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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.

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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.

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.

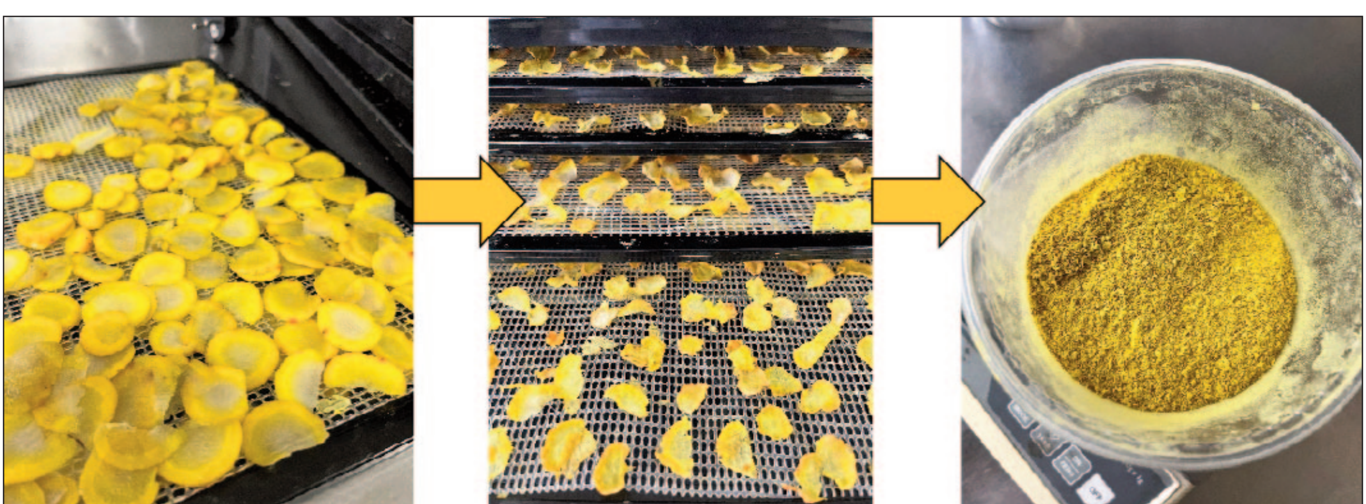


Figure 1. Process of making Olluco flour

Production of Olluco Bread dough

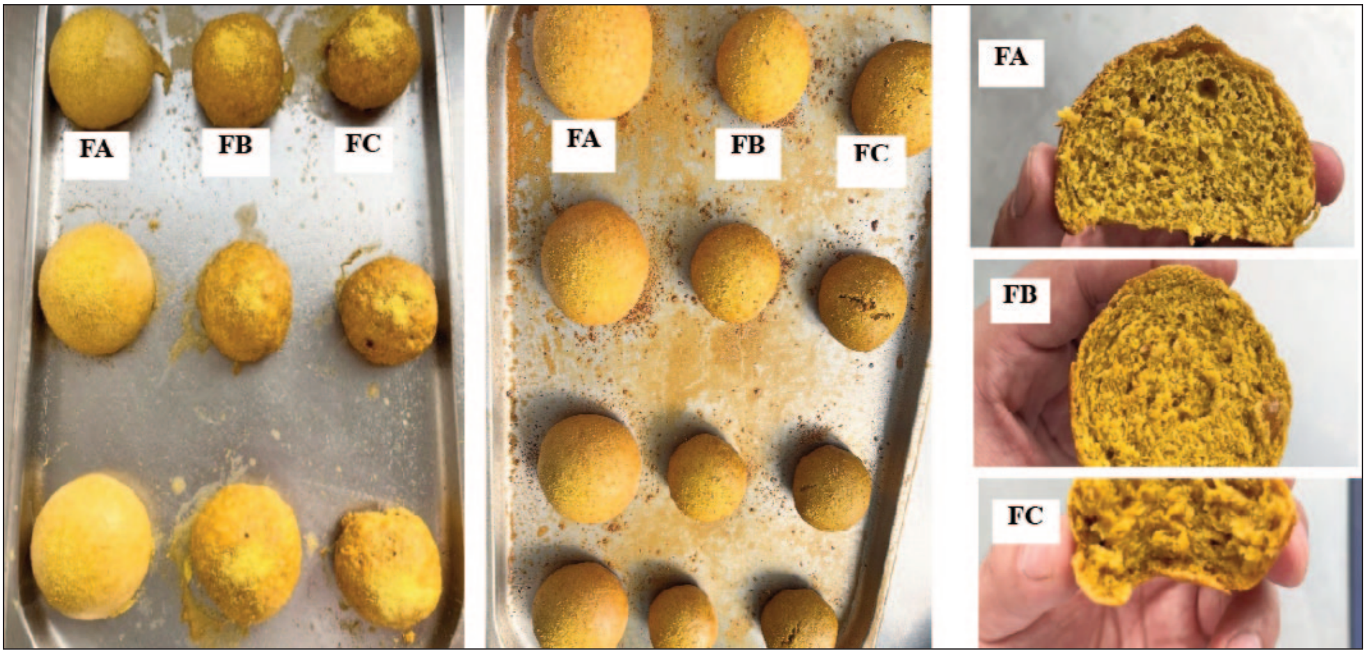


Figure 2. Images of Pre-Baking, Post-Baking and Crumb

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.

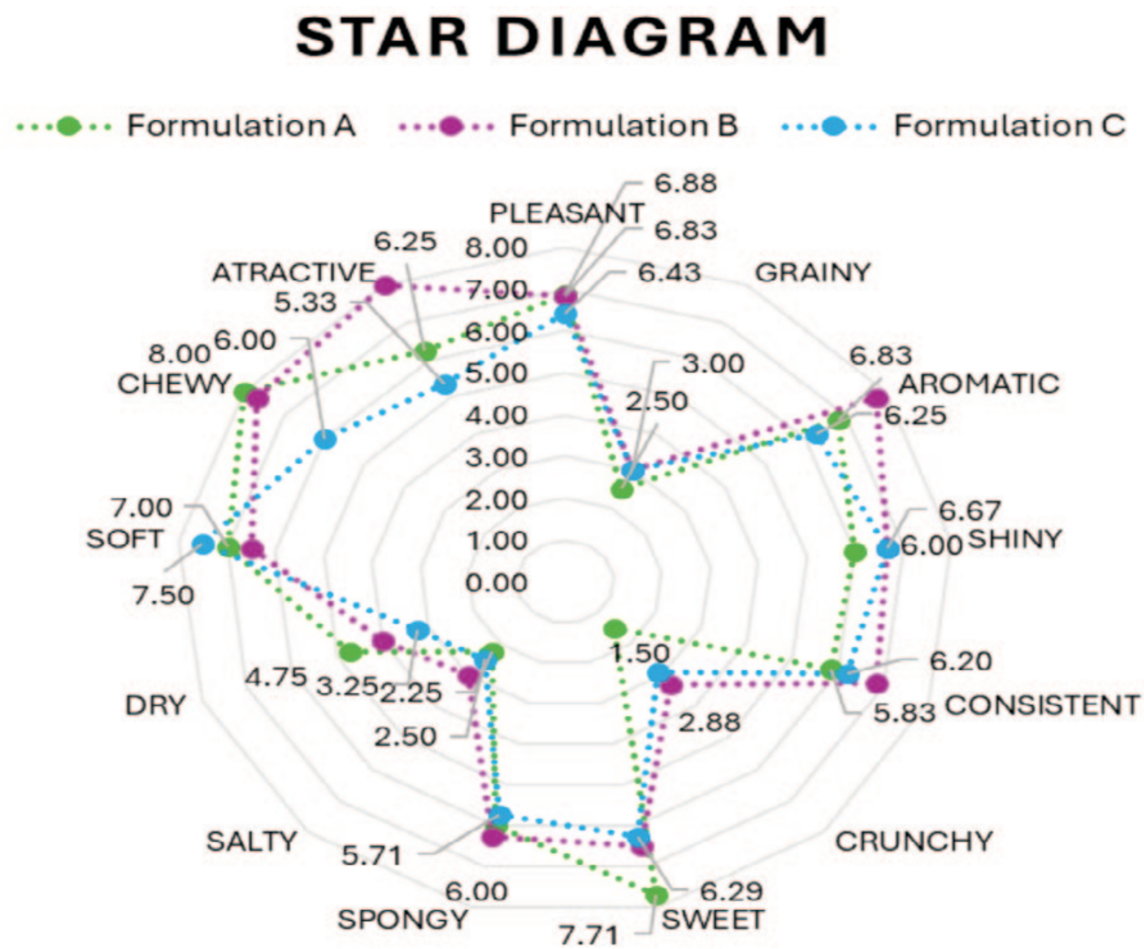
The star diagram illustrates the specific flavor characteristics evaluated by the expert panel. The most frequently noted characteristic was the sweet flavor in formulation FA of the Olluco bread, in contrast to formulations FB and FC. Another notable characteristic associated with Olluco flour is its 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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