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Acceptability and Nutritional Content of Mocaf Cheese Sticks with Soybean and Butternut Squash Flour as Alternative Snack for Elementary School Children

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ABSTRACT

Background: Snack foods contribute to meeting children's energy and nutritional needs. Cheese sticks are a potential snack product because of their crunchy texture and savory taste, which are favored by children
Objective: This study aimed to determine the effect of soybean substitution and the addition of butternut squash flour on the acceptability (color, aroma, texture, and taste) and nutritional content (energy, carbohydrates, protein, and fat) of the best mocaf flour cheese stick formula.
Methods: This study employed an experimental design using a Completely Randomized Design. Sensory testing was conducted on four formulations by 40 untrained panelists, namely F1 (5% soybean flour + 5% butternut squash flour), F2 (10% + 5%), F3 (15% + 5%), and F4 (20% + 5%). Data were analyzed using the Kruskal-Wallis test, followed by the Mann-Whitney test. **Results:** The results showed significant differences in the acceptability of color, texture, and taste ($p<0.05$), but there were no significant differences in the acceptability of aroma ($p>0.05$).
Conclusions: Based on the acceptability test, F2 was identified as the best formula. Laboratory analysis of F2 showed that every 100 g of product contained 527.6 kcal of energy, 39.6 g of carbohydrates, 7.93 g of protein, and 37.5 g of fat.

Keyword: children, cheese sticks, mocaf, soybean, butternut squash.

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INTRODUCTION

Elementary school children comprise those between 6 and 12 years of age (1). During this period, the body depends on food as its principal source of energy and essential nutrients (2). Optimal growth and development can be achieved through adequate energy and nutrient intake (3). Based on Indonesian Ministry of Health Regulation No. 28 of 2019, children aged 7–12 years require a daily intake of 1,650–2,000 kcal of energy, 40–55 g of protein, 55–65 g of fat, and 270–300 g of carbohydrates. Inadequate nutrient intake may increase the risk of nutritional problems, including protein-energy malnutrition (PEM). Data from the 2010 Basic Health Research (Riskesdas) showed that the prevalence of PEM in Indonesia, based on the weight-for-age indicator, was 17.9%, consisting of 13.0% underweight and 4.9% severely underweight children. This condition can impair immune function, making children more susceptible to infectious diseases (4).

Snack consumption contributes to meeting children's daily energy and nutrient requirements (5). Children's snacking behavior is influenced by the new environment and experiences they encounter upon entering elementary school at approximately 7 years of age (6). The Food and Agriculture Organization (FAO) defines snack foods as a wide variety of ready-to-eat foods and beverages produced and sold in public places or by street vendors for immediate consumption (7). One snack product with considerable potential for development is cheese sticks, as it is widely recognized, popular among consumers, convenient to consume, readily available in the market, easy to produce, and relatively affordable (8). In addition, its crispy texture and savory flavor make cheese sticks particularly appealing to children.

Cheese stick is a dry, stick-shaped snack traditionally made from wheat flour (9). This product is generally long and flat, resembling a thin flour-based stick (8). According to the nutrition facts of the commercially available “NakDe” cheese stick, every 100 g contains 570 kcal of energy, 3.54 g of protein, 37.8 g of fat, and 54.01 g of carbohydrates. Despite its high energy content, the product provides relatively low protein, indicating that its nutritional quality could be improved. Furthermore, although wheat flour plays an essential role in producing the characteristic crispy texture and dough elasticity of cheese sticks, its gluten content may pose health concerns for certain individuals.

The extensive use of wheat flour in various food products, including cheese sticks, warrants attention because it may pose health risks for individuals with gluten intolerance. Gluten is a type of protein naturally found in cereals such as wheat, oats, and barley. However, not all individuals can tolerate gluten. Therefore, people with gluten-related disorders, such as gluten allergy, celiac disease, and autism spectrum disorder (ASD), are advised to avoid gluten consumption to prevent adverse health effects (10). In addition, Indonesia imported approximately 11.7 million tons of wheat in 2024, reflecting the country's heavy dependence on imported wheat as the primary raw material for wheat flour production (11). This situation highlights the need to utilize locally available food resources, such as modified cassava flour (mocaf), as an alternative to reduce wheat flour utilization.

Modified cassava flour (mocaf) is produced by fermenting cassava, a process that modifies its physicochemical properties (12). Owing to its gluten-free nature, mocaf can replace up to 100% of wheat flour, particularly in food products that do not require dough expansion during processing (13). In addition, mocaf has several desirable characteristics, including a neutral flavor, a light color, and a fine texture,

making it suitable for the development of gluten-free products (14). However, gluten-free products are generally lower in certain nutrients, particularly protein (15). Therefore, incorporating protein-rich ingredients, such as soybeans, is necessary to improve the nutritional quality of these products.

Soybean (Glycine max) is a legume widely used as a food ingredient worldwide (8). Compared with other legumes, soybeans contain a higher amount of plant-based protein. Soybean protein accounts for approximately 40.4 g per 100 g, which is higher than that of kidney beans (22.3 g/100 g) and mung beans (22.0 g/100 g) (9). Based on the 2019 Indonesian Food Composition Table (TKPI), soybeans provide 286 kcal of energy, 30.2 g of protein, 15.6 g of fat, and 30.1 g of carbohydrates per 100 g, making them a nutrient-dense food. In addition to improving the nutritional value of the product, its sensory appeal can be enhanced by incorporating butternut squash, which contributes a naturally sweet flavor and an attractive bright color.

Butternut squash (Cucurbita moschata) is an annual horticultural crop rich in nutrients that provide various health benefits. It has a naturally sweet flavor and soft flesh, making it popular among consumers (16). Its appealing shape, sweet taste, tender texture, and favorable nutritional composition contribute to its desirability as a food ingredient (17). The characteristic orange color of butternut squash indicates its high β-carotene content, an antioxidant that serves as a precursor of vitamin A (18). Therefore, incorporating butternut squash is expected to impart a subtle sweetness while producing a brighter color in the cheese stick product.

The use of mocaf in cheese stick production, combined with soybean flour substitution and butternut squash flour addition, is expected to produce a nutritious alternative snack for elementary school children. Therefore, this study aimed to evaluate the effects of soybean flour substitution and butternut squash flour addition on the sensory acceptability of mocaf-based cheese sticks in terms of color, aroma, texture, and taste, as well as to determine the energy, carbohydrate, protein, and fat contents of the best formulation.

METODE

This study employed a true experimental design using a Completely Randomized Design (CRD). Four formulations of mocaf-based cheese sticks were developed by substituting soybean flour and adding butternut squash flour: F1 (5% soybean flour + 5% butternut squash flour), F2 (10% soybean flour + 5% butternut squash flour), F3 (15% soybean flour + 5% butternut squash flour), and F4 (20% soybean flour + 5% butternut squash flour). Product development and preparation were conducted at the Dietetics Laboratory, State University of Surabaya.

Sensory acceptability was evaluated by 40 untrained panelists. The sensory evaluation data were analyzed descriptively. Differences among formulations were analyzed using the Kruskal–Wallis test. When significant differences were detected ($p < 0.05$), pairwise comparisons were performed using the Mann–Whitney U test. The best formulation was selected using the De Garmo method based on the sensory acceptability results. Subsequently, the selected formulation was analyzed to determine its energy, carbohydrate, protein, and fat contents at the Surabaya Center for Standardization and Industrial Service.

RESULT

Sensory Acceptability

The sensory acceptability test of mocaf-based cheese sticks formulated with soybean flour substitution and butternut squash flour addition was conducted to evaluate panelists' preferences for the four formulations. The evaluation aimed to identify the best-performing formulation based on the panelists' sensory preferences. A four-point hedonic scale was used, where 1 = dislike very much, 2 = dislike, 3 = like, and 4 = like very much. The mean sensory acceptability scores are presented below.

Table 1
Mean Sensory Score of Mocaf-Based Cheese Stick Formulations

Parameter	Formulation			
	F1	F2	F3	F4
Color	3,58	3,55	3,20	3,30
Aroma	3,15	3,48	3,30	3,43
Texture	3,23	3,65	3,43	3,25
Taste	3,25	3,68	3,30	3,03

The mean acceptability scores varied across the four sensory attributes. Color acceptability scores ranged from 3.20 to 3.58, with formulation F1 receiving the highest mean score (3.58) and F3 the lowest (3.20). Aroma acceptability scores ranged from 3.14 to 3.48, with formulation F2 receiving the highest mean score (3.48) and F1 the lowest (3.15). Texture acceptability scores ranged from 3.23 to 3.65, with formulation F2 receiving the highest mean score (3.65) and F1 the lowest (3.23). Taste acceptability scores ranged from 3.03 to 3.68, with formulation F2 receiving the highest mean score (3.68) and F4 the lowest (3.03).

Table 2
Result of the Kruskal-Wallis Test for Sensory Acceptability

Parameter	Asymp. Sig.
Color	,022
Aroma	,095
Texture	,032
Taste	,001

The Kruskal–Wallis test revealed significant differences in color, texture, and taste acceptability among the formulations ($p < 0.05$). Therefore, post hoc pairwise comparisons were performed using the Mann–Whitney test. In contrast, no significant difference was observed in aroma acceptability ($p > 0.05$) therefore, no post hoc analysis was conducted.

Table 3
Result of the Mann-Whitney Test for Sensory Acceptability

Parameter	Formulation	Asymp. Sig. (2-tailed)
Color	FI and F2	0,929
	F1 and F3	0,008
	F1 and F4	0,091
	F2 and F3	0,013
	F2 and F4	0,117
	F3 and F4	0,435
Texture	FI and F2	0,005
	F1 and F3	0,209
	F1 and F4	0,751
	F2 and F3	0,087
	F2 and F4	0,028
	F3 and F4	0,438
Taste	FI and F2	0,005
	F1 and F3	0,209
	F1 and F4	0,751

F2 and F3	0,087
F2 and F4	0,028
F3 and F4	0,438

The Mann–Whitney test showed significant differences in color acceptability between F1 and F3, and between F2 and F3 ($p < 0.05$), whereas no significant differences were found between F1 and F2, F1 and F4, F2 and F4, or F3 and F4 ($p > 0.05$). For texture acceptability, significant differences were found between F1 and F2, and between F2 and F4 ($p < 0.05$), while no significant differences were found between F1 and F3, F1 and F4, F2 and F3, or F3 and F4 ($p > 0.05$). Similarly, significant differences in taste acceptability were found between F1 and F2, F2 and F3, and F2 and F4 ($p < 0.05$), whereas no significant differences were found between F1 and F3, F1 and F4, or F3 and F4 ($p > 0.05$).

Selection of the Best Formulation

Color, aroma, texture, and taste acceptability were used as the criteria for selecting the best formulation of the mocaf-based cheese stick. The mean scores for each sensory parameter were calculated and used in the De Garmo method to identify the best formulation.

Table 4
Calculation of Mean Score Differences for Best Formulation Selection

Parameter	Rank	Score	Formulation				Highest Value	Lowest Value	Difference
			F1	F2	F3	F4			
Color	3	2	3,58	3,55	3,20	3,30	3,58	3,20	0,38
Aroma	4	1	3,15	3,47	3,30	3,43	3,47	3,15	0,32
Texture	2	3	3,23	3,65	3,43	3,25	3,65	3,23	0,42
Taste	1	4	3,25	3,68	3,30	3,02	3,68	3,02	0,66

Table 5
Selection of the Best Formulation using the De Garmo Method

Parameter	Weight	Formulation							
		F1		F2		F3		F4	
		EV	PV	EV	PV	EV	PV	EV	PV
Color	0.2	1	0.1	0.921	0.092	0	0	0.263	0.026
Aroma	0.1	0	0	1	0.2	0.469	0.094	0.875	0.175
Texture	0.3	0	0	1	0,3	0,476	0,143	0,048	0,014
Taste	0.4	0,348	0,139	1	0,4	0,424	0,170	0	0
Total	1		0.239		0.992		0.406		0.216
Rank		3		1		2		4	

Keterangan:
EV = Effectiveness Value
PV = Productivity Value

In the De Garmo method, each sensory parameter was assigned a weight according to its relative importance in overall product acceptability. The weighting order, from the highest to the lowest, was taste, texture, aroma, and color (19). Based on the De Garmo analysis, formulation F2 achieved the highest mean score (3.59) and the highest productivity value (0.992). Therefore, F2, containing 10% soybean flour substitution and 5% butternut squash flour addition, was selected as the best-performing formulation. The selected formulation was subsequently subjected to laboratory analysis to determine its nutritional composition.

Nutritional Composition

Based on the results of the best-formulation analysis, the F2 mocaf-based cheese stick, formulated with 10% soybean flour substitution and 5% butternut squash flour addition, was selected as the best-performing formulation. The results of the nutritional composition analysis are presented below.

Table 6
Nutritional Composition of Mocaf-Based Cheese Sticks

Nutrient	per 100 g	per Serving 50 g
Energy (kcal)	527,6	263,8
Carbohydrates (g)	39,6	19,8
Protein (g)	7,93	3,97
Fat (g)	37,5	18,75

The nutritional composition of the best formulation (F2) was compared with that of the commercially available "NakDe" cheese stick to evaluate differences in energy, carbohydrate, protein, and fat contents per 50 g serving. The comparison of the nutritional composition is presented below.

Table 7
Comparison of the Nutritional Composition of Cheese Sticks per Serving (50 g)

Nutritient	Modified Cheese Sticks	"NakDe" Cheese Sticks
Energy (kcal)	263,8	285
Carbohydrates (g)	19,8	27
Protein (g)	3,97	1,77
Fat (g)	18,75	18,9

Optimal growth and development in school children depend on adequate energy and nutrient intake. In addition to main meals, these nutritional requirements can also be met through the consumption of snacks. Snacks are expected to contribute approximately 20% of the daily recommended nutrient intake. The contribution of the mocaf-based cheese stick to the recommended nutrient intake for school children is presented below.

Table 8
Nutrient Contribution of a 50 g Serving of Mocaf-Based Cheese Sticks

Age Group	Nutritient	Recommended Intake for Snack (20%)	Contribution (%)
7-9 years	Energy	330 kcal	79,94%
	Carbohydrates	50 g	39,6%
	Protein	8 g	49,63%
	Fat	11 g	170,45%
Boys 10-12 years	Energy	400 kcal	65,95%
	Carbohydrates	60 g	33%
	Protein	10 g	39,7%
	Fat	13 g	144,23%
Girls 10-12 years	Energy	380 kcal	69,42%
	Carbohydrates	56 g	35,36%
	Protein	11 g	36,09%
	Fat	13 g	144,23%

DISCUSSIONS

Color Acceptability

The mocaf-based cheese sticks formulated with soybean flour and butternut squash flour exhibited a yellowish-brown color. Among all formulations, F1 (5% soybean flour substitution and 5% butternut squash flour addition) received the highest color acceptability score, with a mean value of 3.58. The F1 formulation produced a more attractive yellowish-brown color that was less dark than the other formulations, making it more preferred by the panelists. The Kruskal–Wallis test showed a significant difference in color acceptability among the formulations ($p < 0.05$).

The effect of soybean flour substitution on the color of mocaf-based cheese sticks was evident from the changes in the appearance of the final product. Sastri et al. (9) reported that increasing the proportion of soybean flour resulted in a darker product color. Conversely, the β-carotene present in butternut squash flour contributed a natural yellow pigment to the product (12). The combination of the darker color associated with soybean flour substitution and the yellow pigment derived from butternut squash flour produced the characteristic yellowish-brown color of the mocaf-based cheese sticks. In addition, the frying process also influenced product color because the Maillard reaction and the formation of volatile compounds occurred during heating (9).

These findings are consistent with those reported by Fanny et al. (8), who found that soybean flour substitution significantly affected color acceptability ($p = 0.000$). As the proportion of soybean flour increased, panelists' preference for the color of the cheese sticks decreased.

Aroma Acceptability

The mocaf-based cheese sticks formulated with soybean flour and butternut squash flour exhibited the characteristic aroma of cheese with a subtle soybean aroma. Among all formulations, F2 (10% soybean flour substitution and 5% butternut squash flour addition) received the highest aroma acceptability score, with a mean value of 3.48. The F2 formulation produced a well-balanced aroma without an excessively strong beany odor from the soybean flour, resulting in greater panelist acceptance. The Kruskal–Wallis test indicated no significant differences in aroma acceptability among the formulations ($p > 0.05$).

The aroma characteristics of the mocaf-based cheese sticks were generally similar across all formulations, which may explain the absence of significant differences in aroma acceptability among the panelists. The aroma of the products was predominantly influenced by the cheese, thereby minimizing the effect of varying levels of soybean flour substitution. Nevertheless, soybean flour is known to produce a characteristic beany odor caused by off-flavor compounds generated through the activity of the lipoxygenase enzyme (20). In addition, butternut squash flour may also contribute a slight beany odor due to the presence of flavonoid compounds (12). However, these odors were not dominant because they were masked by the aroma of the cheese.

These findings are consistent with those reported by Sastri et al. (9), who found no significant differences in the aroma acceptability of cheese sticks formulated with soybean flour and red snapper fish flour substitution ($p = 0.465$). The mean aroma acceptability scores were relatively similar across all formulations, resulting in no significant differences among the treatments.

Texture Acceptability

The mocaf-based cheese sticks formulated with soybean flour and butternut squash flour exhibited a crispy texture. Among all formulations, F2 (10% soybean flour substitution and 5% butternut squash flour addition) received the highest texture acceptability score, with a mean value of 3.65. The F2 formulation produced a crispy texture while remaining pleasant to consume, making it the most preferred by the

panelists. The Kruskal–Wallis test revealed a significant difference in texture acceptability among the formulations ($p < 0.05$).

The effect of soybean flour substitution on the texture of the mocaf-based cheese sticks was evident from the differences in the texture of the final products. Product texture is influenced by the protein content of its ingredients. Increasing the proportion of soybean flour increased the protein content of the dough, resulting in a firmer texture and reduced crispness of the final product (21). In addition, Rasyid et al. (12) reported that the incorporation of butternut squash flour also reduced product crispness. Therefore, the combination of soybean flour substitution and butternut squash flour addition influenced the texture of the resulting cheese sticks.

These findings are consistent with those reported by Kamilah et al. (21), who found that substituting soybean flour and jelly flour in cookie formulations significantly affected texture acceptability ($p = 0.031$). In that study, the cookies exhibited textural characteristics ranging from crispy to moderately crispy across all formulations.

Taste Acceptability

The mocaf-based cheese sticks formulated with soybean flour and butternut squash flour exhibited the characteristic flavors of cheese and soybean. Among all formulations, F2 (10% soybean flour substitution and 5% butternut squash flour addition) received the highest taste acceptability score, with a mean value of 3.68. The 10% soybean flour substitution reduced the dominant salty taste of the cheese while maintaining the characteristic soybean flavor at an acceptable intensity, resulting in greater panelist acceptance. The Kruskal–Wallis test revealed a significant difference in taste acceptability among the formulations ($p < 0.05$).

The effect of soybean flour substitution on the taste of the mocaf-based cheese sticks was evident from the differences in the flavor of the final products. Soybeans possess a characteristic bitter and chalky taste, which is attributed to the presence of glycoside compounds (22). In addition, the incorporation of butternut squash flour also influenced the flavor of the product. Rismaya et al. (23) reported that the addition of butternut squash flour imparted a natural sweetness to food products. The combination of these ingredients produced a more balanced flavor profile, with the natural sweetness of butternut squash complementing the characteristic flavor of soybean.

These findings are consistent with those reported by Fanny et al. (8), who found that soybean flour substitution significantly affected the taste acceptability of cheese sticks ($p = 0.000$). As the proportion of soybean flour increased, panelists' preference for the taste of the cheese sticks decreased.

Nutritional Composition

The modified mocaf-based cheese stick contained lower energy and carbohydrate contents than the commercially available “NakDe” cheese stick. This difference can be attributed to the use of mocaf, soybean flour, and butternut squash flour, which contain lower amounts of energy and carbohydrates than the wheat flour used as the primary ingredient in the commercial product. In contrast, the mocaf-based cheese stick contained a higher protein content, primarily due to the substitution of soybean flour, which is a rich source of protein. Meanwhile, the fat content of the two products was relatively similar. These findings suggest that the mocaf-based cheese stick has the potential to serve as a healthier alternative snack for elementary school children.

A 50 g serving of the mocaf-based cheese stick, equivalent to approximately 50 sticks, provided 65.95–79.94% of the recommended energy intake allocated for snacks among children aged 7–12 years. This finding indicates that the product is capable of meeting a substantial proportion of the energy requirement for snacks. The contribution of a 50 g serving to the recommended carbohydrate intake for snacks ranged from 33.0% to 39.6%, while the contribution to the recommended protein intake ranged from

36.09% to 49.63% for children aged 7–12 years. These results indicate that a single serving of the product was insufficient to fully meet the recommended carbohydrate and protein requirements for snacks. Nevertheless, the incorporation of soybean flour increased the protein content of the cheese sticks, thereby contributing to the protein intake of school-aged children.

A 50 g serving of the mocaf-based cheese stick provided 144.23–170.45% of the recommended fat intake allocated for snacks among children aged 7–12 years. This high contribution was primarily attributable to the use of cheese as one of the main ingredients and to oil absorption during the frying process. On the other hand, the relatively high fat content may be beneficial for school-aged children with underweight status, who require higher energy and fat intake to support adequate growth, as fat is an important source of dietary energy. This is supported by the findings of Listyawardhani et al. (24), who reported that inadequate fat intake may adversely affect body mass and tissue development, ultimately influencing body weight. However, for children with overweight status, consumption of the mocaf-based cheese stick should be moderated because its high fat content may increase total daily energy intake when consumed excessively. Excessive dietary fat consumption may increase the risk of overweight and obesity in children (25).

CONCLUSIONS

The sensory evaluation of mocaf-based cheese sticks formulated with soybean flour substitution and butternut squash flour addition showed significant differences in color, texture, and taste acceptability, whereas no significant difference was observed in aroma acceptability. The best-performing formulation was F2, containing 10% soybean flour substitution and 5% butternut squash flour addition. Based on laboratory analysis, the F2 formulation contained 527.6 kcal of energy, 39.6 g of carbohydrates, 7.93 g of protein, and 37.5 g of fat per 100 g of mocaf-based cheese sticks.

CONFLICT OF INTEREST

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

AUTOR CONTRIBUTIONS

APR was responsible for developing the study concept, collecting and analyzing the data, interpreting the results, and drafting the manuscript. AR contributed to the study design, supervised the research, participated in data analysis and interpretation, and critically reviewed and revised the manuscript. All authors reviewed and approved the final manuscript and accept responsibility for its content.

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DECLARATION OF ARTIFICIAL INTELLIGENCE USE

The authors used ChatGPT (OpenAI, version GPT-5) to assist in improving the language and grammar of the manuscript. The authors reviewed and verified the content to ensure accuracy and integrity.

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