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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.

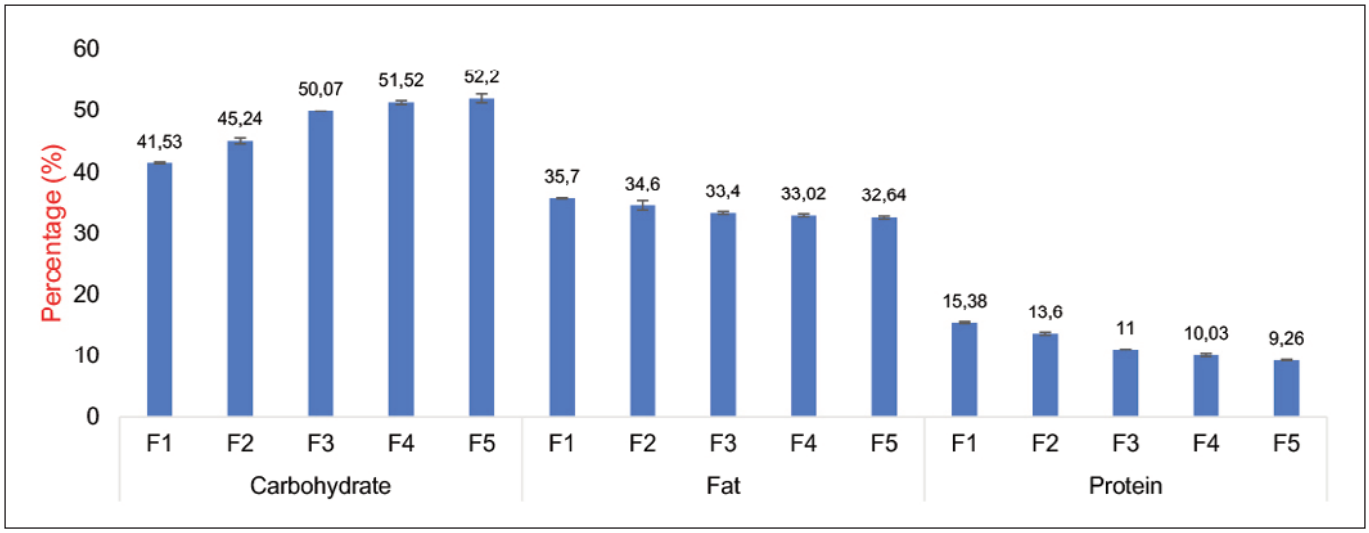

Figure 1. Average Value and Standard Deviation of Carbohydrate (%), Fat (%), and Protein (%) Based on 5 Formula Groups

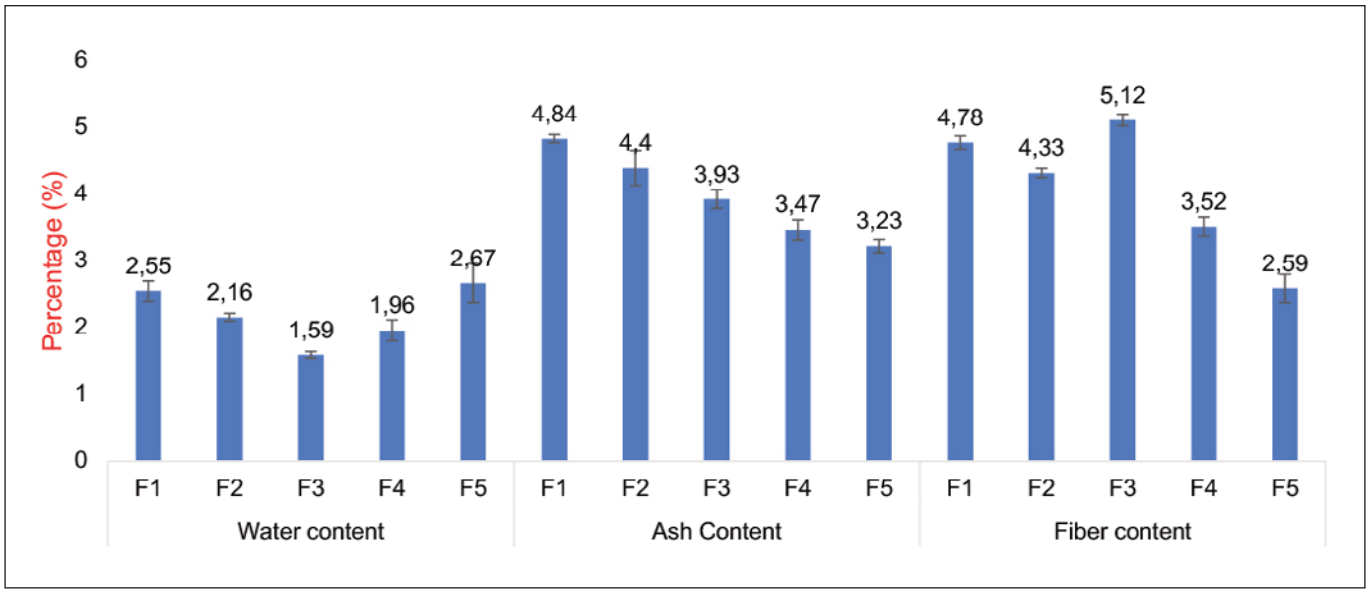

Figure 2. Average Value and Standard Deviation of Water content (%), ash content (%), and fiber content (%) based on 5 formula groups

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.

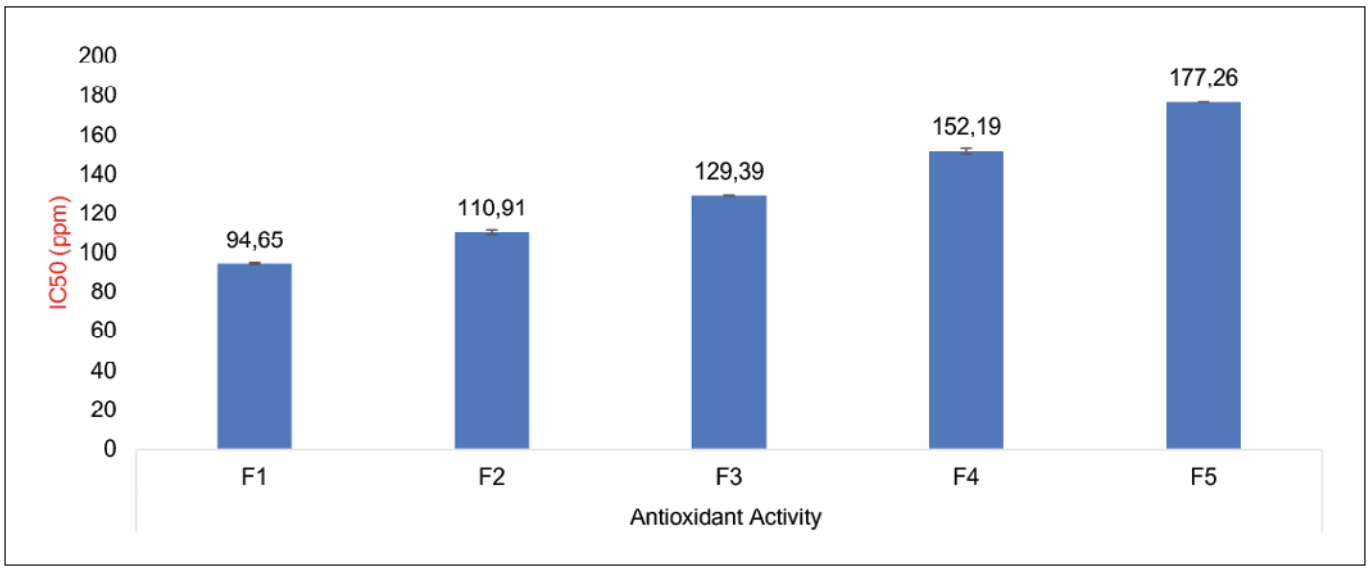

Figure 3. Antioxidant Activity based on 5 formula groups

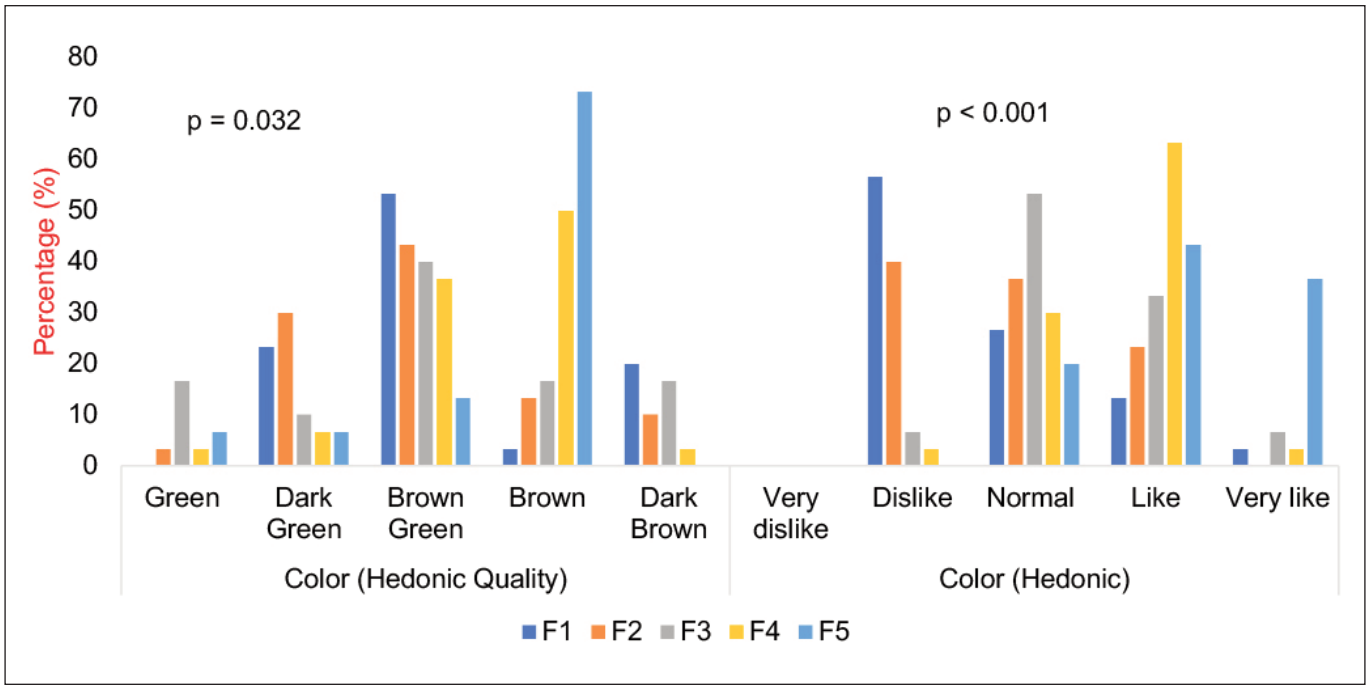

Figure 4. Color (Quality and Hedonic) based on 5 formula groups

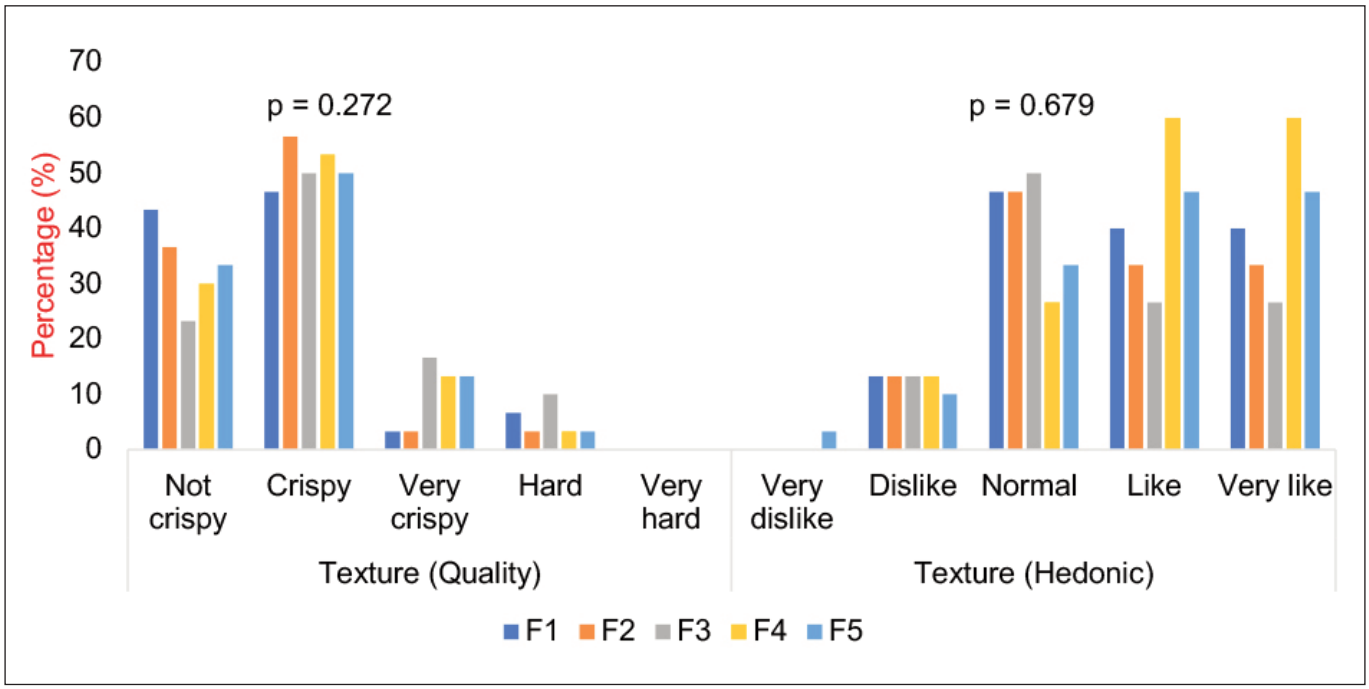

Figure 5. Texture (Quality and Hedonic) based on 5 formula groups

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

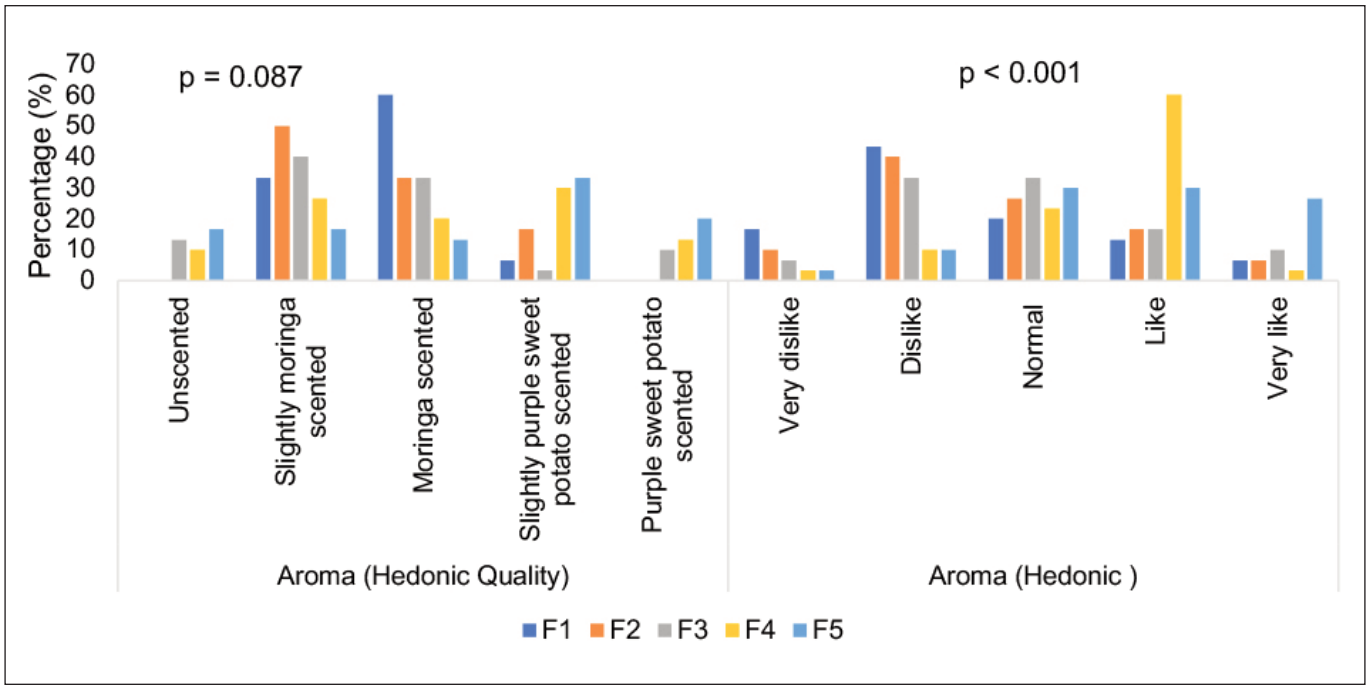

Figure 6. Aroma (Quality and Hedonic) based on 5 formula groups

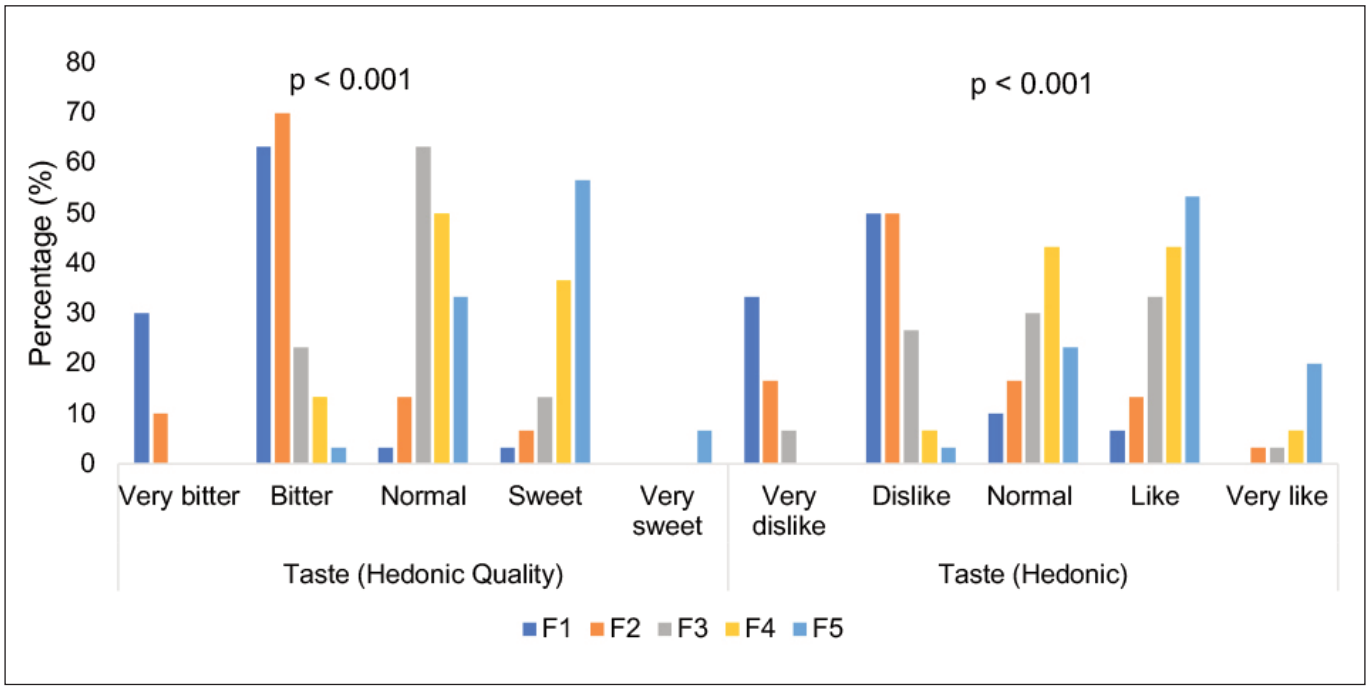

Figure 7. Taste (Quality and Hedonic) based on 5 formula groups

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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