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Development of Snakehead Fish (Channa Striata) Roulade as a Healthy Snack

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ABSTRACTS

Snakehead (Channa Striata) fish is a high source of albumin. However, its use in food products remains very limited. Roulade is a type of food commonly consumed by people of various ages, made from processed meat. This study aims to determine the best concentration and level of public preference for snakehead fish roulade. The research was conducted in four stages: defining to identify reference recipes; designing to develop selected reference recipes, namely replacing beef-based ingredients with snakehead fish meat; developing for validity testing with food and nutrition experts; and finally disseminating to test product preferences with 30 panelists, including adolescent children. The favorability test results showed that reference products were in the preferred category, with an average of 3.5, and that development products were in the highly favored category, with an average of 4.1. The best formula for making roulade is to substitute beef for the whole. The results of product innovation show that the use of snakehead fish meat has a real effect on the color, texture, aroma, and taste of the roulade.

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1. INTRODUCTION

Indonesia, as a maritime country, has abundant fish resources that can be utilized as a source of food to achieve national food security and nutrition. National fish consumption in 2021 reached 55.16 kg/capita, equivalent to whole fresh fish. This figure increased by 1.10% compared to the previous year, to 54.56 kg/capita, equivalent to fresh whole fish. Fish consumption in 2024 is targeted at 62.5 kg/capita, equivalent to fresh whole fish (Kementrian Kelautan dan Perikanan, 2022). To date, the distribution of national fish consumption across Indonesia's islands has been uneven. The significant disparity in fish consumption between Java and eastern Indonesia has led to relatively low national fish consumption figures (Virgantari et al., 2022). In 2024, per capita calorie and protein consumption from fish declined to 51.90 kcal and 9.38 kcal, respectively. Per capita fish consumption in Indonesia has increased over the past five years, despite a slight decline from 2023 to 2024 (GoodStats Data, 2025). Indonesia is currently experiencing significant socioeconomic growth. Modern lifestyles in Indonesia have brought about changes, particularly among millennials; these changes will affect health and the body's nutrient intake. The millennial generation is the largest consumer group in Indonesia (Salampessy et al., 2024).

Food is anything that comes from biological sources, including agricultural, aquatic, fishery, forestry, plantation, and livestock products, which are processed or not processed as food or drink for humans, including food additives, food raw materials and other materials used in the process of preparing, processing and/or making food or drink (Susanti et al., 2016). Food diversification programs to improve community nutrition can be well developed if they leverage the potential of local food ingredients (Asih & Arsil, 2020). A healthy lifestyle can be achieved by consuming more nutritious foods, engaging in regular physical activity, and keeping the environment clean (Fadilah et al., 2022).

Roulade is a processed animal food made from a mixture of minced beef or chicken mixed with starch or flour, with or without additional ingredients and other spices, which is formed into balls (Ruswandani & Putri, 2017). Fish is one example of a food ingredient that is rich in protein and minerals and is also easily damaged due to its very high water content, neutral pH, soft texture, and high nutritional content, making it an excellent medium for bacterial growth. Several freshwater fish are available in the community, including pomfret, snakehead, gourami, catfish, tilapia, and patin. Fish that live in saltwater include skipjack tuna, salmon, snapper, mackerel, and mackerel (Susanti et al., 2016).

Snakehead fish is a predatory freshwater species that offers benefits, including increasing albumin levels and body resistance, speeding up post-operative healing, and accelerating wound healing (Attaftazani et al., 2013). Snakehead fish (Channa striata) is a species of the family Channidae, with several local names, namely kutuk (East Java), haruan (South Kalimantan), behau (Central Kalimantan), and snakehead (Selviana et al., 2020). Snakehead fish are carnivorous and have a body that is almost round, long, and flattened towards the back. Snakehead fish have a convex back, a flat belly, and a flat head. Snakehead fish do not have hard fin rays. Snakehead fish body size varies greatly and can reach a length of (90-110) cm. Snakehead fish are very rich in albumin, an important type of protein. Albumin is needed by the human body every day. Snakehead fish are a source of albumin for people with hypoalbuminemia (low albumin) and for people with wounds. Snakehead fish have an albumin content of 6.22% (Widodo et al., 2015). A supplementary feeding program with the right quality and quantity is essential for children to meet their daily nutritional needs. Current products tend to be single-ingredient snacks, such as plant-based foods, resulting in

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a lack of nutritional diversity. Food diversity is demonstrated by the completeness of its composition and nutritional quality (Faroj, 2019).

Previous research on snakehead fish substitutions, including the use of snakehead fish flour in making crackers, showed that the treatment had a significant effect on chemical analyses, namely ash, protein, fat, carbohydrate, and calcium content. In contrast, physical analysis included hardness, swelling volume, brightness, and chroma, and sensory analysis included hardness and taste (Putra et al., 2015). Another study examined surabi products made from snakehead fish. The results showed that the product's nutritional content was in the outstanding category, which is expected to motivate the community to participate in innovation by utilizing local food (Setiati et al., 2024).

Another interesting processed snakehead fish product that could be used to increase public interest is roulade. Product innovation is a new invention that differs from existing ones. One such innovation uses meat as a high-protein source and is easy to prepare. Roulade is considered a main course, meaning it is the most significant portion among other dishes (Masitoh & Chayati, 2020).

Roulade is an innovative way to process meat as a high-protein animal protein source. However, animal protein consumption in Indonesia remains relatively low (Pratiwi et al., 2021). This study aims to determine the optimal concentration of innovation for developing snakehead fish meat roulade products and the level of public acceptance of these products using organoleptic tests.

2. METHODS

The research method used is the type of research and development (R&D) with the 4D concept, consisting of the define stage (reference product study) to determine one selected reference recipe from several other recipes that will later be developed into a development product, design (product development) where the product is made according to the reference recipe to determine the best development recipe. This recipe development is carried out to determine the best sensory substitution for the main ingredients. The results are closest to the reference recipe. Development (product testing) aims to determine the product's presentation technique, including packaging, and to disseminate (product distribution) to assess the level of acceptance of the development product, which has been tested previously on a limited or large scale.

2.1. Materials and Equipment

The ingredients for this snakehead fish roll are beef, snakehead fish, tapioca flour, eggs, garlic, oyster sauce, pepper, salt, broth, cooking oil, plastic wrap, and white bread. The equipment used to make this snakehead fish roll includes a stove, a frying pan, a Teflon pan, a steamer, a cutting board, a container, a knife, and scales.

2.2 The Process of Making Snakehead Fish Roulade

The process of making snakehead fish roulade begins by steaming the fish with lime juice to remove the fishy smell. Then, weigh the ingredients according to the recipe. Next, make an omelette as the roulade's skin. The next step is to mix the fish meat with dry ingredients such as white bread and tapioca flour. The next step is to add broth, salt, sugar, and pepper to the dough. Then, arrange the dough on top of the egg and wrap it in plastic wrap. The dough is then steamed for 20 minutes, removed, and cooled or refrigerated before consumption. The dough is now ready and can be processed as the customer wishes.

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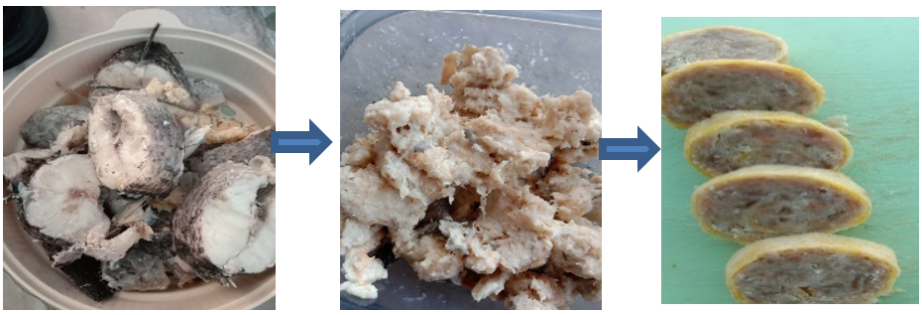

Figure 1. The process of making roulade.

2.3 Data Analysis

The data analysis used in this study was descriptive. Panelists' preference for the quality of the snakehead fish roulade was determined through an organoleptic assessment of five indicators: color, aroma, taste, texture, and overall taste. Panelists' responses to the organoleptic score sheet were categorized (very much like, like, somewhat like, and dislike). The panelists' score sheet for the organoleptic test was analyzed using SPSS. The data were analyzed using a paired t-test at the 5% significance level.

3. RESULTS AND DISCUSSION

3.1. Define Stage

The define stage involves determining the specifications of the product to be developed using three reference recipes, resulting in one reference recipe for development. These three reference recipes were obtained from reliable sources: the first, a journal article by Masitoh & Chayati (2017) on the development of eelroulade (eel roulade) made from eel as an innovative processed fish product; the second, an e-book by Ayustaningwarno (2018); and the third, a channel (Uyung Dheppy, 2022). At this Stage, the three recipes were tested by five trained panelists using a score sheet, with each panelist assessing the sensory parameters of shape, size, color, aroma, taste, texture, and overall characteristics. The recipe with the highest percentage was then selected for development in the next Stage. After testing with five trained panelists, one reference recipe was identified: Uyung Dheppy's third recipe (2022). The reference recipe for roulade is shown in **Table 1**.

Table 1. Recipe Reference.

No	Ingredients	Reference 1	Reference 2	Reference 3
1	Ground Beef	300 g	250 g	250 g
2	Eggs	3 eggs	4 eggs	3 eggs
3	Breadcrumbs	15 g	2 tbsp	
4	Wheat Flour	35 g		
5	Onions	½ piece	½ piece	
6	Garlic	5 cloves	2 cloves	2 cloves
7	Carrots	50 g		
8	Nutmeg Powder	2,5 g	¼ tsp	
9	Tapioca Flour	15 g		15 g
10	Pepper	2,5 g	1 tsp	½ tsp
11	Salt	2,5 g	1 tsp	1 tsp
12	Sugar	2 g		½ tsp
13	Beef Stock	2 g		2 g
14	Cooking Oil	15 ml	20 ml	15 ml
15	White Bread			2 slices

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No	Ingredients	Reference 1	Reference 2	Reference 3
16	Oyster Sauce			1 tbsp

The scoresheet results from the defined stage, as determined by five trained panelists, are shown in **Table 2** below.

Table 2. Define Stage Assessment Results.

Sensory	Average		
	R1	R2	R3
Shape	3,6	3,4	4
Size	4	3,2	3,8
Color	4,2	3,6	3,8
Aroma	3,6	3,6	4
Taste	3,8	3,2	4
Texture	3	3,2	3,6
Overall	3,2	3,4	4,2

3.2. Design Stage

During the design stage, three roulade products were produced, substituting 100% snakehead fish for beef, with flour ratios of 15, 30, and 45 grams to achieve criteria nearly identical to those of the reference product and acceptable to the public. The three developed recipes were then tested on five trained researchers using the same scoring system as the reference recipe. The results of the trials and comparisons of the three percentages indicated that the selected roulade product, which yielded the best results, was the one with a snakehead fish-to-flour ratio of 30 grams. This product had an attractive brownish-yellow color, a savory taste, and a dense and soft texture. The selected recipes from the design stage are shown in **Table 3**.

Table 3. Product Development Recipe.

No	Ingredients	Development
1	Snakehead fish meat	250 g
2	Eggs	3 eggs
3	Garlic	5 cloves
4	Tapioca flour	30 g
5	Pepper	½ tsp
6	Salt	1 tsp
7	Sugar	½ tsp
8	Beef broth	2 g
9	Cooking oil	15 ml
10	White bread	2 slices
11	Oyster sauce	1 tbsp

3.3. Development Stage

The development stage includes product validation for snakehead fish roulade using vacuum-sealed plastic packaging, specifically for frozen food presentation. The selected packaging design is a 15 x 20 cm vacuum-embossed package.

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Figure 2. Packaging Design.

3.4. Dissemination Stage

Dissemination involves testing the product with 30 untrained panelists using a score sheet and assessing sensory parameters such as shape, size, color, aroma, taste, texture, and overall characteristics. The products tested are the selected reference product and the selected development product. The data is then statistically analyzed using average scores and paired-sample t-tests.

3.5. Organoleptic Testing

Several factors can influence organoleptic results, both internal and external. Organoleptic testing in this study refers to previous research that tested two samples: a reference product, beef roulade, and a developed product, snakehead fish roulade (Yuliani et al., 2018). The results of the organoleptic testing on both samples are shown in **Table 3**. Based on organoleptic testing results, panelists preferred the developed product across color, aroma, taste, texture, and overall taste.

3.6. Color

The paired t-test on the color parameter showed a significant difference between the reference and developed products. This indicates that snakehead fish roulade, a developed product with 100% fish meat substitution, was more preferred by panelists.

Snakehead fish-based products produced colors that panelists liked with a preference value of 5.187 (somewhat like), where the resulting colors ranged from dark brown to golden brown depending on the processing method (Sulistiyati et al., 2017). Color is the first visual parameter that influences consumer acceptance of snakehead fish processed products, and products with attractive colors tend to have higher preference levels (Sari et al., 2022).

3.7. Aroma

Preference analysis of snakehead fish in roulade products showed that the product produced a distinctive aroma and was well-liked by the panelists. This indicates that the aroma of snakehead fish differs significantly from that of the reference product, beef.

The distinctive aroma of snakehead fish can be modified by adding aromatic spices such as bay leaves and basil to enhance organoleptic acceptance, with preference values reaching 6.44 (somewhat like) (Baehaki & Azzahra, 2024). The aroma of snakehead fish nugget products received a "somewhat like" response from panelists, indicating that consumers can

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well accept the distinctive aroma of snakehead fish (Yuliani et al., 2021). The organoleptic quality of the aroma in snakehead fish processed products, such as sausages, shows unique characteristics and is well accepted by semi-trained panelists (Marlinda, 2020).

3.8. Taste

The paired t-test results showed a difference in taste between the reference product and the developed roulade. The taste difference originated from the different basic ingredients used. Although people are accustomed to consuming beef roulade, the developed product made from snakehead fish was also liked by the panelists.

Snakehead fish nuggets received strong acceptance and significant taste preference values from panelists (Mustika et al., 2024). The addition of complementary ingredients can enhance the organoleptic quality of snakehead fish products, bringing them to the "like" level (Islamy & Senas, 2023). Snakehead fish seruit products showed a taste preference value of 3.87±0.94, indicating that the taste of snakehead fish can be well accepted despite having different characteristics from beef-based products (Bertalina et al., 2025).

3.9. Texture

The paired t-test results for the texture parameter showed a difference in texture between the reference and developed products. This texture difference was caused by differences in the main ingredients of the reference product (beef) and the developed product (snakehead fish). The texture of the snakehead fish roulade was preferred more than the reference product because it was softer.

The texture of snakehead fish-based products tends to be more tender and soft, with preference values reaching 5.36 (somewhat like) (Gobel et al., 2022). This soft texture characteristic is supported by the low collagen protein content of snakehead fish, which is only 3-5%, much lower than beef, which reaches 15-20%, so that the texture of snakehead fish is easier to digest and provides a soft sensation in the mouth (Chasanah et al., 2015). The tender texture (scoring value of 4.573) in snakehead fish minced jerky products was one of the main acceptance factors by consumers (Sulistiyati et al., 2017).

Table 4. Panelist Organoleptic Test Results.

Sensory Properties	Reference Product			Development Product		
Color	3,37	±	0,49[a]	3,93	±	0,59[a]
Aroma	3,41	±	0,62[a]	4,06	±	0,68[b]
Taste	3,68	±	0,84[a]	4,24	±	0,73[b]
Texture	3,58	±	0,73[a]	3,86	±	0,74[a]
Overall	3,72	±	0,84[a]	4,13	±	0,88[b]

(Different notations on the same row indicate significant differences at the 5% significance level)

3.10. Nutritional Content and Product Innovation

This study developed a food product in the form of snacks made from snakehead fish, which is generally still rarely used in food processing. Snakehead fish contains many nutrients and compounds that are beneficial to health; therefore, further development is needed to make it more innovative and usable in people's daily lives. Snakehead fish has a protein content of 25.2 g/100g and albumin content reaching 6.224 g/100g, higher than other freshwater fish (Kemenkes RI, 2018). The albumin protein profile of snakehead fish has a molecular weight of 50-52 kDa and is effective in wound healing and immune system enhancement (Nurilmala et al., 2020).

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Snakehead fish, both from nature and from aquaculture, are rich in essential amino acids such as leucine, lysine, and phenylalanine, as well as non-essential amino acids such as alanine, aspartic acid, and glycine, which are important for growth and repair of body tissues (Chasanah et al., 2015). The content of macro (Na, K, Ca) and micro (Zn, Fe) minerals in snakehead fish is also very high, with Zn levels reaching 1.7412 mg/100g, which plays an important role in wound healing (Zeng et al., 2024). Snakehead fish-based product innovations, such as snakehead fish mocaf brownies, have the potential to become functional foods to overcome malnutrition and stunting problems due to their high protein and albumin content (Asysyifa et al., 2024). Thus, the development of this snakehead fish roulade aligns with efforts to diversify local food and increase consumption of high-quality animal protein among Indonesians.

4. CONCLUSION

Based on the research results, it can be concluded that the use of 100% snakehead fish is capable of producing a good-quality roulade product, as evidenced by sensory evaluation conducted with 30 untrained panelists and supported by quantitative data analysis, which showed a significant difference between the reference product and the developed product, with scores of 3.5 (liked) and 4.1 (very liked), respectively, indicating positive assessments in terms of taste, aroma, color, and texture. Furthermore, the level of public acceptance of snakehead fish roulade was high, suggesting it is suitable for consumption. Overall, snakehead fish roulade is an innovative fish-based product with potential for commercial marketing and use as a functional food; however, including nutritional information is necessary to meet dietary requirements and enhance consumer confidence in its quality.

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