Fisheries Journal, 15 (3), 1135-1146 (2025)
http://doi.org/10.29303/jp.v15i3.1484

VARIATIONS IN THE ADDITION OF SNAKEHEAD FISH (*Channa striata*) FLOUR ON THE LEVEL OF FAVORABILITY AND NUTRITIONAL PROFILE OF VELVET BEAN TEMPEH

Variasi Penambahan Tepung Daging Ikan Gabus (*Channa striata*) terhadap Tingkat Kesukaan dan Profil Nutrisi Tempe Koro Benguk

Achmad Syauqibik[1*], Junianto[1], Nur Fitrianto[2], Iis Rostini[1]

[1]Fisheries Study Program, Padjadjaran University, [2]Research Center for Food Technology and Processing, National Research and Innovation Agency

Jl. Raya Bandung Sumedang KM.21, Kec. Jatinangor, Jawa Barat 45363

[*]Coresponding author: achmad21004@mail.unpad.ac.id

(Received March 22th 2025; Accepted May 20th 2025)

ABSTRACT

This research utilizes the potential of snakehead fish (Channa striata) rich in albumin (62.9%) and essential nutrients for functional food development. Snakehead fish has superior nutritional value with 25.2% protein, important minerals such as calcium and phosphorus, and essential amino acids that play roles in growth and immune system. The effort to diversify snakehead fish processing into flour and its fortification into velvet bean (Mucuna pruriens) tempeh was carried out to increase nutritional value and consumer acceptance. The research employed an experimental method with 4 treatments of snakehead fish meat flour addition: 0% (TB0), 8.5% (TB1), 9.5% (TB2), and 10.5% (TB3). Parameters tested included organoleptic properties and proximate analysis. Results showed formula TB2 (9.5%) obtained the highest alternative value (6.58) with 39.34% protein content, 13.89% fat, 8.90% moisture, 2.43% ash, and 43.10% carbohydrate. Compared to control, the addition of snakehead fish flour increased protein content by 8.49% and decreased fat content by 5.39%. It can be concluded that the fortification of 9.5% snakehead fish flour produced velvet bean tempeh with the highest organoleptic acceptance and successfully utilized local food ingredients to produce highly nutritious functional food acceptable to consumers.

Keywords: Albumin, Organoleptic, Proximate, Snakehead Fish, Velvet Bean Tempeh

ABSTRAK

Penelitian ini memanfaatkan potensi ikan gabus (*Channa striata*) yang kaya albumin (62,9%) dan nutrisi esensial untuk pengembangan pangan fungsional. Ikan gabus memiliki nilai gizi unggul dengan protein 25,2%, mineral penting seperti kalsium dan fosfor, serta asam amino esensial yang berperan dalam pertumbuhan dan sistem kekebalan tubuh. Upaya diversifikasi pengolahan ikan gabus menjadi tepung dan fortifikasinya ke dalam tempe koro benguk (*Mucuna pruriens*) dilakukan untuk meningkatkan nilai gizi dan penerimaan konsumen.

Penelitian menggunakan metode eksperimental dengan 4 perlakuan penambahan tepung daging ikan gabus: 0% (TB0), 8,5% (TB1), 9,5% (TB2), dan 10,5% (TB3). Parameter yang diuji meliputi organoleptik dan uji proksimat. Hasil penelitian menunjukkan formula TB2 (9,5%) mendapatkan nilai alternatif tertinggi (6,58) dengan kadar protein 39,34%, lemak 13,89%, air 8,90%, abu 2,43%, dan karbohidrat 43,10%. Dibandingkan kontrol, penambahan tepung ikan gabus meningkatkan kadar protein sebesar 8,49% dan menurunkan kadar lemak sebesar 5,39%. Dapat disimpulkan bahwa fortifikasi tepung ikan gabus 9,5% menghasilkan tempe koro benguk dengan tingkat penerimaan organoleptik tertinggi dan berhasil memanfaatkan bahan pangan lokal untuk menghasilkan pangan fungsional bernutrisi tinggi yang dapat diterima konsumen.

Kata Kunci: Albumin, Ikan Gabus, Organoleptik, Proksimat, Tempe Koro Benguk

INTRODUCTION

Snakehead fish (*Channa striata*) is a popular freshwater commodity in Indonesia with aquaculture production increasing from 12.2 million tons (2019) to 19.1 million tons (2020) due to its economic value and health benefits (KKP, 2022). This fish has superior nutritional content, especially protein (25.2%) and albumin (62.9% of total protein) which is higher than other types of fish for consumption (Asfar et al., 2019; Alkhamdan & Husain, 2022).

The superior nutritional value of snakehead fish lies in the albumin content which plays a role in accelerating the recovery of body tissue, regulating blood osmotic pressure, and supporting metabolic processes (Hadi et al., 2024). In addition, snakehead fish is rich in important minerals such as calcium (62 mg/100 g) and phosphorus (176 mg/100g), and contains essential amino acids including arginine (1.34%), lysine (1.67%), and leucine (1.13%) which play a role in growth and the immune system (Sari et al., 2014). Diversification of snakehead fish processing into flour can maintain its nutritional content, with snakehead fish flour containing 73.81% protein and 14.65 µg/g albumin (Nadimin & Lestari, 2019). This high nutritional potential makes snakehead fish a functional food ingredient with strategic value.

Substitution of snakehead fish flour into various food products has been widely implemented in the development of functional foods. Research by Sopandi & Hakiki (2024) shows that snakehead fish flour can be fortified into cookies to produce high-protein functional food products. This flour has also been applied in the manufacture of complementary breast milk biscuits (Kusnadi et al., 2024). A study by Afianti & Indrawati (2015) proved that the addition of snakehead fish flour can improve the organoleptic characteristics of crackers. Dewantara et al., (2019) reported an increase in the physicochemical and sensory properties of macaroni pasta with the addition of snakehead fish flour. Madjid (2021) also confirmed that fortification of snakehead fish flour can increase the nutritional value of serabi cakes. In addition to these applications, snakehead fish flour also has the potential to enrich the nutritional content of koro benguk tempeh.

Koro benguk tempeh is a fermented product processed from koro benguk beans (*Mucuna pruriens*) using Rhizopus mold or tempeh yeast. This product has the disadvantage of a harder and denser texture. The protein and fat content of koro benguk tempeh are 31.5% and 7.3% per 100 g, respectively (Sari, 2017). Sowdhanya et al. (2024), reported that koro benguk beans contain 23-43 g of protein and 14.39 g of fat per 100 g of material. These beans are also rich in carbohydrates (55.7 g), fiber (25.5-26.6 g), and iron (9.42 mg) per 100 g of material (Ningrum et al., 2019; Rahayu et al., 2019).

In an effort to increase fish consumption and utilize local commodities, diversification of fish processing is a promising strategy. Fortification of snakehead fish flour which is rich in essential amino acids into koro benguk tempeh can increase consumer acceptance while enriching its nutritional profile. Enriching nutrition in the innovation of koro benguk tempeh

with snakehead fish flour provides significant added value to the product. The addition of this flour produces a distinctive savory taste, increases the appeal of the product, but it is necessary to pay attention to the optimal proportion of addition so that it remains popular with consumers. Considering that snakehead fish meal affects the nutritional content and level of product acceptance, this study aims to determine the optimal percentage of snakehead fish meal addition in koro benguk tempeh.

METHODS

This research was conducted from November 2024 to February 2025. Organoleptic testing was conducted at the Fisheries Product Processing Laboratory, Faculty of Fisheries and Marine Sciences, Padjadjaran University. While chemical testing was conducted at the Good Manufacturing Practices (GMP) and Food Microbiology Laboratory, Center for Food Technology and Process Research (PRTPP), National Research and Innovation Agency (BRIN), Gunungkidul-Yogyakarta.

The method used was an experimental method. The research consisted of 4 treatments and 25 panelists as replications. The level of addition of snakehead fish meat flour was based on the weight of koro benguk beans used to make tempeh. The treatment of making koro benguk tempeh with the addition of snakehead fish meat flour consisted of 4 treatments, namely the addition of 0% snakehead fish meat flour (TB0), the addition of 8.5% snakehead fish meat flour (TB1), the addition of 9.5% snakehead fish meat flour (TB2), and the addition of 10.5% snakehead fish meat flour (TB3) as independent variables. The dependent variables observed in this study were organoleptic in the form of hedonic and Bayes tests with several parameters such as color, aroma, texture, taste, aftertaste, and overall, as well as chemical tests namely proximate with several parameters such as water content, ash content, protein content, fat content, and carbohydrate content.

The materials used in this study were snakehead fish, koro benguk beans, tempeh yeast, banana leaves, H_2SO_4, NaOH, Kjedahl, boric acid, phenolphthalein, HCl, aquadest, and n-hexane. The tools used in this study were gas stoves, pans, containers, baking sheets, spoons, digital scales, moisture analyzers, porcelain cups, filter paper, analytical scales, ovens, desiccators, furnaces, 100 mL Kjeldhal flasks, fat flasks, a set of soxhlet apparatus, and gloves.

The research procedure is divided into five stages, namely the stage of making snakehead fish flour, the stage of making koro benguk tempeh, the stage of organoleptic testing using hedonic and Bayes tests, the stage of chemical testing in the form of proximate including water, ash, protein, fat, and carbohydrate content in the control treatment (TB0) and the most preferred treatment based on organoleptic testing, and the last stage is data analysis and data interpretation. The organoleptic research data were analyzed using the Friedman Test and Bayes Test followed by a multiple comparison test at the 5% level using Microsoft Excel 2021 for Windows 10, while the proximate test data were analyzed descriptively comparatively compared to SNI 3144:2015 concerning Tempeh Quality Standards.

RESULTS

Organoleptic Analysis

The organoleptic analysis conducted in this study included hedonic tests and Bayes tests with parameters of color, aroma, texture, taste, aftertaste, and overall. The results of the hedonic test of various treatments of the addition of snakehead fish meat flour to koro benguk tempeh are presented in Table 1 and Figure 1.

Table 1. Hedonic Test Results of Snakehead Fish Koro Benguk Tempeh

Parameter	Formula			
	TB0	TB1	TB2	TB3
Color	5.84±1.07^{a}	5.76±1.13^{a}	6.12±0.78^{a}	5.92±0.99^{a}
Aroma	6.44±0.87^{a}	6.20±0.87^{a}	6.48±0.59^{a}	6.24±0.88^{a}
Texture	5.04±1.17^{a}	5.56±0.92^{ab}	5.72±1.06^{ab}	6.24±0.88^{a}
Taste	6.16±0.89^{ab}	6.20±0.5^{ab}	6.48±0.59^{b}	5.52±1.16^{a}
Aftertaste	6.32±0.98^{b}	6.00±0.71^{ab}	5.92±0.86^{ab}	5.48±1.12^{a}
Overall	6.56±0.58^{ab}	6.04±0.79^{a}	6.64±0.49^{b}	6.28±0.54^{ab}

Description:
1= very dislike; 2= dislike; 3= rather dislike; 4= neutral/normal; 5= rather like; 6= like; 7= very like.
a,b = Similar letter notation on one line means there is no real difference at the multiple comparison test level which has a value of 5%.

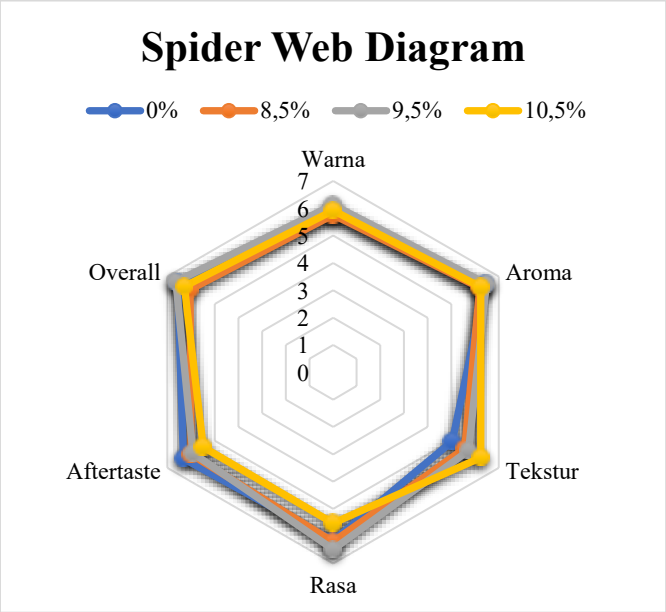

Figure 1. Hedonic Spider Web Diagram

In addition to hedonic evaluation, decisions are also made using the Bayes method. The process of determining priorities for characteristics such as color, aroma, texture, taste, aftertaste, and overall in tempeh from koro benguk can be carried out through a two-element comparison technique (Paired Comparison), which converts the comparison into a series of numbers that reflect the relative importance between criteria and treatment variations. The calculation of the importance value for the sensory aspects of koro benguk tempeh can be seen in Table 2.

Table 2. Weight Value of Koro Benguk Tempeh Criteria

Criteria	Criteria Weight
Color	0.11
Aroma	0.07
Texture	0.16
Taste	0.52
Aftertaste	0.15

The Bayes method is one of the techniques used to conduct analysis in making the best decision for a number of alternatives or treatments by considering the criteria (Zulfikar & Fahmi, 2019). The calculation results considering the criteria of color, aroma, texture, taste, and aftertaste with the best assessment of koro benguk tempeh are presented in Table 3.

Table 3. Decision Matrix for the Assessment of Koro Benguk Tempeh with the Bayes Method Based on Median Values

Formula	Criteria					Alternative Values
	Color	Aroma	Texture	Taste	Aftertaste	
TB0	6	7	5	6	7	6.05
TB1	6	6	5	6	6	5.84
TB2	6	7	6	7	6	6.58
TB3	6	6	6	6	6	6.00

Chemical Analysis (Proximate)

Chemical analysis in the form of proximate was carried out on the control treatment (TB0) and the most preferred treatment (TB2) in the hedonic test. Proximate analysis was carried out to determine the content of koro benguk tempeh with the addition of snakehead fish meat flour. Proximate analysis includes water content, ash content, protein content, fat content, and carbohydrate content. The results of the proximate analysis on the control koro benguk tempeh (TB0) and the addition of 9.5% snakehead fish meat flour (TB2) are presented in Table 4.

Table 4. Proximate Test Results of Koro Benguk Tempeh Snakehead Fish

Parameter	Formula		SNI 3144: 2015
	TB0	TB2	
Water Content (%)	9.26	8.90	Max. 65%
Ash Content (%)	2.01	2.43	Max. 1,5%
Protein Content (%)	30.85	39.34	Min. 15%
Fat Content (%)	19.28	13.89	Min. 7%
Carbohydrate Content (%)	43.33	43.10	-

DISCUSSION

Organoleptic Analysis

The results of the hedonic test (Figure 1) showed that the addition of snakehead fish meat flour to koro benguk tempeh significantly affected sensory acceptance, with the 9.5% formulation showing the best overall performance (score 6.64) and superior in color attributes (6.12), taste (6.48), and flavor (6.48). Increasing the concentration of fish flour to 10.5% improved the texture (6.24), but decreased the acceptance of taste and aftertaste, while tempeh without the addition of fish flour (0%) was superior in aftertaste (6.32) but less preferred in terms of texture (5.04), indicating that the optimal level of 9.5% provided the best balance between sensory attributes and the highest panelist acceptance score.

Color

The addition of snakehead fish meat flour did not have a significant effect on all treatments on the color of koro benguk tempeh based on multiple comparison tests at a 95% confidence level. The color of the koro benguk tempeh produced from each treatment is relatively the same, namely blackish brown, rectangular in shape, and even. This is due to the cooking process into bacem tempeh with the same amount of herbs and spices in each

treatment. Tempeh bacem is the first derivative product of tempeh, by changing the appearance of the color, aroma and taste of tempeh, but not changing the shape significantly. Tempeh bacem is processed tempeh with a combination of spices and sugar, which has a dominant sweet taste (Astawan, 2015). The taste of bacem tempeh cannot be separated from the influence of the cooking process. The cooking process affects the physical, chemical and sensory characteristics of a product (Rizqi, 2019). In the process, bacem tempeh uses a hot cooking technique called "ungkep".

Based on the results of the color preference test, all treatments of the addition of snakehead fish meat flour were included in the liking category because they had a median of 6. The highest average value of the color preference level of koro benguk tempeh was 6.12 in the TB2 formula because it produced koro benguk tempeh that was evenly dark brown and the lowest value was 5.76 in the TB1 formula.

The color preference level of the addition of snakehead fish meat flour of 8.5% (TB1) had the lowest value. This happened because the small amount of snakehead fish flour (8.5%) caused low water binding capacity. As a result, the spices could not be absorbed perfectly and optimally. With a small flour content, the ability of tempeh to bind water and spices is limited, so that spices and brown sugar cannot be absorbed optimally. This condition causes the color of bacem tempeh to be less attractive and uneven, which ultimately has an impact on the low level of consumer preference for the color of the product (Rizqi, 2019). The image of Koro Benguk Tempeh with all treatments is presented in Figure 2.

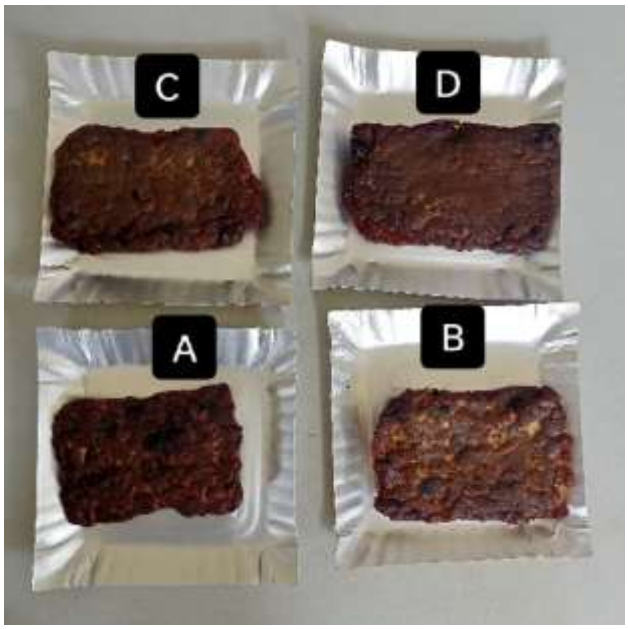

Figure 2. Color of Koro Benguk Tempeh with Various Treatments

Aroma

Based on the assessment of the aroma of koro benguk tempeh shown in Table 1, the media value ranged from 6 (liked) in the TB1 and TB3 formulas, and 7 (very much liked) in the TB0 and TB2 formulas. The addition of snakehead fish meat flour did not reduce the panelists' preference for the aroma of koro benguk tempeh. The aroma of koro benguk tempeh in the TB2 formula had the highest average of 6.48 because the specific aroma of fish was not too strong so that it was liked by the panelists. The TB1 formula had the lowest average of 6.20. This was due to the smell of spices that were too strong during the bacem cooking process. The spices that were smelled such as pepper and ginger were less liked by the panelists. Red ginger is known for its sharper and more intense aroma. The zingiberene component contained

in ginger provides a characteristic spicy taste. The assessors tended to dislike the distinctive pepper aroma profile. When koro benguk tempeh is consumed, the spicy aroma of pepper creates a fairly strong sensation, thus reducing the level of preference of the assessors for the aroma of the tempeh (Hakim et al., 2021).

Based on sensory evaluation, the addition of processed snakehead fish flour did not show a significant impact on all treatment variations. This is because the bacem processing process which is rich in various spices successfully covers the aroma of fish flour so that it does not smell sharp. In terms of acceptance level, all samples were still acceptable to the assessors, as evidenced by the average value of the aroma parameter which was still above the product rejection threshold.

Texture

The panelists' evaluation of the texture of koro benguk tempeh produced a median value between 5 (neutral) and 6 (preferred). The addition of snakehead fish meat flour significantly affected the texture in several treatments. The TB3 formula showed a significant difference compared to TB0, but was not significantly different from TB1 and TB2. The treatment with a concentration of 10.5% obtained the highest average value (6.24) because it produced a softer texture. The lowest value is found in the TB0 formula (5.04) with harder and denser characteristics. The increase in the amount of snakehead fish meat flour is directly proportional to the softness of the texture of the koro benguk tempeh after the bacem processing process.

According to Litaay et al. (2023), the mixing of fish flour in the dough or a product disrupts the bonds between starch molecules, making it easier for water to enter. The faster the penetration of water that enters and the more water that enters during the bacem process, the water content in the tempeh increases, making the tempeh texture softer. This makes the more snakehead fish meat flour added will make the tempeh texture softer.

The TB0 formula still has rather hard characteristics because it does not contain snakehead fish meat flour. The high carbohydrate content in koro benguk beans results in a hard texture when processed into tempeh, so a longer cooking time and the addition of snakehead fish meat flour are required to increase softness (Amanah et al., 2019). Snakehead fish meat flour contributes significantly to the softness of the product's texture. The variation of flour addition significantly affected the level of panelist acceptance, and all formulas were still acceptable because the average texture value was above the product rejection threshold.

Taste

The results of the assessment of the taste of koro benguk tempeh showed a median value of 6 (liked) for all treatments, except for formula TB2 which reached 7 (very much liked). The addition of snakehead fish meat flour affected the taste characteristics of each treatment. Formula TB3 was significantly different from TB2, but not significantly different from TB0 and TB1. TB3 obtained the lowest average value (5.52) because snakehead fish meat flour provided a distinctive taste. The higher the concentration of fish flour, the stronger the effect on taste. This finding is in line with the research of Renol et al. (2023), that snakehead fish flour can dominate the taste of biscuits, and the research of Nando et al. (2015), which showed a positive correlation between the concentration of snakehead fish protein and the intensity of fish flavor in biscuits.

Panelist preference for taste increased in formulas TB1 and TB2, but decreased in TB3 because the distinctive taste of fish began to be detected. TB2 formula recorded the highest average (6.48) because at this concentration the fish flavor was not too dominant. All treatments were still acceptable because the average value was above the product rejection threshold.

Aftertaste

Based on the results of the panelist's research on the aftertaste of koro benguk tempeh, the median value for all treatments was 6 (liked) except for 7 (very much liked) in the TB0 formula. The addition of snakehead fish meat flour to koro benguk tempeh affected the aftertaste of each treatment. The aftertaste of koro benguk tempeh in the TB3 formula was significantly different from the TB0 formula, but not significantly different from the TB1 and TB2 formulas. The TB3 formula had the lowest average value of 5.48 because the snakehead fish meat flour gave a distinctive aftertaste to koro benguk tempeh. The higher the addition of snakehead fish flour, the lower the level of preference. This is because snakehead fish has a distinctive taste, but is not sharp like tuna and anchovies (Nadimin et al., 2018). The addition of too much snakehead fish flour can reduce the acceptance of the aftertaste of koro benguk tempeh because it contains high protein which makes it taste a little fishy. Previous research on biscuits showed that the more snakehead fish flour added to koro benguk tempeh, the lower the preference for the aftertaste of the product (Nupitasari et al., 2023).

The level of preference for the aftertaste of koro benguk tempeh decreased with increasing concentration of snakehead fish flour in formulas TB1, TB2, and TB3. Formula TB0 recorded the highest average (6.32) because it did not contain fish flour so it did not have a typical fish aftertaste. Although the addition of flour had a significant effect on the level of acceptance, all treatments were still acceptable because the average value was above the rejection threshold.

Overall

The overall assessment of koro benguk tempeh received a median value of 6 (liked) in TB1 and TB3, and 7 (very much liked) in TB0 and TB2. The addition of snakehead fish flour affected the overall acceptance of the product. Formula TB2 was significantly different from TB1, but not significantly different from TB0 and TB3. TB1 obtained the lowest score (6.04) due to the less favorable color and taste characteristics, while TB2 recorded the highest score (6.64) due to the optimal combination of color, aroma, texture, and taste. The overall evaluation represents a holistic assessment of the product, not just a specific sensory aspect. This test aims to identify public acceptance of a commodity (Kusumastuti et al., 2022). The addition of snakehead fish meat flour had a significant effect on the overall acceptance level, but all formulas were still acceptable because the average value was above the product rejection threshold.

Decision Making with the Bayes Method

Based on Table 2, the calculation of the weight of the color, aroma, texture, taste, and aftertaste criteria for koro benguk tempeh, the results showed that the taste assessment was the most important criterion that determined the panelists' final decision in choosing the koro benguk tempeh product with a criteria weight of 0.52 followed by texture, aftertaste, color, and aroma.

Based on Table 3, the calculation using the Bayes method showed that the TB2 formula koro benguk tempeh obtained the highest relative value of 6.58, followed by the control treatment of 6.05. Koro benguk tempeh with the addition of 9.5% snakehead fish meat flour was the most preferred, allegedly because the panelists liked the savory fishy koro benguk tempeh, the right texture, which was not too soft or hard, and had the aroma of snakehead fish meat flour that still smelled a little/not too fishy.

Chemical Analysis (Proximate)

Water Content

The addition of snakehead fish meat flour affects the water content of koro benguk tempeh, with a value of 9.26% in TB0 and 8.9% in TB2. Based on the data in Table 4, the addition of this flour is inversely proportional to the water content of the product. The concentration of fishmeal added produces tempeh with a non-soft structure and lower water content. This phenomenon is due to the hygroscopic nature of fishmeal which easily absorbs water, as well as the hydrophilic characteristics of the protein in fishmeal which is able to bind water (Valentina et al., 2021). The water content of the tempeh product in this study meets the SNI 3144:2015 standard which sets a maximum limit of 65%.

Ash Content

Table 4 shows the ash content of koro benguk tempeh in the TB0 formula, which is 2.01% and TB2, which is 2.43%. The treatment of adding snakehead fish meat flour causes high ash content. The ash content produced from both treatments did not comply with SNI 3144:2015, which is a maximum of 1.5%. This is caused by the high ash content in snakehead fish flour. Animal food products contain high ash content due to the content of several minerals such as calcium, iron, and phosphorus. In this case, the calcium, iron, and phosphorus content in snakehead fish is quite high, namely 62 mg; 0.9 mg; and 176 mg/100 g of fresh snakehead fish (Tungadi, 2019). Therefore, the addition of snakehead fish flour makes the ash content of koro benguk tempeh higher.

Protein Content

Table 4 shows the protein content of koro benguk tempeh of 30.85% in TB0 and 39.34% in TB2. The addition of snakehead fish meat flour increases the protein content of the product. Both treatments meet the SNI 3144:2015 standard which sets a minimum of 15%. The high protein content is due to the protein content in snakehead fish flour which can reach 86.13% based on research by Mahardika et al. (2017). In addition, Rhizopus mold in yeast contributes to the protein content of tempeh. The fermentation process by Rhizopus oligosporus plays an important role in the nutritional aspect by synthesizing more protease enzymes than other mold species. This enzyme breaks down protein into amino acids so that it is more easily absorbed by the body (Wibowo et al., 2020).

Fat Content

The data in Table 4 shows the fat content of koro benguk tempeh is 19.28% in TB0 and 13.89% in TB2. The addition of snakehead fish meat flour reduces the fat content of the product. Both treatments meet the SNI 3144:2015 standard which sets a minimum of 7%. This decrease is due to the activity of the lipase enzyme produced by the mold Rhizopus sp. During fermentation, this enzyme hydrolyzes triglycerol into free fatty acids which are then used as an energy source by the mold. Rhizopus sp. more easily utilizes fat than carbohydrates as an energy source, thus reducing fat content during the fermentation process (Safitri et al., 2021). The oxidation process also contributes to a decrease in fat content, as explained by Milinda et al. (2021), that unsaturated fatty acids in snakehead fish are more susceptible to oxidation during tempeh fermentation, especially at the optimal temperature for mold growth.

Carbohydrate Content

Based on Table 4, the carbohydrate content of koro benguk tempeh is 43.33% in TB0 and 43.10% in TB2. The addition of snakehead fish meat flour slightly reduces the carbohydrate content. SNI 3144:2015 does not stipulate carbohydrate content requirements for tempeh. Low carbohydrate levels can be caused by mold activity in yeast that synthesizes the

α-amylase enzyme which breaks down carbohydrates into simpler substrates. This process takes place under aerobic conditions and produces ATP energy for mold metabolism and growth. In addition, Rhizopus sp. mold produces carbohydrase enzymes such as polygalacturonase, endocellulase, silanase, arabinose, and α-D-galactosidase. The lower activity of the carbohydrase enzyme compared to lipase and protease during tempeh fermentation results in higher protein content and lower carbohydrate levels (Maryam, 2015).

CONCLUSION

Based on research on fortification of snakehead fish flour in koro benguk tempeh, it can be concluded that the addition of 9.5% snakehead fish flour (TB2 formula) produces koro benguk tempeh with the highest organoleptic acceptance level based on the Bayes method, with a value of 6.58 out of 7. This fortification significantly increases the protein content from 30.85% to 39.34%, reduces the fat content from 19.28% to 13.89%, and slightly reduces the water content from 9.26% to 8.90% and carbohydrates from 43.33% to 43.10%. Although the ash content is 2.43% which exceeds the SNI 3144:2015 standard, this increase in minerals comes from the high calcium, iron, and phosphorus content in snakehead fish. The development of this product has succeeded in utilizing the potential of snakehead fish which is rich in albumin and essential amino acids, as well as koro benguk as a local food ingredient to produce functional food that is highly nutritious and acceptable to consumers.

ACKNOWLEDGEMENT

On this occasion, the author would like to thank all parties who have helped in the creation of this article.

REFERENCES

Afianti, F., & Indrawati, V. (2015). Pengaruh Penambahan Tepung Ikan Gabus (Ophiocephalus striatus) dan Air Terhadap Sifat Organoleptik Crackers. *E-Journal Boga*, *4*(1), 46–55.

Alkhamdan, T., & Husain, R. (2022). Pemanfaatan Tepung Ikan Gabus (Channa striata) Dalam Pembuatan Kerupuk Ikan. *Jambura Fish Processing Journal*, *4*(1), 25–36.

Amanah, Y. S., Sya'di, Y. K., & Handarsari, E. (2019). Kadar Protein dan Tekstur pada Tempe Koro Benguk dengan Substitusi Kedelai Hitam. *Jurnal Pangan Dan Gizi*, *9*(2), 69–78.

Asfar, M., Tawali, A. B., Pirman., & Mahendradatta, M. (2019). Ekstraksi Albumin Ikan Gabus (Channa striata) pada Titik Isoeletriknya. *Jurnal Agercolere*, *1*(1), 6–12.

Astawan, M. (2015). Kombinasi Kemasan Vakum dan Penyimpanan Dingin untuk Memperpanjang Umur Simpan Tempe Bacem. *Jurnal Pangan*, *24*(2), 125–134.

Dewantara, E. C., Wijayanti, I., & Anggo, A. D. (2019). Karakteristik Fisiko Kimia dan Sensori Pasta Makaroni dengan Penambahan Tepung Ikan Gabus (Channa striata). *Jurnal Ilmu Dan Teknologi Perikanan*, *1*(2), 22–29.

Hadi, A. O., Ofsah, O. N., & Primaningsih, R. A. (2024). Evektifitas Minyak Ikan Gabus (Channa striata) terhadap Penyembuhan Luka Sectio Caesarea pada Tikus Wistar (Rattus norvegicus). *Journal of TSCNers*, *9*(1), 119–128.

Hakim, G. L., Nefasa, A. N., & Abdurrahman, Z. H. (2021). Pengaruh Penambahan Ekstrak Jahe Merah (Zingiber officinale var. rubrum) terhadap Kualitas Organoleptik dan pH Kefir Susu Kambing. *Tropical Animal Science*, *3*(1), 19–25.

Kusnadi, Purgiyanti, & Andari, I. D. (2024). Formulasi Tepung Ikan Gabus dengan Penambahan Ekstrak Rosella terhadap Karakteristik Kimia dan Aktivitas Antioksidan Biskuit Pendamping Air Susu Ibu. *Jambura: Journal of Health Sciences and Research*, *6*(3), 266–276.

Kusumastuti, I., Kusumah, S. H., & Tatang, T. (2022). Daya Terima Panelis terhadap Sifat Sensoris Velva Tomat dengan Penambahan Madu Murni pada berbagai Konsentrasi.

Jurnal Fakultas Teknik UNISA Kuningan, *3*(2), 456019.

Litaay, C., Mutiara, T. A., Indriati, A., Novianti, F., Nuraini, L., & Rahman, N. (2023). Fortifikasi Tepung Ikan Teri (Stolephorus sp.) terhadap Karakteristik Fisik dan Mikrostruktur Mi Berbasis Sagu. *Jurnal Pengolahan Hasil Perikanan Indonesia*, *26*(1), 127–138.

Madjid, U. S. (2021). *Produksi Kue Serabi dengan Penambahan Puree dan Tepung Ikan Gabus (Channa striata) sebagai Produk Olahan Tinggi Gizi*. Prodi Ilmu dan Teknologi Pangan Fakultas Pertanian. Universitas Hasanuddin. Makassar.

Mahardika, N., Karnila, R., & Edison. (2017). Analisis Komposisi Kimia Daging dan Tepung Ikan Gabus (Channa striata). *JOM Unri*, 1–8.

Maryam, S. (2015). Potensi Tempe Kacang Hijau (vigna radiata L) Hasil Fermentasi Menggunakan Inokulum Tradisional sebagai Pangan Fungsional. *JST (Jurnal Sains Dan Teknologi)*, *4*(2).

Milinda, I. R., Dieny, F. F., Noer, E. R., & Ayustaningwarno, F. (2021). Analisis Sifat Fisik, Organoleptik dan Kandungan Asam Lemak pada Tempe Mete dan Tempe Kedelai. *Jurnal Aplikasi Teknologi Pangan*, *10*(4), 119–126.

Nadimin, N., & Lestari, R. S. (2019). Peningkatan nilai gizi mikro kudapan lokal melalui subtitusi tepung ikan gabus untuk pencegahan stunting di Sulawesi Selatan. *Media Kesehatan Politeknik Kesehatan Makassar*, *14*(2), 152–157.

Nadimin, Nurjaya, & Lestari, R. S. (2018). Daya Terima terhadap Jajanan Lokal Sulawesi Selatan Subtitusi Tepung Ikan Gabus (Channa striata). *Jurnal AcTion: Aceh Nutrition Journal*, *3*(2), 141–148. https://doi.org/10.30867/action.v3i2.115

Nando, R. P., Suparni, & Dewita. (2015). Studi Pembuatan Biskuit Dengan Penambahan Konsentrat Protein Ikan Gabus (Channa striata). *Jom*, 1–10.

Ningrum, A., Anggrahini, S., & Setyanings, W. (2019). Valorization of Jack Bean as Raw Material for Indonesian Traditional Food Tempeh and Its Functional Properties. *Journal of Applied Sciences*, *19*(2), 56–61.

Nupitasari, P., Muhlishoh, A., & Ma'rifah, B. (2023). Kandungan Gizi Dan Organoleptik Biskuit Substitusi Tepung Ikan Gabus Dan Tepung Daun Katuk Sebagai Alternatif Camilan Ibu Menyusui. *Jurnal Gizi Dan Pangan Soedirman*, *7*(245). https://doi.org/10.20884/1.jgipas.2023.7.2.9289.

Rahayu, N. A., Cahyanto, M. N., & Indrati, R. (2019). The Pattern of Changes in Protein of Velvet Bean (Mucuna pruriens) during Tempe Fermentation using Raprima Inoculum. *Agritech*, *39*(2), 128–135.

Renol, R., Akbar, M., Finarti, F., Mubin, M., Ula, R., Aristawati, A. T., & Syahril, M. (2023). Analisis Kadar Lemak, Kadar Albumin Dan Uji Organoleptik Pada Biskuit Ikan Gabus (Channa striata). *JAGO TOLIS: Jurnal Agrokompleks Tolis*, *3*(2), 45–52.

Rizqi, F. A. (2019). *Karakteristik Mutu Fisik, Kimia dan Sensori Tempe Bacem Koro Pedang (Canavalia ensiformis L.) Hasil Variasi Lama Pemasakan dan Jenis Pengemas*. Fakultas Teknologi Pertanian Universitas Jember. Jember.

Safitri, R. A., Ikhsan, M., Putri, I. V. T., Ahda, Y., & Fevria, R. (2021). Conventional Biotechnology Application in Making Soybean Tempeh Aplikasi Bioteknologi Konvensional dalam Pembuatan Tempe Kacang Kedelai. *Prosiding Seminar Nasional Biologi*, *1*(2), 1189–1198.

Sari, C. R. (2017). *Kualitas Sosis dengan Variasi Tepung Tempe Koro Benguk (Mucuna pruriens L.) dan Labu Kuning (Cucurbita moschata)*. Fakultas Teknobiologi. Universitas Atma Jaya. Yogyakarta.

Sari, D. K., Marliyati, S. A., Kustiyah, L., Khomsan, A., & Gantohe, T. M. (2014). Uji Organoleptik Formula Biskuit Fungsional Berbasis Tepung Ikan Gabus (Ophiocephalus

striatus). *Agritech*, *34*(2).

Sopandi, R. M., & Hakiki, D. N. (2024). Formulation of Cookies with Substitution of Fish Cork (Channa Striata) and Moringa (Moringa Oleifera) Flour as Foods Functional Protein Wealthy. *E3S Web of Conferences*, *482*(02001).

Sowdhanya, D., Singh, J., Rasane, P., & Kaur, S. (2024). Nutritional Significance of Velvet Bean (Mucuna pruriens) and Opportunities for Its Processing into Value-Added Products. *Journal of Agriculture and Food Research*, *15*(3), 100921.

Tungadi, R. (2019). Potensi Ikan Gabus (Ophiocephalus striatus) dalam Mempercepat Penyembuhan Luka. *Jambura Fish Processing Journal*, *1*(1), 46–57.

Valentina, A., Masirah, M., & Lailatussifa, R. (2021). Pengaruh Fortifikasi Jenis Ikan yang Berbeda terhadap Tingkat Kesukaan dan Karakteristik Fisik Mi Basah. *Chanos Chanos*, *19*(1), 125–134.

Wibowo, R. S. A., Yuliatmo, R., Maryati, T., & Pahlawan, I. F. (2020). *Enzime For Leather*. PT Sepadan Putra Mandiri.

Zulfikar, M., & Fahmi, H. (2019). Penerapan Sistem Pendukung Keputusan Dengan Metode Naïve Bayes Dalam Menentukan Kualitas Bibit Padi Unggul Pada Balai Pertanian Pasar Miring. *Jurnal Nasional Komputasi Dan Teknologi Informasi*, *2*(2), 159–165.