



## Application of Minced Mackerel Fish (*Scomberomorus commerson*) Meat as A Protein Source in Cassava Crackers

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### Article Info

Submitted : 30 October 2025  
Revised : 23 December 2025  
Accepted : 28 December 2025  
Published : 10 March 2026  
Available Online : 12 March 2026

### Keywords:

Level of preference;  
mackerel;  
minced meat;  
protein;  
proximate



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### ABSTRACT

The protein content of cassava crackers can be increased by incorporating minced mackerel (*Scomberomorus commerson*). This study aimed to identify the optimal proportion of mackerel fish mince to be incorporate into cassava cracker that yields the most preferred product, and to elucidated the proximate composition of this desired product. The employed methodology was experimental, involving the manufacture of cassava crackers with varying proportions of mackerel mince (0%, 7.5%, 10%, and 12.5%) and the use of 20 semi-trained panelists to assess their preferences for the crackers. This study examined preference levels using a hedonic test and analysed the results with nonparametric statistics (Friedman test), supplemented by multiple-comparison and Bayesian decision-making tests. Additionally, proximate analyses were conducted to determine the moisture, ash, fat, protein, carbohydrate, and calcium contents. The findings indicated that cassava crackers with 10% mackerel meat were the most favoured, as determined by Bayes method analysis and preference ratings, with mean scores of 8.3 for appearance, 8.3 for aroma, 8.6 for flavour, and 8 for texture. The proximate test findings indicated a moisture content of 4.12%, ash content of 3.41%, fat content of 25.53%, protein content of 4.51%, and carbohydrate content of 72.26%, with an expandability of 59.22%. The study concluded that cassava crackers containing 10% mackerel meat demonstrated the greatest consumer preference and satisfactory sensory quality, supported by favourable proximate composition and expandability, suggesting that this formulation was optimal for producing value-added cassava crackers.

**How to Cite this Article:** Ardytiandi, R., J. Junianto, K. Haetami & I. Rostini. 2026. Effect of adding minced mackerel fish (*Scomberomorus commerson*) meat as a protein source in the production of cassava crackers. Jurnal Perikanan Universitas Gadjah Mada. 28 (1): 31-38. <https://doi.org/10.22146/jfs.112618>

## INTRODUCTION

Minced mackerel fish (*Scomberomorus commerson*) is a highly valuable pelagic marine fish that is widely sought after for its distinctive taste and high protein content. The nutritional composition of mackerel includes water (76.5%), protein (21.4%), fat (0.56%), carbohydrates (0.61%), and ash (0.93%) (Rahayu & Destiana, 2022). Protein has a significant role in the human body as a source of energy, a building block, and a regulator of metabolism, so the use of mackerel can be an effort to increase the nutritional value of a food product (Anissa & Dewi, 2021).

Fish meat is typically incorporated into food products via grinding to achieve a smooth, homogeneous texture (Ginting *et al.*, 2022). One product that can be nutritionally enhanced by the addition of minced mackerel meat is cassava crackers. Cassava crackers are starch-based snacks that have a crispy texture, but their protein content is low, at around 1-3% (Handajani *et al.*, 2024). The addition of minced mackerel meat to cassava crackers will affect their protein content. In addition to minced mackerel meat, the product will affect the level of preference for cassava crackers.

Based on the above description, this research was conducted to determine the optimal proportion of minced mackerel meat in the production of cassava crackers that maximizes consumer preference. In addition, this study is expected to provide an innovative approach to optimizing the utilization of fishery products while creating highly nutritious, environmentally friendly, and economically valuable food products.

## MATERIALS AND METHODS

### Location and time

The research was conducted from August to September 2025. Cassava cracker production, organoleptic testing, and cracker expandability test were carried out at the Fisheries Product Processing Laboratory, Faculty of Fisheries and Marine Sciences, Padjadjaran University. Proximate testing was conducted at the Central Laboratory of

Padjadjaran University.

### Materials and tools

The tools used in this study were digital scales, knives, graters, stoves, steaming pots, meat grinders, plastic basins, baking pans, frying pans, spatulas, oil strainers, plastic spoons, gloves, and label paper. The ingredients used in this study were mackerel, cassava, tapioca flour, salt, garlic powder, coriander, pepper, water, and oil.

### Research method

This research employed a laboratory experimental design to produce cassava crackers with four treatments varying the amount of minced mackerel meat added. A hedonic test to assess the level of preference was conducted by 20 semi-trained panellists. Based on the amount of cassava used, four treatments of minced mackerel meat addition, were: Treatment A (no addition of minced mackerel meat); Treatment B (the addition of 7.5% minced mackerel meat); Treatment C (the addition of 10% minced mackerel meat); Treatment D (the addition of 12.5% minced mackerel meat).

### Work procedure

This research was conducted in several stages: preparing minced mackerel, producing cassava crackers with the minced mackerel added according to the treatment, and analysing the resulted crackers against predetermined criteria.

### Minced mackerel meat preparation

The procedure of minced mackerel meat preparation by Aisyah *et al.* (2016) was modified as follows: The mackerel was cleaned, the head and tail were removed, the meat was separated from the skin and bones using a knife, then the meat was washed thoroughly; The mackerel meat was minced using a meat grinder until smooth; and finally, the minced mackerel meat was ready for use.

### Making cassava crackers with the addition of minced mackerel meat

The formulation of cassava crackers with the addition of minced mackerel fish is presented in Table 1.

Table 1. Formulation of cassava crackers with the addition of minced mackerel meat.

Materials	Treatments			
	A	B	C	D
Cassava (g)	100	100	100	100
Tapioca flour (g)	200	200	200	200
Minced mackerel meat (g)	-	22.5	30	37.5
Garlic powder (g)	4	4	4	4
Salt (g)	5	5	5	5
Coriander powder (g)	5	5	5	5
Ground pepper (g)	3	3	3	3

The procedure for making cassava crackers by Hidayat *et al.* (2015) was modified by adding minced mackerel meat as follows: All ingredients were weighed according to the recipe; The cassava was cut at each end and then peeled using a knife; The peeled cassava was washed with clean water to thoroughly remove any dirt and slime; The clean cassava was grated until smooth; The minced mackerel meat was mixed into the finely grated cassava dough and homogenized; Salt, garlic powder, coriander powder, and pepper powder were mixed into the dough, then homoge-

nized; The homogenized dough was put into a baking pan; The baking pan filled with dough was put into a steamer and steamed for 30 minutes; After steaming, the dough was dried for 24 hours; The dried dough was cut into thin slices using a knife 2 mm thick; The sliced dough was then dried under the hot sun from 8:00 a.m. to 4:00 p.m. for 2 days, and the crackers were then turned over every hour; The dried cracker sheets were fried in hot oil. The crackers were fried until completely cooked, indicating by the absence of air bubbles. The crackers were removed

with a slotted spoon, drained in a colander, and then were ready to serve.

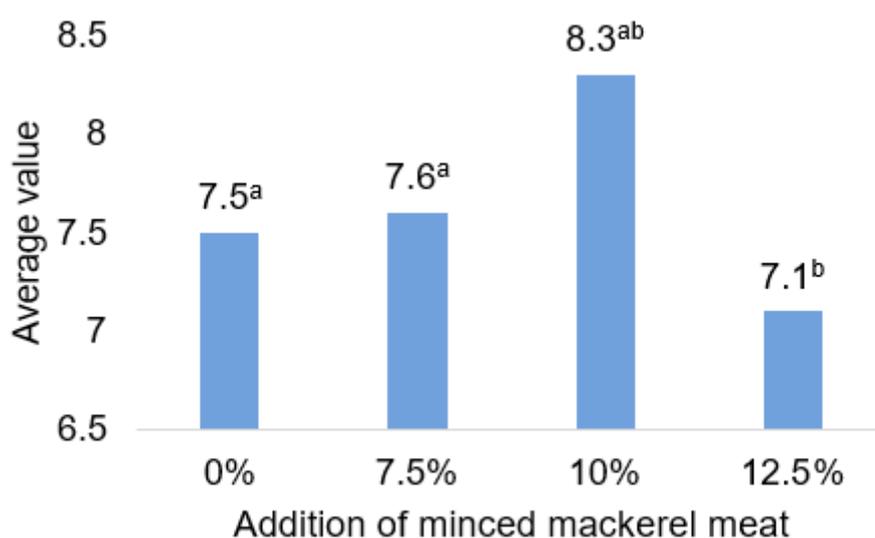
**Observed parameters**

The parameters observed in this study were the levels of preference for the appearance, aroma, texture, and taste of cassava chips containing minced mackerel. Next, a cracker expandability test was conducted to determine the effect of adding minced mackerel meat on cracker expansion. The preference level was tested using a hedonic test in accordance with SNI 2346-2011, with a 5-point scale ranging from 1 to 9 (1 = strongly dislike, 3 = dislike, 5 = neutral, 7 = like, and 9 = strongly like). The preference level was tested using a hedonic test followed by a Bayesian test to determine the best decision. In addition, a proximate analysis was conducted in accordance with SNI 01-2891-1992 on Food and Beverage Testing Methods, including measurements of water, ash, fat, protein, and carbohydrate content.

**RESULTS AND DISCUSSION**

*Level of appearance preference*

One of the important organoleptic parameters to be evaluated by panelists is appearance. If panelists like the appearance of a product, they are usually interested in evaluating other organoleptic parameters, such as aroma, texture, and taste. A uniform color makes a product look more attractive, high-quality, and convincing to consumers. According to Rochima et al. (2015), products with a uniform, intact shape tend to attract more attention from panelists and are preferred over products that are not uniform or intact. The assessment of product appearance aimed to evaluate the quality and panelists' acceptance of the appearance of cassava crackers produced under several treatments incorporating minced mackerel meat. The average results of the appearance of cassava crackers with the addition of minced mackerel meat across various treatments are shown in Figure 1.



**Figure 1.** Average results of cassava cracker appearance for each treatment. Notes: 1 = strongly dislike; 3 = dislike; 5 = neutral; 7 = like; 9 = strongly like

Friedman's nonparametric statistical analysis indicated that the addition of minced mackerel meat affected the perceived appearance of cassava crackers. These results indicated that the appearance of cassava crackers with 10% minced mackerel differed significantly from cassava crackers containing 0%, 7.5%, and 12.5% minced mackerel. The 10% treatment had the highest average (8.3), whereas the 12.5% treatment had the lowest (7.1). The appearance of cassava crackers with minced mackerel in the 10% treatment was brownish-yellow. Meanwhile, the appearance of cassava crackers with minced mackerel from the 12.5% treatment exhibited a brown, darker colour. This showed that the greater the amounts of minced mackerel added to cassava crackers, the less appealing the crackers' appearance became to the panellists. This resulted in a lower preference score because the crackers produced are darker brownish yellow in colour. The results of the appearance of cassava crackers under several treatments are shown in Figure 2.

The dark colour of cassava crackers was caused by the Maillard reaction during frying, as the minced mackerel increased the protein content of the cassava crackers. According to Saputra et al. (2016), the more fish has been added, the higher was the protein content of the crackers;

the higher was the protein content, the more likely the crackers developed brown colour during frying, a process known as the Maillard reaction. The Maillard reaction occurs when the amino acid lysine reacts with glucose at high temperatures, forming brown-coloured melanoidin compounds (Muna et al., 2017).



**Figure 2.** Appearance of minced mackerel cassava crackers with various treatments.

### Level of aroma preference

Aroma is one aspect used to assess the taste of food through the sense of smell, as it can quickly give an initial impression of whether a product is liked or not (Pratiwi,

2024). The mean results of the aroma of minced mackerel cassava crackers across various treatments are shown in Figure 3.

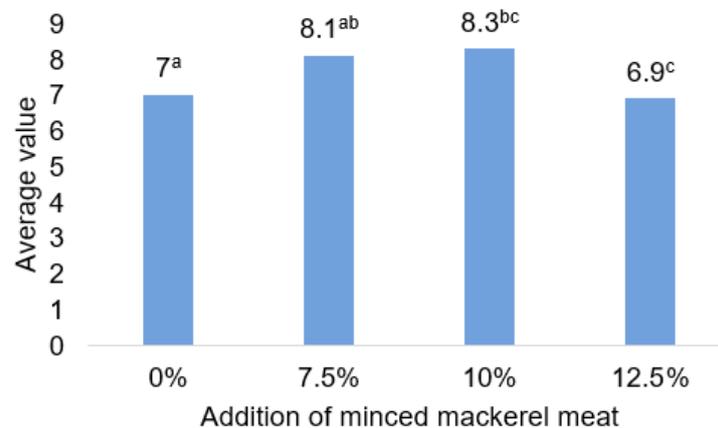


Figure 3. Average results of cassava cracker aroma for each treatment.

Notes: 1 = strongly dislike; 3 = dislike; 5 = neutral; 7 = like; 9 = strongly like

Friedman's nonparametric statistical analysis indicated that adding minced mackerel affects the preference for the aroma of cassava crackers. These results indicated that the aroma of cassava crackers with 10% minced mackerel was significantly different from that of cassava crackers containing 0%, 7.5%, or 12.5% minced mackerel. The 10% treatment had the highest average (8.3), whereas the 12.5% treatment had the lowest (6.9). The aroma of cassava crackers with minced mackerel in the 10% treatment was distinctive, with a mackerel component, yet it retained a cassava aroma. Meanwhile, the aroma of cassava crackers with minced mackerel in the 12.5% treatment was very strong. This indicated that the greater the amount of minced mackerel added, the stronger the fish's aroma. According to Pharwati & Sas-

mita (2023), the higher portion of fish meat addition to a product, the sharper the fish aroma of that product.

### Level of taste preference

Taste is an aspect of product evaluation used to measure the degree of a product's acceptance or liking (Iqbal *et al.*, 2016). In addition, taste plays an important role in determining whether consumers accept a product; even if the aroma, appearance, and texture are good, the product will not be accepted if it does not taste good (Rochima *et al.*, 2015). Taste is assessed by the tongue. Taste can be categorized into four types, namely salty, sweet, sour, and bitter (Pratiwi, 2024). The mean results for the preference for the taste of minced mackerel cassava crackers across various treatments are shown in Figure 4.

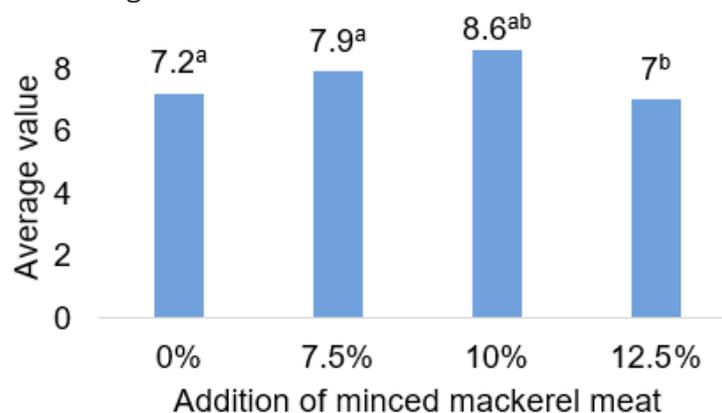


Figure 4. Average cassava cracker taste results for each treatment.

Notes: 1 = strongly dislike; 3 = dislike; 5 = neutral; 7 = like; 9 = strongly like

Friedman's nonparametric statistical analysis indicated that the addition of minced mackerel affected the level of preference for cassava crackers. These results showed that the taste of cassava crackers with 10% minced mackerel was significantly different from that of cassava crackers containing 0%, 7.5%, or 12.5% minced mackerel. The 10% treatment had the highest average

value of 8.6, while the lowest average value was found in the 12.5% treatment, which was 7. The taste of cassava crackers with minced mackerel in the 10% treatment was savoury and fish-like, yet still discernible as cassava. Meanwhile, the taste of cassava crackers with minced mackerel fish from the 12.5% treatment had a strong fish flavour and no cassava flavour.

**Level of texture preference**

Texture is one of the parameters used to determine the level of preference for a product (Pratiwi, 2024). The assessment of texture aims to evaluate the extent to which

panellists perceive the product’s crispness through touch (Permana et al., 2012). The mean test results for the texture-preference level of minced mackerel cassava crackers across various treatments are shown in Figure 5.

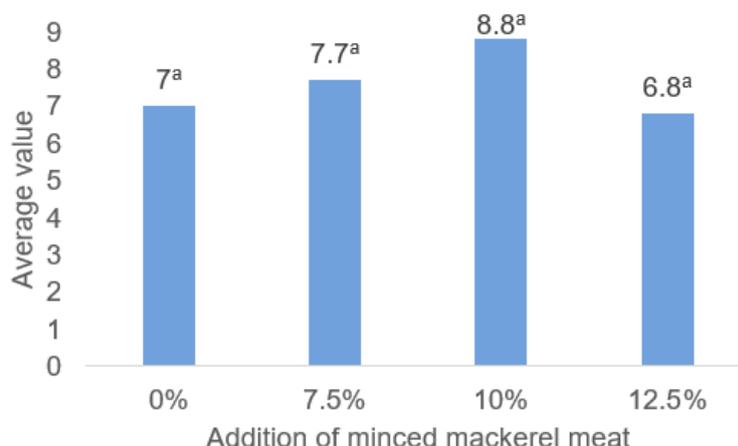


Figure 5. Average results of cassava cracker texture for each treatment.

Notes: 1 = strongly dislike; 3 = dislike; 5 = neutral; 7 = like; 9 = strongly like

Based on testing, the texture preference for cassava crackers with the addition of minced mackerel, 10% addition showed the highest crispness. Based on Friedman’s nonparametric statistical analysis, the addition of minced mackerel had no effect on the acceptance of the cassava crackers’ texture. The texture of cassava crackers with various treatments of minced mackerel addition was acceptable to the panellists. The differences in texture among treatments were not significant because the level of minced mackerel addition remained within a reasonable range, so the texture of cassava crackers from mackerel mince was not too noticeable to the panellists. The average texture of cassava crackers with mackerel mince was crispy.

**Decision-making using the Bayesian method**

Based on the results of calculating the weight criteria for appearance, aroma, taste, and texture of cassava crackers with the addition of minced mackerel fish, it was found that the assessment of appearance was the main factor influencing the panellist’s final decision in choosing cassava crackers, with a weight criterion value of 0.47. The weight criteria for cassava crackers are presented in Table 2.

Table 2 shows that 47% of panellists considered the appearance criteria for cassava crackers. Meanwhile, the remaining 53% of panellists were divided into three additional criteria: aroma, texture, and taste. According to Prakoso et al. (2015), appearance is the first aspect consumers attend to when evaluating a product. If the product’s appearance is attractive, consumers will continue to evaluate other characteristics, such as aroma, taste, and texture. The results of the Bayesian calculation indicated that cassava crackers containing 10% minced mackerel were the most preferred variant among the panellists, as they received the highest alternative and priority scores in the hedonic test.

**Expandability of cassava crackers**

The development of crackers is a critical quality factor because it influences consumer acceptance. In principle, this expansion process occurs because steam pressure generated by heating the water in the ingredients compresses the ingredients’ structure, producing expanded crackers (Koswara, 2009). The average test results for the expansion of cassava crackers with minced mackerel meat from various treatments are shown in Figure 6.

Table 2. Criteria weight of cassava crackers.

Criteria	Weight Criteria
Appearance	0.47
Aroma	0.28
Texture	0.05
Taste	0.20

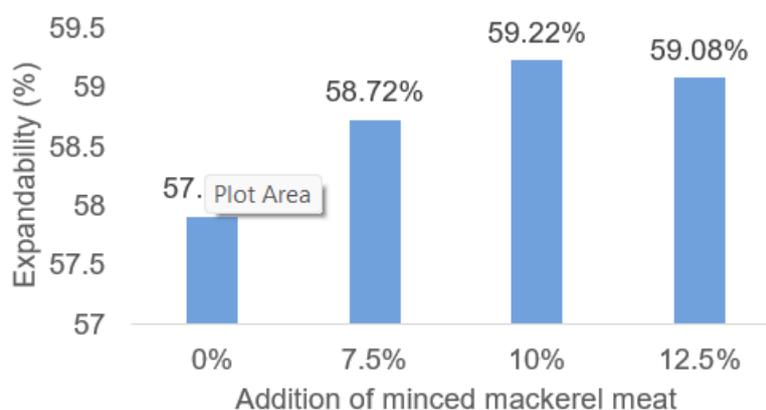


Figure 6. Average results for cassava cracker expandability across treatments.

Based on the figure above, the highest expansion rate of cassava crackers was observed in the treatment with 10% minced mackerel meat, at 59.22%. Meanwhile, the lowest expansion rate of cassava crackers was observed in the treatment with 0% minced mackerel meat, at 57.90%. The addition of 12.5% minced mackerel meat reduced the expansion percentage. This occurred because the expansion of crackers is strongly influenced by their water content; adding fish meat increases the water content of cassava crackers. According to Rohaman & Supriatna (1998), cracker expansion is influenced by water content because, during frying, water vaporizes, thereby causing the starch matrix to form cavities. Therefore, if

the water content is too low, the crackers will not expand sufficiently; if it is too high, the dough will become soft, thereby inhibiting expansion.

*Proximate test of cassava crackers*

One way to evaluate the quality of a food product is by determining its nutritional content (Muzhahir *et al.*, 2023). The parameters analysed include moisture, ash, protein, fat, and carbohydrate content. The results of the proximate analysis of cassava crackers in the control treatment (0%) and the treatment with the addition of minced mackerel, which was most preferred by the panellists (10%), are presented in Table 3.

Table 3. Proximate test results.

Chemical Content	Treatment		SNI 8646-2018
	0%	5%	
Water	3.84	4.12*	Max. 4%
Ash	2.86*	3.41*	Max. 0,3%
Fat	25.33	25.53	Max. 30%
Protein	2.09	8.12	Min. 2%
Carbohydrate	71.87	72.26	-

\*Not compliant with SNI 8646-2018

*Water content*

The water content in food ingredients is closely related to product quality and can be used as an initial indicator to assess food quality (Nadia *et al.*, 2023). Water is an important component in food ingredients because it can affect the appearance, texture, and taste of the food (Pratiwi, 2024). Proximate analysis results showed that the water content in the control cassava crackers is 3.84%, while that of in cassava crackers with the addition of 10% minced mackerel reached 4.12%. Based on SNI 8646-2018, both samples did not meet the specified requirements, so it was concluded that cassava crackers with added minced mackerel do not meet the SNI quality standards for crackers, which had a maximum water content limit of 4%. This might be due to the addition of minced mackerel meat. Mackerel has contained 76.5% of water (Rahayu & Destiana 2022). Moisture content can affect the texture of cassava crackers, namely the crispness of the product (Pratiwi, 2024). According to (Normilawati *et al.* 2019), the water content in food ingredients

greatly affects product shelf life, because high water content can facilitate bacterial growth, thereby accelerating spoilage.

*Ash content*

Ash content testing is often used as a benchmark in assessing product quality (Sulistyoningsih *et al.*, 2019). Ash content in food ingredients refers to the mineral matter present and is determined by the complete combustion of samples during incineration (Smith *et al.*, 2023). Based on the results of the proximate ash content in cassava crackers with a control treatment of 2.86% and cassava crackers with the addition of 10% minced mackerel meat, the ash content was 3.41%. According to SNI 8646-2018, both samples exceeded the SNI requirements; therefore, cassava crackers containing minced mackerel meat did not meet the SNI quality requirements, which are a maximum of 0.3%. This could be due to the cooking and drying process, which causes the ingredients to lose protein and some of their water and fat content, ultimately increasing

the ash content (Pratiwi, 2024). In addition, the increase in ash content in cassava crackers could be attributable to the addition of minerals from mackerel. The ash content in mackerel was 0.93% (Nugroho et al., 2014).

#### Fat content

Fat content greatly affects the shelf life of a product. A high fat content in a product can shorten its shelf life by increasing the risk of rancidity due to lipid oxidation (Iqbal et al., 2016). Based on the results of the proximate fat content test in cassava crackers with a control treatment of 25.33% and cassava crackers with the addition of 10% minced mackerel meat, the fat content was 25.53%. According to SNI 8646-2018, both samples met the SNI requirements; therefore, cassava crackers with the addition of minced mackerel meat met the quality requirements for crackers under SNI. The fat content in cassava crackers could be influenced by the level of oil absorption during frying. Factors such as frying temperature and duration, material characteristics, porosity, and pre-frying treatment also affect the level of oil absorption (Pratiwi, 2024).

#### Protein content

Protein is an essential nutrient for the body, not only as a source of energy, but also as a regulator and builder of body tissue. (Pratiwi, 2024). Based on the results of the proximate protein content in cassava crackers with a control treatment of 2.09% and cassava crackers with the addition of 10% minced mackerel meat, the protein content was 8.12%. According to SNI 8646-2018, both samples met the SNI requirements; therefore, cassava crackers containing minced mackerel meat met the quality standards for cassava crackers under SNI. According to Nugroho et al. (2014), mackerel meat has contained 21.4% protein. Therefore, the more minced mackerel meat added, the higher the product's protein content.

#### Carbohydrate content

Carbohydrates are the main source of energy for humans. In addition, carbohydrates play an important role in shaping the characteristics of foodstuffs, such as taste, colour, and texture. (Fitri & Fitriana, 2020). Based on the proximate analysis, the carbohydrate content in cassava crackers with the control treatment was 71.87%, and cassava crackers with 10% minced mackerel meat added, it was 72.26%. According to SNI 8646-2018, both samples met the SNI requirements; therefore, cassava crackers containing minced mackerel meat met the quality requirements for cassava crackers under SNI. The increase in carbohydrate content in cassava crackers might be attributable to the addition of minced mackerel meat, which contains 0.61% carbohydrates (Rahayu & Destiana, 2022). In addition, the tapioca flour used in the manufacture of cassava crackers also contains carbohydrates. The carbohydrate content in tapioca flour was 84.2% (Ratnajunita et al., 2024). Therefore, the carbohydrate content in cassava crackers increased.

## CONCLUSION AND RECOMMENDATION

### Conclusion

The addition of minced mackerel meat significantly affected the appearance, aroma, texture, and taste of cassava crackers. Based on the results of the preference test for cassava crackers containing minced mackerel, a 10% addition was the most preferred by the panellists. This treatment obtained the highest average scores for ap-

pearance (8.3), aroma (8.3), taste (8.6), and texture (8). Based on the calculated criterion values, appearance was the most important criterion for the panellists when assessing cassava crackers containing minced mackerel meat. The proximate test results for cassava crackers with 10% minced mackerel meat addition showed a moisture content of 4.12%, ash content of 3.41%, fat content of 25.53%, protein content of 4.51%, and carbohydrate content of 72.26%, with an expandability of 59.22%.

### Recommendation

Research on the addition of minced mackerel meat to cassava crackers is needed, particularly regarding protein content, which is essential for the body.

## AUTHORS' CONTRIBUTIONS

In preparing this article, RA, J, KH, and IR contributed to several activities, ranging from conducting research to drafting the manuscript, while NIA was specifically involved in data analysis and manuscript preparation.

## ACKNOWLEDGEMENT

The authors express their gratitude to the Department of Fisheries, Faculty of Fisheries and Marine Sciences, Padjadjaran University, Jatinangor, West Java, Indonesia, for their support. They also thank the Fisheries Product Processing Laboratory, Faculty of Fisheries and Marine Sciences, Padjadjaran University and the Central Laboratory of Padjadjaran University.

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