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Development of Mackerel Odeng Substituted with Sword Bean Flour: Sensory Acceptability and Nutritional Composition

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ABSTRACT

High snack consumption among adolescents demands balance with nutritious food products that are also appealing. Odeng, as Korean street food, has gained acceptance among adolescents. This study develops a product made from local food, mackerel odeng with sword bean flour substitution. The research used a Completely Randomized Design with three treatments: F1, F2, and F3. The organoleptic assessment of the products involved 30 semi-trained panelists to determine the level of preference and the characteristics of each formulation. Statistical analysis was done with SPSS 27.0, applying the Kruskal-Wallis test and the Mann-Whitney U test. The results of the hedonic organoleptic tests on the aspects of color, aroma, taste, and texture showed that F1 was the selected formula based on the Weighted Sum Method (WSM) with a substitution of 5 grams of sword bean flour. F1 contains 171 Cal/100 g; 17.95% protein; 6.75% fat; 9.62% carbohydrate; 0.2% omega 3; and 1.9% omega 6. The formula developed for this product has the potential to serve as a protein-rich snack and promote dietary diversification through the utilization of local food resources.

Key Messages:

- The development of mackerel (*Rastrelliger kanagurta*) odeng with sword bean (*Canavalia ensiformis*) flour substitution integrates the utilization of locally available food resources with the growing snack consumption trend among adolescents.
- The developed product has the potential to serve as an alternative source of protein, omega-3, and omega-6 fatty acids while supporting food diversification and promoting the value-added utilization of local agricultural commodities.

GRAPHICAL ABSTRACT

INTRODUCTION

Adolescence is a critical stage of life characterized by rapid growth and development, requiring adequate nutritional intake to support optimal physical and cognitive maturation. However, this period is also associated with an increased tendency to consume snacks that are generally high in calories but low in nutritional value. According to the 2023 Indonesian Health Survey (SKI), the prevalence of obesity among adolescents aged 16–18 years increased from 21.8% in 2021 to 23.4% in 2023 (1). Approximately 20% of adolescents' daily energy intake is derived from snacks, many of which contribute primarily energy-dense, nutrient-poor snacks and increase the risk of obesity and other non-communicable diseases (2,3). Therefore, there is a need to develop innovative snack products that are not only appealing but also provide substantial nutritional benefits.

Protein, omega-3, and omega-6 fatty acids are essential nutrients that play important roles in supporting adolescent growth, brain development, and various metabolic processes (4-6). Fish is one of the richest dietary sources of these nutrients. Although fish consumption in Indonesia has gradually increased, the national per capita consumption in 2024 remained below the government target, while fish consumption in West Java reached 46.61 kg per capita annually (7). These findings highlight the opportunity to promote fish consumption through the development of innovative fish-based products that better align with adolescents' food preferences.

Mackerel (*Rastrelliger sp*.) is an abundant local fishery commodity with high protein content and significant levels of omega-3 and omega-6 fatty acids. Its omega-3 content has been reported to be higher than that of salmon, reaching 2.6 g per 100 g (8). In addition, mackerel can be combined with sword bean (*Canavalia ensiformis)* flour, a local agricultural commodity with high protein content that has considerable potential as a flour substitute. Its wide availability and adaptability to diverse growing conditions make sword bean a promising ingredient for supporting food diversification while enhancing the value of local agricultural products. Odeng, better known as “eomuk” or Korean fish cake, is a processed food in the form of thin, long strips that is typically served with warm broth and eaten during the winter (9). Odeng is usually made from ground white fish, such as pollock or cod, mixed with flour and seasonings, and prepared by steaming or frying(10).

This study differs from previous research in that it develops odeng made from mackerel, using sword bean flour as a substitute, as a locally produced food product with nutritional value. In addition to examining sensory acceptance, this study also analyses the protein, omega-3 and omega-6 content, as well as their contribution to the Recommended Daily Intake (RDI) and Adequate Intake (AI). This study therefore contributes to the literature on fish-based product diversification and the use of sword bean meal as an innovative local food ingredient.

Based on these considerations, this study aimed to develop odeng made from mackerel with partial substitution of sword bean flour as a protein-, omega-3-, and omega-6-rich snack. Odeng was selected because of the growing popularity of Korean cuisine among adolescents, making it a promising product to encourage greater

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acceptance of fish-based foods (11). The development of this product integrates the utilization of locally available food resources with current snack consumption trends among adolescents. Furthermore, it has the potential to support food diversification, enhance the added value of mackerel and sword bean, and promote the sustainable utilization of locally produced agricultural commodities.

METHODS

The study used an experimental design with a one-factor Completely Randomized Design (CRD) consisting of three treatment levels for developing mackerel odeng products with the substitution of sword bean flour. The treatment involved three different formulations with the ratio of sword bean flour and tapioca flour, namely F1 (5 g : 40 g), F2 (10 g : 35 g), and F3 (15 g : 30 g). Testing of the three treatments was carried out with hedonic tests and hedonic quality tests to identify the preferred formula. Selected formulation from sensory test results was then subjected to nutritional content analysis using proximate tests and essential fatty acid tests to determine the macronutrient content and omega 3 and omega 6 content in the product, which was carried out at PT Saraswanti Indo Genetech (SIG) Bogor. The product manufacturing trial process was carried out at the Gunung Gede Culinary Laboratory and organoleptic tests were carried out at the IPB University Vocational School. The research was conducted from January to April 2026. Subjects were selected using purposive sampling method, including 30 semi-trained panelists with inclusion criteria were organoleptic training, good health, and availability for testing. Samples consisting of one skewer per formulation (10 g each) served with broth in 80-ml cups were provided to 30 semi-trained panelists.

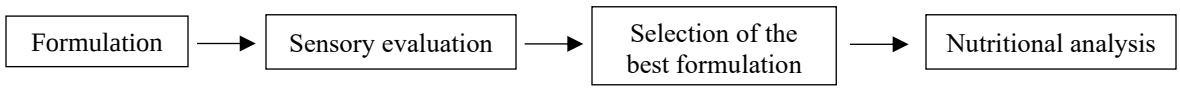

Figure 1. Flowchart of experimental workflow

Data analysis using Microsoft Excel 2021 and SPSS version 27.0 began with the Shapiro-Wilk normality test, followed by the Kruskal-Wallis and Mann-Whitney tests. Hedonic parameters included color, aroma, taste, and texture attributes, using a four-point rating scale (1=dislike very much, 2=dislike, 3=like, 4=like very much). Hedonic quality assessment with the same assessment parameters using 4 specific characteristic scales for each parameter includes color (1=brownish yellow, 2=dark brown, 3=grayish brown, 4=brown), aroma (1=very fishy, 2=moderately fishy, 3=fragrant, 4=very fragrant), taste (1=very bitter, 2=bitter, 3=slightly bitter, 4=salty and savory), and texture (1=very hard, 2=slightly hard, 3=soft, 4=chewy). Odeng mackerel substituted with sword bean flour consists of several ingredients such as tofu skin, mackerel fillet, sword bean flour, tapioca flour, eggs, garlic, salt, soy sauce, sesame oil, spring onions, and oyster sauce.

Table 1. formulation of each treatments

Ingredient	F1 (5:40)	F2 (10:35)	F3 (15:30)
Tofu skin	5 sheets	5 sheets	5 sheets
Mackerel fillet	300 g	300 g	300 g
Sword bean flour	5 g	10 g	15 g
Tapioca flour	40 g	35 g	30 g
Egg	1 piece	1 piece	1 piece
Garlic	3 cloves	3 cloves	3 cloves
Salt	1 tsp	1 tsp	1 tsp
Soy sauce	1 tbsp	1 tbsp	1 tbsp
Sesame oil	1 tbsp	1 tbsp	1 tbsp
Spring onion	1 stalk	1 stalk	1 stalk
Oyster sauce	1 tbsp	1 tbsp	1 tbsp

The procedure for making odeng for all three recipes follows the same steps. First, fillet the fish so it's easier to break down. Combine all the ingredients and place them in a food processor in the specified amounts, then process using the "all-in" method until well blended. Add the chopped green onions and stir with a spatula. Spread the mixed batter evenly over half of the tofu skin, then fold the other half over to cover the batter. Steam the odeng batter over medium heat for 15 minutes. The odeng is done when it becomes firmer and slightly

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shriveled; remove it from the steamer and let it cool to room temperature.

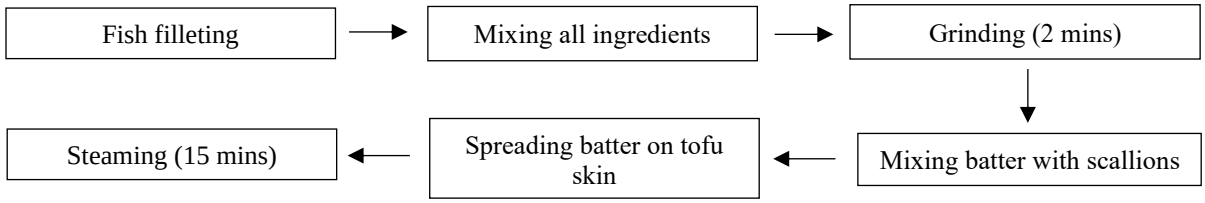

Figure 3. Flowchart of Odeng processing method

CODE OF HEALTH ETHICS

This study has been approved by the IPB University Health Research Ethics Committee under number 2296/IT3.KEP-IPB/SK/2026.

RESULTS

In this study, the innovation focused on developing a modified formulation by combining mackerel, tapioca flour, and sword bean flour to produce a product with distinctive sensory characteristics and enhanced nutritional value, particularly as a source of protein and a product containing essential omega-3 and omega-6 fatty acids. The results of the odeng product development are presented in Figure 4.

Figure 4. Odeng product development result

A hedonic test was used to determine the panelists' level of preference for each formulation, and a hedonic quality test was conducted to identify the characteristics of each formulation based on the panelists' evaluations of four parameters—color, aroma, taste, and texture using four-point rating scales. The results of the hedonic test for the products are presented in Table 2.

Table 2. Results of hedonic test

Indicator	F1	F2	F3	*P-value*
Color	2.93 ± 0.640^{a}	2.73 ± 0.521^{a}	2.83 ± 0.648^{a}	0.487
Aroma	3.07 ± 0.691^{a}	2.87 ± 0.681^{a}	3.00 ± 0.743^{a}	0.410
Taste	2.93 ± 0.785^{ac}	2.67 ± 0.711^{ab}	3.17 ± 0.834^{c}	0.030*
Texture	3.10 ± 0.607^{a}	2.47 ± 0.776^{b}	2.90 ± 0.712^{a}	0.004*

Note: *$p < 0.05$ based on the Kruskal-Wallis test; $^{a, b, c}$ = different letter codes indicate significant differences

Based on the test results, significant differences were found in the taste and texture parameters, while the color and aroma parameters did not differ significantly. A post-hoc Mann-Whitney test of the taste parameters showed that F2 and F3 were significantly different ($p < 0.05$), indicated by the notation "ab." A post-hoc Mann-Whitney test of the texture parameters showed that F1 and F2, as well as F2 and F3, were significantly different ($p < 0.05$), indicated by the notation "b.". Results of the hedonic quality test for the product are presented in Table 3.

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Table 3. Results of hedonic quality test

Indicator	F1	F2	F3	*P-value*
Color	2.43 ± 0.679[a]	2.57 ± 0.817[a]	2.40 ± 0.814[a]	0.688
Aroma	3.00 ± 0.947[a]	2.83 ± 0.791[a]	3.03 ± 0.890[a]	0.473
Taste	3.17 ± 0.648[a]	2.97 ± 0.890[a]	3.37 ± 0.765[a]	0.161
Texture	3.03 ± 0.765[a]	2.77 ± 0.971[a]	2.90 ± 0.995[a]	0.622

Note: *p < 0.05 based on the Kruskal-Wallis test; [a, b, c] = different letter codes indicate significant differences

The results of the data analysis for the hedonic quality test showed no significant differences in the parameters of color, aroma, taste, and texture; therefore, no further tests were conducted. The selection of the preferred odeng substitute formula was carried out using the Weighted Sum Method (WSM), based on scores obtained from the hedonic organoleptic test. The weighting for each formula was adjusted according to the parameters to be emphasised. The selected formula is presented in Table 4.

Table 4. Hedonic test ranking scores

Indicator	Weight	Alternative Component Scores					
		F1		F2		F3	
		Rank	Score	Rank	Score	Rank	Score
Color	20%	1	0.2	3	0.75	2	0.4
Aroma	25%	1	0.25	3	0.75	2	0.5
Taste	30%	2	0.6	3	0.75	1	0.3
Texture	25%	1	0.25	3	0.75	2	0.5
Score total	**100%**	**-**	**1.3**	**-**	**3**	**-**	**1.7**
Ranking		**1**		**3**		**2**	

Based on the table, F1 was identified as the selected formula, using the lowest amount of sword bean flour and achieving first place in the rankings. The tests conducted in this study consisted of proximate analysis, including measurements of ash, moisture, energy, protein, fat, and carbohydrate content to determine the macronutrient content of F1 as the selected product formula. Another laboratory analysis used was a test for essential fatty acids, specifically omega-3 and omega-6. The results of the laboratory tests on the selected odeng substitute formula are presented in Table 5.

Table 5. Laboratory test results for selected formula

No.	Indicator	Unit	Per 100 g	Per *serving size* (70 g)
1.	Ash	%	2.28	1.60
2.	Energy from fat	Kcal/100 g	60.71	43
3.	Fat	%	6.75	4.73
4.	Moisture	%	63.42	44.40
5.	Energy	Kcal/100 g	170.97	120
6.	Carbohydrate	%	9.62	6.73
7.	Protein	%	17.95	12.57
8.	Omega-3	g/100 g	0.2	0.14
9.	Omega-6	g/100 g	1.9	1.3

Source: Primary Data (2026)

Based on the test results, the following values were obtained: 170.97 kcal; 17.95 grams of protein; 6.75 grams of fat; 9.62 grams of carbohydrates; 0.2 grams of omega-3; and 1.9 grams of omega-6. Once the nutritional content of the selected odeng formula had been determined, the contribution of the selected odeng formula to the general Nutrition Labelling Refrence (NLR) was calculated. The calculation of the contribution to the general NLR are presented in Table 6.

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Table 6. Contribution of nutritional content to General NLR

Nutrients	General NLR	Nutrients		% NLR serving size	% NLR 100 g	Claim
		Serving size (70 g)	100 g			
Energy (Kcal)	2150	120	170.97	6%	8%	-
Protein (g)	60	12.57	17.95	21%	30%	Source
Fat (g)	67	4.73	6.75	7%	10%	-
Carbohydrate (g)	325	6.73	9.62	2%	3%	-
Omega-3 (g)	1.4	0.14	0.2	10%	14%	Contain
Omega-6 (g)	13	1.3	1.9	10%	15%	Contain

Compliance with protein source claims is based on BPOM Regulation No. 1 of 2022, which states that a food product may be claimed as a source of protein if its protein content is at least 20% of the Nutrition Label Reference Value per 100 grams of solid matter. The Nutritional Label Reference for processed foods used in this study is for the general population, with 60 grams of protein; 1.4 grams of omega-3; and 13 grams of omega-6, in accordance with BPOM Regulation No. 9 of 2016 (12). The contribution of macronutrients and essential fatty acids to the Recommended Dietary Allowances (RDAs) for adolescent males and females per serving (70 g) of the mackerel odeng made with sword bean flour as a substitute is presented in Table 7.

Table 7. Contribution of nutritional content to RDAs for adolescent

Nutrients	Serving size (70 g)	Adolescent male aged 16-18		Adolescent female aged 16-18	
		RDA	%RDA	RDA	% RDA
Energy (Kal)	120	2650	5%	2100	6%
Protein (g)	12.57	75	17%	65	19%
Fat (g)	4.73	85	6%	70	7%
Carbohydrate (g)	6.73	400	2%	300	2%
Omega-3 (g)	0.14	1.6	9%	1.1	13%
Omega-6 (g)	1.3	16	8%	11	12%

According to Ministry of Health Regulation No. 28 of 2019 on the Recommended Dietary Allowances (RDAs) for adolescents aged 16–18, the recommended energy intake is 2100–2650 calories; the recommended protein intake is 70–75 grams; the recommended fat intake is 70–85 grams; the recommended carbohydrate intake is 300–400 grams; the recommended omega-3 intake is 1.1–1.6 grams; and the recommended omega-6 intake is 11–16 grams.

DISCUSSION

The results of the hedonic test of color parameters showed that F1 was more appealing. The low polyphenol content (13), of sword bean flour used resulted in a color that tended to be stable, making the color of F1 more preferred. *P-value* > 0.05 indicates no significant difference among treatments. The similarity in color among the three formulations may be due to the relatively low substitution rate of sword bean flour, which prevents the dark color characteristic of the final product from dominating the product (14) and makes it still acceptable to the panelists.

The results of the hedonic test for aroma parameters showed that F1 was preferred. This was due to the low level of lipoxygenase enzyme activity in sword bean flour, which produces a musty odor (15), thereby influencing the panelists' preference ratings. *P-value* > 0.05 indicates that there was no significant difference between the treatments.

The results of the hedonic test of taste parameters indicate that F3 was preferred. The higher proportion of mackerel contributes to the distinctive fishy flavor, whilst the musty flavor characteristic of sword bean flour helps to mask the strong fishy odor (16). Consequently, the balance of these flavors enhances the overall flavor acceptability, leading the panelists to prefer the product. The release of glutamic acid from higher protein content (17) was also a factor contributing to the greater preference for the flavor of F3. *P-value* < 0.05 indicates a significant difference between F2 and F3. This may be due to the higher proportion of sword bean flour used in F3, as the distinctive nutty flavor and slight savory note characteristic of sword bean flour (18) result in a more

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savory flavor in the final product.

The results of the hedonic test for texture parameters showed that F1 was preferred. The sandy texture of sword bean flour tended to result in a less favourable final product (19) according to the panelists; consequently, the texture of F1 was preferred by the panelists. *P-value* < 0.05 indicates that there are significant differences between F1 and F2, and between F2 and F3. This is influenced by the use of different amounts of tapioca flour in each formulation. A sufficiently high binding capacity can result in a chewier texture as the amount of tapioca flour used increases (20).

The results of the hedonic quality test for colour parameters indicate that F2 is more appealing. This is suggested by the more balanced starch content of the tapioca and protein content of the sword bean flour, which results in a more even colour distribution in the dough (21). Descriptively, all three formulations fall into the dark brown category, which results from the Maillard reaction—that is, the reaction between proteins and reducing sugars during the steaming process (22)—thereby producing a brown colour in the odeng product. There were no significant differences between the treatments.

The results of the hedonic quality test for aroma parameters showed that F3 was preferred. This was indicated by the higher protein content of supporting proteins, which resulted in a stronger aroma (23), specifically. Descriptively, all three formulations fell into the 'moderately fishy to fragrant' category; this was due to the Maillard reaction and oxidation occurring during the manufacturing process, which contributed to the formation of aromatic compounds (24) and the development of a fragrant aroma in the products. There were no significant differences between the treatments.

The results of the hedonic quality test for the flavor parameter showed that F3 was preferred. This is indicated by the interaction between the higher protein content in sword bean flour and other ingredients, which enhances water-binding capacity and the distribution of seasoning (25), thereby making the flavor of F3 superior to that of the other formulations. Descriptively, all three formulations fall into the 'slightly bitter' category, due to the presence of small concentrations of HCN in sword bean flour (26). There were no significant differences between the treatments.

The results of the hedonic quality test for texture parameters showed that F1 was preferred. This is indicated by the fact that the increased use of sword bean flour is directly proportional to its tendency not to bind together (19), resulting in a decrease in density. Descriptively, all three formulations fall into the 'soft' category; this is due to the use of sword bean flour in the products, which reduces the dough's ability to develop strength, as the degraded starch and protein are unable to form a firm network (27), resulting in a soft texture in the final product. There were no significant differences between the treatments.

The selected formula in this study was determined using the Weighted Sum Method (WSM), based on the overall average of the parameters that achieved the highest ranking. Using this method, Formula F1 was identified as the selected formula, and further nutritional analysis was carried out in the form of a proximate analysis to determine the macronutrient content and an essential fatty acid analysis to determine the omega-3 content.

Based on the results of laboratory tests, the ash content of the selected formulation per 100 grams of product was found to be 2.28%. The mineral content of the product, based on the raw materials used, consists of potassium, phosphorus, calcium and magnesium (28,29). The moisture content of the selected formulation is 63.42% per 100 grams of product. Much of the product's moisture content originates from the raw materials used. Furthermore, the steaming process causes the bonds between the ingredients to break down due to the heat of the steam, resulting in an increase in moisture content through the absorption of heat from the water vapour (30).

The energy content of the selected formula per 100 grams of product is 170.97 kcal, derived from the raw materials used. The protein content of the selected formula per 100 grams of product is 17.95%, which is relatively higher than that of similar odeng products on the market—which contain only around 2–12 grams of protein per 100 grams of product—and catfish odeng products, which contain only 15.9 grams of protein per 100 grams of product (31). The fat content of the selected formula is 6.75% per 100 grams of product, which contributes to its savory sensory characteristics. The carbohydrate content of the selected formula is 9.62% per 100 grams of product and derives from the raw materials used.

The levels of essential fatty acids tested in the selected formula, per 100 grams of product, were 0.2 grams of omega-3 and 1.9 grams of omega-6. The omega-3 and omega-6 content in the substitute odeng is largely derived from the use of mackerel, which is present in significant quantities (8), as a raw material. The omega-3

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content in the substitute odeng is superior when compared to mackerel sausages, which contain only 0.18 grams of omega-3 per 100 grams of product (32).

Based on laboratory test results, it was found that F1, as the selected formula, meets the claim of being a protein source with a protein content of 30% and contains 14% omega-3 essential fatty acids and 15% omega-6 essential fatty acids. Odeng falls into the snack category; therefore, when comparing the energy contribution per 70-gram serving towards meeting the requirements for between-meal snacks in the 10–20 per cent range (33) for male and female adolescents aged 16–18 years, this is still insufficient. Therefore, given the limitations of this study, odeng should be supplemented with other foods to ensure that energy requirements during snacking are met.

CONCLUSION

This study shows that the use of sword bean flour as a substitute in mackerel odeng significantly affects both the sensory characteristics and the nutritional composition. Three variations of the odeng formula were developed using different substitutions of sword bean flour, revealing significant differences in sensory parameters relating to flavor and texture; formula F1 was identified as the panelists' favourite. The formulation with the lowest proportion of sword bean flour received the highest panelist acceptance as it produced a product with the desired sensory properties. The nutritional content per 100 grams of the selected product formula provides 170.97 kcal of energy; 17.95% protein; 6.75% of fat; 9.62% of carbohydrates; 0.2 grams of omega-3; and 1.9 grams of omega-6. The odeng substitute used in the study can also be considered a source of protein, as its protein content accounts for 30% of the general Nutrition Labeling Reference (NLR) and contributes to the Recommended Dietary Allowances (RDAs) for adolescents aged 16–18 years per serving: energy 5–6 %; protein 17–19%; fat 6–7%; carbohydrates 2%; omega-3 at 9–13%; and omega-6 at 8–12%. Odeng, which is rich in protein, omega-3 and omega-6, shows potential as an alternative food product aimed at teenagers, particularly those who tend to consume a considerable amount of snacks, thereby supporting optimal physical and cognitive development.

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CONFLICTS OF INTEREST

The authors declare no conflict of interest.

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