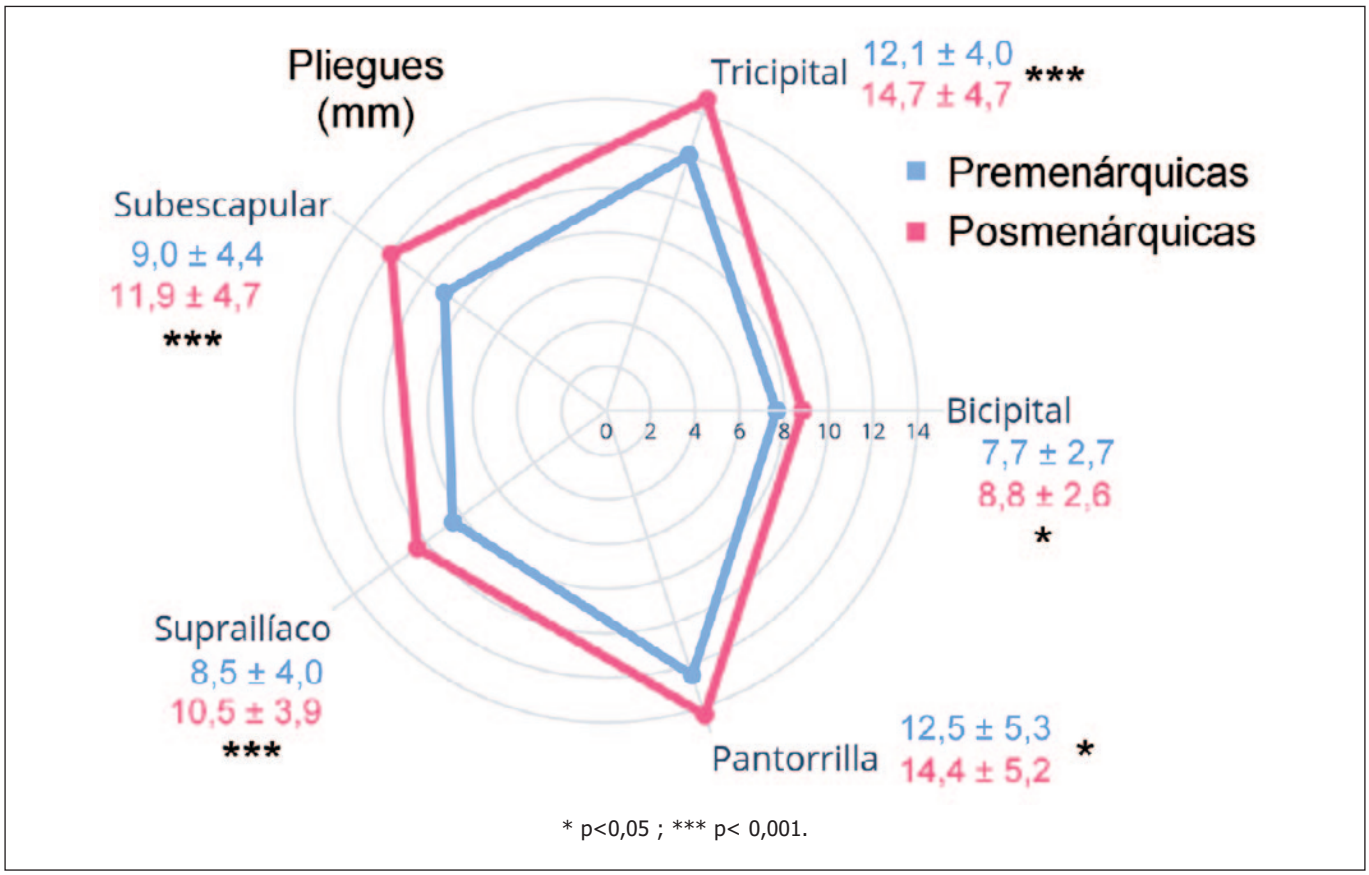

Figura 2. Perfil de distribución de los pliegues adiposos subcutáneos en niñas pre y postmenárquicas

respecto de la maduración reproductiva se advierte que únicamente el 13,1% de las niñas con bajo peso a los 12 años, habían tenido ya la menarquia, frente al 61,4% de las clasificadas con peso normal, o el 72,5 % de aquellas con exceso de peso.

DISCUSIÓN

Los hallazgos del presente estudio muestran diferencias significativas entre niñas de 12 años con y sin menarquia de manera que aquellas que ya han tenido su primera regla, tienen mayor estatura, peso, IMC, grasa total y relativa, además de una distribución de la adiposidad más centralizada. Además, los porcentajes de NP y SP son mayores en chicas con menarquia que sin ella, al contrario de lo que ocurre con la IP que es mayor en las niñas premenárquicas.

Para encontrar una explicación a este fenómeno, hay que señalar que la maduración sexual conlleva transformaciones físicas asociadas a la reactivación del eje hipotálamo-hipófiso gonadal por el cual da comienzo el proceso puberal. Algunos investigadores, como Pozo Román[17], indican que la leptina, hormona producida en los adipocitos, actúa sobre el hipotálamo y este estimula la secreción de la GnRH (hormona liberadora de gonadotropinas) que a su vez activa los mecanismos responsables de la menarquia. Los niveles de leptina son por lo tanto sensibles a la cantidad de grasa corporal, lo que explicaría las asociaciones observadas entre el desarrollo del tejido adiposo y la aparición de la primera menstruación. Por ello, si la cantidad de grasa corporal es demasiado baja, como ocurre en algunas condiciones de desnutrición por trastornos alimentarios o exceso de actividad física el inicio de la menarquia puede verse retrasado o la regla interrumpirse[18-20].

En la década de los ochenta del pasado siglo, Frisch[18] estableció que el %GC mínimo necesario para el debut de la menarquia se encontraba entre el 17 y el 22%, en torno a este porcentaje graso se producen con mayor frecuencia ciclos anovulatorios y periodos de amenorrea. Es evidente que, si bien el IMC no es una medida precisa de la composición corporal, presenta una correlación directa con los pliegues subcutáneos y con la masa grasa en edades infantojuveniles. Algunas investigaciones han reportado asociación entre IMC y la aparición de la menarquia, como por ejemplo el estudio italiano *Health Behaviour in School-aged Children (HBSC)* de Marconi *et al.*[21] o el realizado en población argentina por Torres *et al.*[22].

Los resultados del presente trabajo ponen de manifiesto que al confrontar niñas pre y postmenárquicas, con una misma edad cronológica, las segundas tienen mayor estatura, peso, PUC y %CG. Del mismo modo, Kim *et al* [9], observaron, en una amplia muestra de coreanas, que las niñas menstruantes eran más altas y tenían mayor peso, perímetro de la cintura y %GC que las niñas sin menarquia.

En la misma línea, Żurawiecka *et al.*[23] encontraron relaciones estadísticamente significativas entre la edad de la menarquia, el PUC y el IMC a partir de un estudio efectuado en dos encuestas transversales realizadas a 2419 mujeres polacas de entre 19 y 24 años. Los valores antropométricos disminuyeron con el aumento de la edad de la menarquia y, además, el inicio de la menstruación antes de los 12 años, se asoció con un mayor riesgo de sobrepeso y obesidad abdominal en edad adulta. En contraposición, la primera menstruación después de los 14 años se asoció con un menor riesgo de sobrepeso y obesidad, así como con una mayor probabilidad de insuficiencia ponderal.

Merece citarse el estudio denominado ERICA (Estudio de Riesgos Cardiovasculares en Adolescentes) efectuado por Barros *et al.*[24] en Brasil, sobre una amplia muestra de 73.624 adolescentes brasileñas de 12 a 17 años de edad, de las cuales 37.390 habían tenido la menarquia, siendo la edad mediana para el conjunto de la muestra de 12,41 años. Esta investigación, puso de manifiesto que las diferencias en función de la etnia, el grado de urbanización o incluso el estatus socioeconómico, fueron menores que las derivadas del estado antropométrico-nutricional ya que la edad de menarquia osciló entre los 11,34 años en las niñas con obesidad y los 12,83 de aquellas con insuficiencia ponderal.

Por último, cabe señalar que la revisión llevada a cabo por Ahmed *et al.*[25] incluyó estudios efectuados desde la década de los años 40 del pasado siglo hasta los años 2000 y puso de relieve la estrecha relación entre el %GC y la aparición de la menarquia, observando un adelanto en el desarrollo puberal de las niñas cuyo IMC estaba por encima del percentil 75, en comparación con aquellas que se encontraban en percentiles iguales o menores al P25. Además, dicha investigación, analiza la asociación entre edad de menarquia temprana y riesgo para el desarrollo de cáncer de mama.

Otros autores han relacionado la menarquia prematura, asociada a obesidad abdominal y exceso de grasa con patologías como la resistencia a la insulina, las enfermedades cardiovasculares o el síndrome metabólico[26-28]. Por ello, con la finalidad de prevenir los citados efectos adversos, parece necesario vigilar la composición corporal y la distribución de la grasa en edades prepuberales.

CONCLUSIONES

Este estudio pone de manifiesto una asociación positiva entre la edad de menarquia, la cantidad y distribución de la grasa corporal y la condición nutricional en las niñas estudiadas. Para la misma edad cronológica, las niñas postmenárquicas presentaron promedios superiores para todas las variables antropométricas de tamaño y composición corporal, excepto el ICT. Asimismo, la presencia de menarquia duplica la prevalencia de exceso ponderal.

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Valoración del estado nutricional utilizando parámetros antropométrico y bioquímicos en pacientes en hemodiálisis de Chile

Assessment of nutritional status using anthropometric and biochemical parameters in hemodialysis patients in Chile

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RESUMEN

Introducción: La desnutrición en pacientes en hemodiálisis tiene una gran prevalencia enfrentando un alto riesgo de morbilidad y mortalidad de manera directa. Sin embargo, se necesita mayor información sobre el estado nutricional de los pacientes en tratamiento con hemodiálisis que viven en Chile.

Objetivo: Valorizar el estado nutricional en pacientes en hemodiálisis utilizando parámetros bioquímicos y antropométricos.

Materiales y Métodos: Estudio descriptivo y de corte transversal en 58 pacientes que se encontraban en tratamiento de hemodiálisis en la Región de Antofagasta, Chile. Se determinó el estado nutricional a través de mediciones antropométricas, fuerza muscular mediante dinamómetro y perfil bioquímico por medio de toma de sangre. Para el análisis estadístico se utilizó la prueba de t-student para comparar grupos por sexo y estado nutricional, con un nivel de significancia del 5% (p-value <0,05).

Resultados: El 19% de los evaluados tiene un estado nutricional enflaquecido, el 43,1% se clasifica como normal, el 29,3% con sobrepeso y el 8,6% presenta obesidad. Los hombres presentan mayores valores que las mujeres respecto a peso (p=0,025), talla (p=0,000), masa muscular (p=0,000), dinamometría (p=0,000) y creatinina sanguínea (p=0,025). El grupo "estado nutricional malnutrición por exceso" expresa mayores valores en peso (p=0,000), IMC (p=0,000), masa grasa (p=0,000) y fósforo (p=0,013) en comparación con el grupo normopeso.

Conclusiones: En los pacientes evaluados se observó un número importante de personas con estado nutricional enflaquecido que se asocia a una mayor morbimortalidad. Es por ello que es de vital importancia pesquisar de manera oportuna los problemas nutricionales en este tipo de pacientes.

PALABRAS CLAVES

Evaluación nutricional, composición corporal, paciente renal, análisis sanguíneos, albumina sérica.

ABSTRACT

Introduction: Malnutrition in hemodialysis patients is highly prevalent and these patients face a high risk of morbidity and mortality directly. However, more information is needed on the nutritional status of patients undergoing hemodialysis treatment living in Chile.

Objective: Assess the nutritional status in patients on hemodialysis using biochemical and anthropometric parameters.

Materials and methods: Descriptive and cross-sectional study in 58 patients undergoing hemodialysis treatment in the Antofagasta Region, Chile. Nutritional status was determined through anthropometric measurements, muscle strength using a dynamometer, and biochemical profile through blood

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sampling. For statistical analysis, the t-student test was used to compare groups by sex and nutritional status, with a significance level of 5% (p-value <0.05).

Results: 19% had underweight status, 43.1% were classified as normal, 29.3% were overweight and 8.6% were obese. Men had higher values than women in terms of weight (p=0.025), height (p=0.000), muscle mass (p=0.000), dynamometry (p=0.000) and blood creatinine (p=0.025). The "malnutrition due to excess" nutritional status group expressed higher values in weight (p=0.000), BMI (p=0.000), fat mass (p=0.000) and phosphorus (p=0.013) compared to the normal weight group.

Conclusions: In the patients evaluated, a significant number of people were observed with poor nutritional status were observed, which is associated with greater morbidity and mortality. This is why it is vitally important to investigate nutritional problems in this type of patient in a timely manner.

KEYWORDS

Nutritional assessment, body composition, renal patient, blood tests, serum albumin.

INTRODUCCIÓN

La importancia de la adecuada nutrición en la insuficiencia renal crónica ha cobrado mayor relevancia en los últimos años. En ello influye el cambio en el perfil habitual del paciente caracterizado por edad avanzada y alta proporción de diabéticos, entre otros, presentando un mayor riesgo de malnutrición. Los avances tecnológicos que han permitido aumentar la calidad y años de vida en nuestros pacientes, han hecho también tomar conciencia de que los pacientes con insuficiencia renal terminal en programa de diálisis presentan un pronóstico mucho peor que la población general, con complicaciones derivadas o relacionadas con un inadecuado estado de nutrición[1].

En este contexto, la desnutrición en pacientes en hemodiálisis tiene una gran prevalencia y repercute en la morbimortalidad de manera directa[2]. La desnutrición calórico-proteica y a su vez proteico-calórica son las que más prevalecen en pacientes en este tratamiento, caracterizado por pérdida simultánea de grasa y músculo, inflamación y menor supervivencia[2,3]. Los factores determinantes de la desnutrición que se observan son anorexia, trastornos digestivos, comorbilidades asociadas, alteraciones hormonales, acidosis metabólica, entorno urémico, dietas no controladas o disminución de la ingesta, siendo está última probablemente la más importante)[2]. A su vez, es considerada un problema frecuente con un mayor número de admisiones hospitalarias y compromiso de la capacidad funcional de los pacientes que reciben reemplazo renal por hemodiálisis[4].

Para poder detectar estas deficiencias nutricionales se requiere de la valoración del estado nutricional, práctica clínica que permite detectar, prevenir, diagnosticar y tratar lo más precozmente posible algún déficit nutricional[5], el diagnóstico precoz contribuye en la reducción del riesgo de infecciones y resultados adversos en su evolución[6]. Se aconseja que la valoración nutricional se realice de manera periódica por parte de nutricionistas, con un intervalo no mayor a los seis meses. Los parámetros para evaluar durante la misma deben basarse en entrevistas a paciente y familiar, registros alimentarios y anamnesis médica, social y nutricional. El examen físico, la evaluación de parámetros de laboratorio, la interpretación de los cambios en el apetito y la medición de variables antropométricas forman parte de esta valoración[7].

Hay métodos subjetivos y objetivos para evaluar el estado nutricional, pero pocas evidencias para plantear un protocolo para estos pacientes debido al estado inflamatorio crónico, retención hídrica y desequilibrio ácido-básico que pueden modificar algunos parámetros. Se sugiere la utilización de diferentes indicadores nutricionales para mejorar la precisión del diagnóstico nutricional, minimizando los errores resultantes de las alteraciones en la masa ósea y en el volumen de agua corporal[6]. Dentro de los métodos que se sugieren se encuentran parámetros bioquímicos, tales como creatinina, albúmina sérica, nitrógeno ureico en sangre, antropométricos como IMC y BIE, además de la EGS y score MIC. Otras herramientas actuales disponibles en la evaluación del estado nutricional es la determinación de la composición corporal total a través de la bioimpedancia. Este procedimiento nos permite medir el estado de hidratación, determinar el peso seco en diálisis y orientarnos sobre el estado nutricional a través de la medición de la masa magra y masa grasa. La principal dificultad es la falta de disponibilidad de los mismos en la mayoría de las salas de diálisis debido a su alto costo. Si bien no existe ningún parámetro individual ni gold estándar en la valoración del estado nutricional de los pacientes en diálisis, es importante realizar la evaluación combinada de varios parámetros tanto bioquímicos como antropométricos[2].

La evidencia indica que la implementación del soporte nutricional tiene el potencial de mejorar el estado nutricional en pacientes en hemodiálisis con desnutrición establecida y/o con riesgo de padecerla. Se destaca también, la importancia de una intervención nutricional oportuna y precoz como así también la realización de la suplementación nutricional oral durante la sesión de hemodiálisis como estrategia para compensar la ingesta inadecuada de proteínas y energía[3].

Para generar intervenciones nutricionales oportunas y prevenir la malnutrición es necesario identificar a aquellos pacientes que se encuentran con riesgo nutricional o francamente desnutridos[2]. Por tal motivo es que esta investigación pretende valorizar el estado nutricional y su evolución en pacientes en hemodiálisis utilizando parámetros bioquímicos y antropométricos que permitan pesquisar de manera temprana problemas nutricionales por déficit en base a su evolución.

MATERIALES Y MÉTODOS

Tipo de estudio y muestra

Estudio de tipo cuantitativo descriptivo, no experimental y transversal. El muestreo fue de tipo no probabilístico por conveniencia. Se evaluaron 58 pacientes, de los cuales 36 pacientes correspondían a hombres y 22 pacientes fueron mujeres residentes de la Región de Antofagasta, Chile, quienes fueron evaluados entre los meses de enero y septiembre del año 2021.

Los criterios de inclusión fueron: Pacientes residentes en la ciudades de Antofagasta y Calama de la Región de Antofagasta de Chile en tratamiento de hemodiálisis por más de un año y que asistían a tratamiento tres veces por semana. Se excluyeron a los pacientes que no completaron la recolección de datos en su totalidad, presentaron algún deterioro de su estado cognitivo y aquellos que manifestaran alguna dificultad física que imposibilitaba las mediciones antropométricas.

Recolección de datos

Las mediciones antropométricas efectuadas fueron peso y estatura. El peso se medió en una balanza modelo Seca 670 en kilogramos, disponiendo al paciente con el mínimo de ropa y descalzo, con el peso distribuido uniformemente en la balanza y mirando hacia el frente. La medición de la estatura se llevó a cabo en un tallímetro modelo Seca 213 en centímetros, el sujeto se encontraba descalzado con la cabeza orientada en el plano de Frankfort. A partir del peso y estatura se calculó el Índice de Masa Corporal (IMC) mediante la fórmula Peso en kg/Talla^2 en m. Los puntos de corte utilizado para población adulta fueron: enflaquecido < 18,5 Kg/m; normal: 18,5 a 24,9 Kg/m; sobrepeso 25 a 29,9 Kg/m y obesidad ≥ 30 Kg/m. En el caso del adulto mayor los criterios fueron: enflaquecido < 23 Kg/m; normal: 23 a 27,9 Kg/m; sobrepeso 28 a 31,9 Kg/m y obesidad ≥ 32 Kg/m[8].

La fuerza muscular se evaluó por medio de un dinamómetro de mano marca JAMAR®, ubicando al paciente de pie con el brazo extendido paralelamente al tronco de su cuerpo, ejerciendo fuerza con su mano sin físstula arterio venosa. Esta prueba se realizó 3 veces, calculando el promedio de las mediciones para obtener el resultado final registrado en kg[9]. La medición de masa grasa y masa muscular fue a través del bioimpedanciometro marca Inbody 120, siguiendo el protocolo recomendado por el fabricante, a partir de las ecuaciones de predicción disponibles en el software del equipo.

El perfil bioquímico se obtuvo a partir de la extracción de sangre, en donde los sujetos debieron ayunar por al menos 6 horas para llevar a cabo las mediciones durante la mañana. Se analizó creatinina (método cinético de Jaffé), albumina (método púrpura BC), fósforo (método fosfomolibdato), calcio (método de o-cresolftaleína complexona) y potasio (método de potenciometría indirecta).

Aspectos éticos

La investigación se llevó a cabo respetando los principios de la Declaración de Helsinki. Cada paciente aceptó participar de manera voluntaria del estudio y para ello firmó un consentimiento informado que incluía los objetivos del estudio, plazos de retiro y vías de comunicación en caso que el participante siéntese que algún aspecto del proceso pueda haber afectado su integridad, entre otros. La investigación fue aprobada por el Comité de Ética de la Universidad de Antofagasta.

Análisis de datos

Los datos se presentan como media y desviación estándar. Asimismo para el análisis y compresión de los datos obtenidos, los pacientes fueron divididos por sexo (hombre y mujer) y por estado nutricional (normal y malnutrición por exceso) para su posterior comparación por medio de la prueba T-Student. El nivel de significatividad fue reportada al 5% con p-value <0,05 mediante dicha prueba. Los datos obtenidos fueron analizados por el software estadístico SPSS versión 25.

RESULTADOS

La muestra se caracterizó por una edad mínima de 22 años y una edad máxima de 99 años con una media de la edad del total de los pacientes evaluados de 59,9 ± 14,3 años.

Respecto al estado nutricional el 19% se encuentra enflaquecido, el 43,1% se clasifica como normal, el 29,3% con sobrepeso y el 8,6% presenta obesidad (datos no se muestran). La tabla 1 presenta las características sociodemográficas y antropométricas de los pacientes evaluados en hemodiálisis según sexo. Se observan diferencias significativas entre ambos sexos, encontrando mayores valores en hombres en lo que respecta a peso (p=0,025); talla (p=0,000); masa muscular (p=0,000) y dinamometría (p=0,000). En el caso del IMC (p=0,047) y masa grasa (p=0,000) se presentan mayores valores en las mujeres estudiadas.

Las variables bioquímicas analizadas en los pacientes se exponen en la tabla 2. Se aprecia que sólo existen diferencias significativas en creatinina (p=0,025), siendo dicho parámetro mayor en los hombres. Respecto al porcentaje de hombres y mujeres que manifiestan problemas en la analítica, el 8,3% de los hombres y el 4,5% tienen bajos niveles de albumina sérica. Caso similar ocurre con el calcio donde el 41,7% de los hombres y el 36,4% de las mujeres evaluadas presenta bajos niveles sanguíneos. En cuanto a los niveles de fósforo y potasio solo se encontraron disminuidos en el 5,6% y 2,8% de los hombres evaluados espectivamente.

La comparación de las características sociodemográficas, antropométricas y bioquímicas de acuerdo al estado nutricional se exponen en la Tabla 3. El "estado nutricional normal" consideró a aquellos sujetos que presentaron estado nutricional normal y bajo peso y en el caso del grupo "estado nutri-

Tabla 1. Características sociodemográficas y antropométricas de los pacientes en hemodiálisis de Chile (n = 58)

Variable	Hombres (n = 36)	Mujeres (n = 22)	Total	Valor-p
Edad (años)	60, 0 ± 14,1	59,7 ± 14,9	59,9 ± 14,3	0,943
Peso (kg)	67,6 ± 10,8	60,9 ± 10,3	65,0 ± 11,0	0,025
Talla (m)	1,67 ± 0,06	1,52 ± 0,53	1,61 ± 0,09	p<0,001
IMC (kg/mt2)	24,1 ± 3,3	26,1 ± 4,3	24,9 ± 3,8	0,047
Masa Grasa (%)	26,9 ± 9,9	38,6 ± 9,5	31,3 ± 11,2	p<0,001
Masa Muscular (%)	31,8 ± 9,6	20,7 ± 7,7	27,6 ± 10,4	p<0,001
Dinamometría (kg)	24,3 ± 8,2	15,3 ± 4,2	20,9 ± 8,2	p<0,001

Los valores se presentan como promedio y desviación estándar.

Tabla 2. Características bioquímicas de los pacientes en hemodiálisis de Chile (n = 58)

Variable	Hombres (n = 36)	Mujeres (n = 22)	Total	Valor-p
Creatinina (mg/dl)	10,5 ± 2,7	8,6 ± 3,4	9,8 ± 3,1	0,025
Albúmina (g/dl)	3,8 ± 0,3	3,9 ± 0,2	3,8 ± 0,3	0,778
Fósforo (mg/dl)	5,2 ± 1,9	5,6 ± 1,6	5,4 ± 1,8	0,402
Calcio (mg/dl)	8,7 ± 0,8	8,9 ± 0,7	8,8 ± 0,8	0,416
Potasio (mg/dl)	5,3 ± 1,2	5,3 ± 0,9	5,3 ± 1,1	0,971

Los valores se presentan como promedio y desviación estándar.

Tabla 3. Características sociodemográficas, antropométricas y bioquímicas de los pacientes en hemodiálisis de Chile según estado nutricional (n = 58)

Variable	Estado Nutricional Normal (n = 36)	Estado Nutricional Malnutrición por exceso (22)	Valor-p
Edad (años)	60,5 ± 16,2	58,9 ± 10,7	0,670
Peso (kg)	60,6 ± 10,0	72,4 ± 8,6	p<0,001
Talla (m)	1,62 ± 0,09	1,59 ± 0,08	0,165
IMC (kg/mt2)	22,7 ± 2,4	28,4 ± 3,0	p<0,001
Masa Grasa (%)	27,2 ± 10,6	38,2 ± 8,8	p<0,001
Masa Muscular (%)	28,0 ± 10,6	26,9 ± 10,2	0,684
Dinamometría (kg)	20,2 ± 7,4	22,2 ± 9,3	0,373
Creatinina (mg/dl)	10,0 ± 3,5	9,4 ± 2,4	0,521
Albúmina (g/dl)	3,8 ± 0,4	3,9 ± 0,2	0,778
Fósforo (mg/dl)	4,9 ± 1,5	6,1 ± 1,9	0,013
Calcio (mg/dl)	8,8 ± 0,9	8,8 ± 0,5	0,871
Potasio (mEq/L)	5,4 ± 1,0	5,1 ± 1,2	0,252

Los valores se presentan como promedio y desviación estándar.

cional malnutrición por exceso" incluyó a los paciente clasificados con estado nutricional sobrepeso y obesidad. Existen diferencias significativas, encontrando mayores valores en el grupo "estado nutricional malnutrición por exceso" en lo que respecta a peso (p=0,000); IMC (p=0,000); masa grasa (p=0,000) y fósforo (p=0,013). Sobre los niveles sanguíneos de calcio, el 44,4% de los pacientes normopeso presentan bajos niveles y en las mujeres alcanza el 31,8%. En cuando a los niveles séricos de albumina y fósforo solo en el 11,1% y 5,6% de las personas normopeso se encuentran disminuidos; a diferencia del potasio que está en niveles bajo en el 4,5% de las personas diagnosticadas con malnutrición por exceso.

DISCUSIÓN

Este estudio transversal investigó el estado nutricional en pacientes chilenos en hemodiálisis a través de parámetros antropométrico y bioquímicos. En Chile existen pocos estudios sobre estado nutricional en este tipo de pacientes, por lo que los datos obtenidos entregan evidencia valiosa para la toma decisiones respecto a la intervención nutricional a implementar. Nuestros hallazgos indicaron que existe un número importante de pacientes que presentan malnutrición por exceso (37,9%), ya sea sobrepeso u obesidad y alrededor del 20% se clasificó con estado nutricional enflaquecido. En 174 pacientes en hemodiálisis de Palestina, las prevalencias de malnutrición por exceso fueron mayores a las evidenciadas en este estudio, donde el 30,5% de los pacientes presentó sobrepeso y el 31,6% fue clasificada con obesidad; en el caso del estado nutricional enflaquecido solo el 2,9% de los evaluados se clasificó en esa categorización[10]. En otro estudio llevado a cabo en 60 pacientes de Turquía la prevalencia de estado nutricional normal fue de 78,8%, valor superior al reportado en esta investigación[11]. La desnutrición es una de las complicaciones más comunes entre los pacientes en diálisis afectando gravemente la calidad de vida y el pronóstico de los pacientes con enfermedad renal terminal (ESRD)[12].

En todos los pacientes en hemodiálisis una evaluación nutricional periódica debiese ser la meta de los equipos de salud, como es la determinación del índice de masa corporal (IMC) dado que existe asociación de que a un menor IMC mayor es la mortalidad[13]. Un IMC más bajo podría ser un índice importante de pérdida de proteínas y energía, es por ello que el IMC al estar relacionado con la mortalidad en pacientes en hemodiálisis es un gran predictor de mortalidad en estos pacientes[14]. En cuanto a valores informados de IMC en pacientes en hemodiálisis, en el estudio de Grzywacz et al, se reportó que aquellos con diabetes mellitus tipo 1 tenían valores promedio de IMC de 25, 3 (kg/m^2)[15]. En otro estudio llevado a cabo en 375 pacientes de Israel en aquellos pacientes que no presentaban diabetes tenían un IMC de 25,9 (kg/m^2)[16], ambos resultados concuerdan a lo comunicado en esta investigación. No obstante, en pacientes japoneses se informaron valores menores de IMC (21,1 kg/m^2)[17].

En pacientes en hemodiálisis un bajo nivel de albúmina sérica implica frecuentemente comorbilidades, un peor estado de salud y desgaste proteico energético (protein-energy wasting PEW, por sus siglas en inglés). En este contexto, la hipoalbuminemia, que puede estar causado por la desnutrición, inflamación, infección y edad avanzada es un indicador confiable y establecido de mortalidad y morbimortalidad entre quienes se someten a diálisis[18]. En relación a los resultados obtenidos respecto a los niveles de albúmina sérica el promedio reportado en este estudio fue de 3,8 gramos en el total de la muestra, niveles similares a lo descrito en un estudio con 3500 pacientes japoneses donde el promedio de albúmina sérica reportada fue de 3,7 gramos[17]. Sin embargo, en otro estudio de más de 100 pacientes de China, un tercio de los sujetos evaluados presentó niveles de albumina bajo 3,5 gramos[19].

Los pacientes sometidos a hemodiálisis tienden a desarrollar disminución de la fuerza muscular causado por una serie de factores como la atrofia muscular, menor capacidad para generar fuerza muscular o una menor capacidad del sistema nervioso central para activar los mecanismos funcionales necesarios[20]. La disminución de la fuerza muscular, uno de los rasgos de fragilidad, se reconoce como uno de los principales problemas que experimentan los pacientes sometidos a hemodiálisis principalmente aquellos de edad avanzada. La fuerza de agarre de mano se utiliza como prueba confiable para determinar el funcionamiento del músculo esquelético y es un predictor de mortalidad en pacientes sometidos a hemodiálisis. Los hallazgos respecto a fuerza de agarre en este estudio son similares a la investigación realizada por Slee et al., en 87 pacientes del Reino Unido, cuya fuerza de agarre fue en promedio de 21,9 kg, presentando valores de 23,8 kg en hombres y 16,9 kg en mujeres[21]. Estos resultados también son similares a los encontrados en pacientes coreanos en hemodiálisis quienes presentaron 21,8 kg, con valores de 25,1 kg en hombres y en mujeres de 17,0 kg. Aunque en otros estudios se informaron valores más elevados de fuerza de agarre de mano como es en el caso de sujetos de Japón (26,9 kg)[22] y de China (27,9 kg)[23]. Sin embargo una de las restricciones del uso de la fuerza de agarre de mano son los diferentes puntos de corte existentes dificultando un diagnóstico certero por la falta de consenso[24]. En América Latina los últimos puntos de corte de fuerza de agarre publicados fueron por Sostisso et al en población brasileña indicando el punto de corte de <23,5 kg para hombres y <14,5 kg para mujeres para diagnosticar desnutrición en pacientes brasileños en hemodiálisis[25].

En el total de la muestra de este estudio, los valores medio de fósforo sérico fue de 5,4 mg/dl, por sobre las concentraciones séricas normales oscilan entre 2,5 y 4,7 mg/dL26[28]. Estos valores coinciden con alrededor de 100 mil sujetos evaluados en Japón donde los valores de fósforo sérico fueron en promedio de 5,3 mg/dL[27]; así como en el estudio de Ye et

donde la media de fósforo sérico en 245.000 pacientes norteamericanos fue de 5,28 mg/dL[28]. La capacidad reducida del riñón para excretar fosfato (P) produce hiperfosfatemia y niveles elevados en sangre de PTH y bajos niveles de 1,25D, perfil hormonal que deja a los pacientes con un mayor riesgo de mortalidad[29]. Es por ello que se recomienda una reducción en el consumo de alimentos ricos en fósforo para equilibrar los niveles sanguíneos de fósforo.

Los rangos normales de calcio en sangre van entre 8,8 y 10,6 mg/dl, encontrando en este estudio valores de calcio sérico en las concentraciones recomendadas[30]. Es primordial mencionar que la concentración sérica de calcio se mantiene en el rango normal hasta muy avanzada la enfermedad renal crónica tarde disminuyendo ligeramente. Pero, se ha observado que el fósforo ejerce un mecanismo competitivo con el calcio que junto con la capacidad reducida de los riñones para convertir la vitamina D inactiva en 1,25-dihidroxivitamina D dificulta la absorción de ese mineral generando una reducción de la concentración plasmática de calcio y favorecer a la hipocalcemia.

Los hallazgos del presente estudio deben considerarse en el marco de sus limitaciones. La primera limitación fue el número relativamente pequeño de participantes en hemodiálisis incluidos. Segundo los pacientes reclutados son de una región de Chile y tampoco son de pueblos originarios, por lo que los resultados no pueden generalizarse limitando la extrapolación de las conclusiones al resto de los pacientes. Por último, no se consideraron otros factores que impactan en el estado nutricional como es la ingesta dietética y de nutrientes. A pesar de que no es una limitante de la investigación es clave señalar, que fue la baja cantidad de artículos actualizados relacionados con este estudio más aún en población chilena, dificultó el análisis y comparación de los resultados. Aún cuando existen estas limitaciones y escaza bibliografía actualizada, consideramos que los hallazgos de esta investigación son confiables y relevantes aportando con datos nutricionales.

CONCLUSIONES

Los hallazgos de este estudio sugieren que las personas en hemodiálisis evaluadas presentan mayores prevalencias de sobrepeso y obesidad, no obstante, existe un grupo que se caracteriza por bajo peso. Todo esto acompañado con valores normales de albúmina sérica e IMC. Los factores pronósticos de mortalidad en estos pacientes incluyen estado nutricional, IMC y nivel de albúmina sérica, que una vez identificados permite abordar las estrategias efectivas para la intervención nutricional dirigida a los pacientes y sus familiares.

Las intervenciones nutricionales en estos pacientes está relacionado con mejoras en los perfiles antropométricos, niveles de albúmina sérica y parámetros bioquímicos de interés, las cuales deben ser sostenibles a largo plazo requieren el compromiso del equipo de atención de salud para que motiven a sus pacientes aumentando así la adherencia al tratamiento nutricional y médico. Un siguiente paso es examinar el efecto del tratamiento nutricional en la calidad de vida de estos pacientes.

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- Resultados
- Discusión
- Conclusiones
- Bibliografía

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Las referencias bibliográficas se ordenarán y numerarán por orden de aparición en el texto, identificándose mediante números arábigos en superíndice. Para citar las revistas médicas se utilizarán las abreviaturas incluidas en el Journals Database, disponible en la URL:
http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?db=journals

9. Figuras y fotografías

Deben elaborarse teniendo en cuenta las siguientes indicaciones:

Se realizarán utilizando programas informáticos adecuados que garanticen una buena reproducción (300 píxeles de resolución por pulgada) en formato BMP, TIF ó JPG. No se admiten ficheros de Power-point ni similares. Los gráficos y las figuras podrán ser enviados preferiblemente en color o, en su defecto, en blanco y negro o en tonos de grises.

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