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NUTRITIONAL IMPROVEMENT OF GLUTEN-FREE ARROWROOT BISCUITS THROUGH CATFISH FLOUR ENRICHMENT

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Abstract

The demand for gluten-free products is increasing along with the growing awareness of gluten intolerance and sensitivity. The use of alternative flours, such as local tubers and fish flour fortification techniques, can help improve the nutritional content of gluten-free products. This study aims to determine the best concentration of catfish flour based on the nutritional content and hedonics of arrowroot flour-based biscuits. A completely randomized design (CRD) was used with four concentrations of catfish flour addition (0, 2, 4, and 6%). The analyses conducted were proximate tests, texture, color, and hedonic. The research results indicate that the addition of 6% catfish flour is the best treatment, with biscuit characteristics including moisture content of 5.59%, ash 1.63%, protein 8.57%, fat 28.46%, and carbohydrates 55.39%. The biscuits with the addition of 6% catfish flour have a texture of 3.43 N, a color of L* 70.82, a* 2.46, and b* 37.69 and meet SNI 2973:2022 for protein parameters. Hedonic tests show that the addition of catfish flour to biscuits is acceptable and liked by the panelists. Overall, catfish flour is beneficial in enhancing the nutritional content of gluten-free biscuits made from arrowroot flour. These biscuits have the potential to become nutritious gluten-free snacks.

Keywords: celiac, *Clarias* spp., protein, snacks, texture

Peningkatan Gizi Biskuit Tepung Garut Bebas Gluten melalui Penambahan Tepung Ikan Lele

Abstrak

Permintaan produk bebas gluten meningkat seiring meningkatnya kesadaran akan intoleransi dan sensitivitas gluten. Penggunaan tepung alternatif, misalnya umbi lokal dan teknik fortifikasi tepung ikan dapat membantu meningkatkan kandungan gizi produk bebas gluten. Penelitian ini bertujuan untuk menentukan konsentrasi tepung ikan lele terbaik berdasarkan kandungan gizi dan hedonik biskuit berbasis tepung garut. Rancangan acak lengkap (RAL) digunakan dengan empat konsentrasi penambahan tepung ikan lele (0, 2, 4, dan 6%). Analisis yang dilakukan, yaitu uji proksimat, tekstur, warna, dan hedonik. Hasil penelitian menunjukkan bahwa penambahan tepung ikan lele 6% merupakan perlakuan terbaik, yaitu dengan karakteristik biskuit meliputi kadar air 5,59%; abu 1,63%; protein 8,57%; lemak 28,46%; dan karbohidrat 55,39%. Biskuit dengan penambahan tepung ikan lele 6% memiliki karakteristik tekstur 3,43 N, warna L* 70,82, a* 2,46, dan b* 37,69 serta memenuhi SNI 2973:2022 untuk parameter protein. Uji hedonik menunjukkan penambahan tepung ikan lele pada biskuit dapat diterima dan disukai oleh panelis. Secara keseluruhan, tepung ikan lele bermanfaat meningkatkan kandungan nutrisi biskuit bebas gluten berbahan dasar tepung garut. Biskuit ini berpotensi menjadi camilan bebas gluten yang bergizi.

Kata kunci: camilan, *Clarias* spp., protein, seliak, tekstur

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INTRODUCTION

The global demand for gluten-free food products continues to increase as gluten sensitivity and the diagnosis of celiac disease become more common worldwide (Quintana *et al*., 2025; El Khoury *et al*., 2018; Padalino *et al*., 2016). Celiac disease is defined as an enteropathy mediated by the immune system caused by gluten exposure in food (Atteno *et al*., 2014). Gluten is a protein found in wheat that can trigger gastrointestinal reactions and other adverse reactions in sensitive individuals, creating a need for products that limit gluten content while still providing balanced nutrition and satisfying sensory quality (Dick *et al*., 2020; Kristanti *et al*., 2020). Bread products, particularly biscuits, have attracted attention among gluten-restricted food alternatives. This appeal is due to its ability and versatility to be enriched with ingredients that enhance its nutritional profile (Brites *et al*., 2018; Gambuś *et al*., 2009).

Arrowroot flour (*Maranta arundinacea*) can be used as a substitute for gluten-containing wheat flour. It can produce gluten-free bread and has proved to be an alternative, with better nutritional and sensory quality than the rice and potato flour that is normally used in celiac products. According to studies conducted by Amante *et al.* (2021) and Rodrigues *et al.* (2018), Arrowroot flour is a viable option for producing gluten-free bread. Arrowroot flour has a drawback, which is its limited protein content, potentially resulting in a lower nutritional profile compared to wheat-based products (Sudaryanti *et al*., 2017). The addition of protein-rich ingredients can be done to address this issue. Some recent studies have shown promising results with the addition of legumes, cereals, and fish meals. These studies include Sibian & Riar (2020), Bakare *et al.* (2020), and Lestari *et al.* (2017).

Processing fish into flour adds value. The change in form makes it easier to use as a substitute for wheat flour or other flours (Istifada *et al*., 2023). Research on the application of fish flour in food includes flying fish flour as sticks and nuggets (Kaimudin *et al*., 2021), anchovy fish flour in noodles (Litaay *et al*., 2023), swanggi fish flour in biscuits (Astiana *et al*., 2023), and catfish flour in donuts (Saputra *et al*., 2024). Catfish (*Clarias* spp.) can be processed into flour that can be used as a nutritional supplement in biscuit fortification, increasing the protein and essential fatty acid content (Bakare *et al*., 2020). Fish flour has been studied to be beneficial and can increase the protein, amino acids, and lipids in food products, making it very suitable for foods intended for individuals with gluten sensitivity (Bakare *et al*., 2020; Muzaki *et al*., 2021; Navia *et al*., 2021). Studies have shown that fish meal added to food products provides biologically absorbable protein and essential fatty acids beneficial for children and adults (Zebib *et al*., 2020).

Research on fish flour in gluten-free bread-based products has been conducted, primarily focusing on the combination of other types of flour (Maulani *et al*., 2024; Safira *et al*., 2022; Yilmas *et al*., 2020; Bakare *et al*., 2020). The exploration of the effects of incorporating fish flour into various types of gluten-free bread products is limited, particularly the specific combination of catfish flour and arrowroot flour in biscuit production, which has not yet been reported. Catfish flour can be used as a source of protein that can be added to foods that have low protein content, such as biscuits (Arvianto, 2016). The protein content in catfish flour is quite high at 63.83% (Mervina, 2012), and it is easy to identify.

This study investigates how the addition of catfish flour in different concentrations affects the nutritional content, texture, and color of gluten-free biscuits made with arrowroot flour. The lowest concentration will be used to determine the effect of adding catfish flour on nutritional value and sensory characteristics in more detail. The findings of this study have the potential to broaden the application of fish flour in gluten-free bread products, specifically biscuits, which can improve proximate nutrition and cater to the needs of individuals with gluten sensitivity. Therefore, this research aims to determine the optimal concentration of catfish flour based on the nutritional content and hedonic test in arrowroot flour-based biscuits.

METHODOLOGY

Ingredients and Biscuits Preparation

The ingredients for making gluten-free biscuits are arrowroot flour (*Maranta arundinacea),* rice flour, catfish meat flour (*Clarias* spp.), margarine, milk, powdered sugar, baking powder, and eggs (Table 1). Arrowroot flour was chosen as the main starch source due to its low gluten content and unique texture, making it suitable for gluten-sensitive formulations. Rice flour is added to improve the texture, while margarine and eggs contribute to the moisture content and binding capacity of the product. Catfish meat flour, as the main source of protein, was added in various concentrations based on the weight of the flour (0, 2, 4, and 6%) to determine its effect on the nutritional and sensory properties of the biscuits.

The biscuit-making process begins with mixing the dry ingredients, namely garut flour, rice flour, catfish meat flour, powdered sugar, and baking powder in a container until well combined. The procedure for making these biscuits refers to the modified research by Asikin *et al*. (2024). In a separate container, beat the butter and eggs until they achieve a smooth and soft consistency. This wet mixture was then gradually combined with the dry ingredients, and milk is added as needed to adjust the dough's consistency, resulting in a cohesive dough. The dough was then flattened until it had an even thickness and cut into biscuit shapes. The shaped biscuits were then baked in a preheated oven at 160°C for 15 minutes or until golden brown in color. After baking, the biscuits were cooled at room temperature and stored in an airtight container for further analysis.

Proximate Composition Analysis

Proximate analysis is conducted to determine the moisture, ash, fat, protein, and carbohydrate content of the biscuits. The moisture content is measured using the oven drying method, where the biscuit samples are heated at a temperature of 105°C until a constant weight is achieved. Ash content was determined through incineration at a temperature of 550°C until only inorganic residue remained, indicating the mineral content. The fat content is assessed through Soxhlet extraction using hexane as a solvent, while the protein content is determined by the Kjeldahl method, which measures total nitrogen and converts it into protein content. The carbohydrate content is calculated by subtracting the amounts of water, ash, protein, and fat from the total weight of the sample (AOAC, 2016).

Texture Analysis

Texture analysis was conducted using a universal testing machine (UTM) texture analyzer to measure the hardness level of the biscuits (maximum force in Newtons) required to break them. This analysis was conducted by compressing each biscuit sample until it broke, which indicates the crispness and hardness of the texture (Bourne *et al*., 2022).

Table 1 Formulation of gluten free biscuits
Tabel 1 Formulasi biskuit bebas gluten

Ingredients	Addition of catfish flour (%)			
	0	2	4	6
Arrowroot flour (g)	25	25	25	25
Rice flour (g)	75	75	75	75
Catfish flour (g)	0	2	4	6
Fine sugar (g)	40	40	40	40
Egg (unit)	1/2	1/2	1/2	1/2
Butter (g)	70	70	70	70
Powdered milk (g)	5	5	5	5
Baking powder (g)	1	1	1	1

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Color Analysis

Color evaluation was conducted using a colorimeter. The principle of this tool is to measure color differences through the reflection of light on the surface of the test sample. Color intensity was measured by evaluating several parameters, namely L*, a*, and b* values. The L* value represents the brightness level of the sample, the a* value represents the light reflection that produces colors from green to red, while the b* value represents the light reflection that produces colors from blue to yellow. This measurement allows for a standard assessment of color changes due to various concentrations of fish meal.

Hedonic Test

The hedonic test was conducted by determining the formula for the selected crispy biscuits based on the hedonic test (color, aroma, taste, texture, and overall) referring to the sensory quality in SNI 2973:2022 on biscuits. The panelists consisted of 30 untrained panelists. The hedonic test evaluation of the biscuits was conducted by presenting the samples simultaneously to the panelists and rated based on the level of preference using a 1-7 scoring scale. The panelists assigned scores ranging from 1 (very dislike), 2 (dislike), 3 (somewhat dislike), 4 (somewhat like), 5 (like), 6 (very like), and 7 (extremely like).

Data Analysis

The research used a completely randomized design (CRD) with four concentrations of added catfish flour (0, 2, 4, and 6%). Proximate analysis, texture, and color data were statistically analyzed using analysis of variance (ANOVA) to determine the significance of differences among biscuit formulations with various levels of catfish meat flour. Each analysis in the study included three replicates. The Duncan's post-hoc test was then conducted for post-hoc analysis to identify specific differences between treatment means at a significance level of 5%. The hedonic data were analyzed using the Kruskal-Wallis test with a significance level of 5%. If there is a real influence, the Mann Whitney test was continued. This statistical approach provides insights into the effects of various concentrations of catfish flour on each parameter, allowing for a comprehensive understanding of its impact on the nutritional and sensory properties of low-gluten biscuits.

RESULTS AND DISCUSSION

Proximate Composition

Moisture

The moisture content in the biscuits ranges from 5.53% to 5.59% (Table 2). There is no significant difference in the moisture content among the produced biscuits. Biscuits with the addition of catfish flour have not met the standard, which is a maximum of 5% (BSN, 2022). The moisture content obtained in the study falls within the moisture range (5.30-7.50%) reported by Youssef and Mousa (2012), lower than the moisture content (7.14-10.20%) by Aduloju (2024), and higher than the moisture content (2.4-5%) reported by Passos *et al*. (2018) in industrial biscuits. In general, the moisture content recorded for all biscuits indicates the stability, quality, and concentrated nutrition. The differences in results may be due to variations in raw materials, fish species, and processing techniques used in the study (Abraha *et al*., 2018).

According to Romani *et al*. (2016), the moisture content will increase during the storage period. Thus, adherence to this moisture content limit ensures that the biscuits maintain a crispy texture while remaining microbiologically stable over time to prevent rapid spoilage and texture degradation. Therefore, the addition of catfish flour to biscuits predicts their suitability for long-term storage without compromising their quality.

Ash

It went from 1.38% to 1.63% in ash content, which is the total mineral content (Table 2). The data shows that the increase in the concentration of catfish flour is directly proportional to the ash content of the biscuits. This increase indicates the contribution of minerals found in fish flour, which is rich in minerals such as calcium, phosphorus, and iron (Zebib *et al*., 2020; Muzaki *et al*., 2021).

Table 2 Proximate and texture of gluten free biscuits
Tabel 2 Proksimat biskuit bebas gluten

Proximate (%)	Addition of catfish flour (%)			
	0	2	4	6
Moisture	5.53±0.13[a]	5.62±0.01[a]	5.63±0.08[a]	5.59±0.02[a]
Ash	1.38±0.02[a]	1.47±0.02[b]	1.51±0.02[b]	1.63±0.07[c]
Fat	28.27±0.06[a]	28.38±0.19[a]	28.39±0.15[a]	28.46±0.11[a]
Protein	6.97±0.06[a]	7.22±0.03[a]	7.83±0.02[b]	8.57±0.26[c]
Carbohydrate	57.43±0.15[c]	57.01±0.26[b]	56.64±0.17[b]	55.39±0.21[a]

The letters indicate significant differences between groups according to the Duncan test (p <0.05)

Minerals are critical for various physiological functions. The addition of catfish flour has become an effective strategy to increase mineral content, thereby enhancing the nutritional value of the final product (Bakare *et al*., 2020). The addition of extra minerals to cake and bread products meets dietary needs and serves consumers seeking functional foods with additional health benefits (Ermis *et al*., 2020). Therefore, the biscuits enriched with catfish flour in this study can serve as a valuable source of dietary minerals.

Fat

The results of the fat content analysis showed relatively stable values in arrowroot-based biscuits with the addition of catfish flour. Statistical analysis using ANOVA indicates that the differences are not statistically significant (p>0.05), which means that the addition of catfish flour up to 6% does not significantly affect the fat content of the biscuits. The stability of this fat content may be due to the relatively low-fat content of catfish flour. Catfish meal has a fat content ranging from 1.27% to 5.53% (Setriyani *et al*., 2024). With that fat content, the addition of catfish flour in small amounts does not significantly contribute to the total fat content of the biscuits.

Moreover, the basic formulation of biscuits already contains a primary fat source, such as margarine, where the fat content can reach 80% (Rosida *et al*., 2020; Ulfa *et al*., 2017), so the addition of catfish flour does not cause significant changes in the total fat content. Other studies have shown different results, where the addition of fishmeal at a high enough concentration will have a significant effect on the fat content of the final product (Manik *et al*., 2020). The evidence indicates that the addition of fish flour in certain amounts tends to play a more significant role in increasing protein content without significantly affecting the fat content. Thus, the addition of catfish meal up to 6% can enhance the nutritional value of biscuits by increasing the protein content without significantly altering the fat content.

Protein

The protein content of the biscuits is 6.97-8.57%. The data shows that the addition of catfish flour concentration is directly proportional to the protein content of the biscuits. Catfish flour provides a high protein source, especially amino acid content (Abdel-Mobdy *et al*., 2021). It can complement the limited protein quality in gluten-free biscuits in general. Fish flour effectively increases the protein content in biscuits, supporting tissue repair and growth (Bakare *et al*., 2020; Muzaki *et al*., 2021; Navia *et al*., 2021).

The increase in protein content meets the SNI 2973:2022 standard for protein-enriched biscuits, which sets a minimum protein content of 4.5%. High-protein snacks are increasingly sought after by health-conscious consumers, making these biscuits suitable for those who want to increase their protein intake. Additionally, protein-rich biscuits have been proven to increase satiety and reduce glycemic response, further enhancing the appeal of fish flour-enriched biscuits as a functional snack (Rasulu *et al*., 2021).

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Carbohydrate

The carbohydrate content of the biscuits is 55.39-57.43%. Data shows that the addition of higher concentrations of catfish flour results in lower carbohydrate levels in the biscuits. This decrease is caused by the substitution effect, where the higher protein and fat content of fish flour reduces the relative concentration of carbohydrates. This usually happens in recipes with extra protein and fat, so adding protein sources to bread products instead of carbs is common (Zebib *et al*., 2020).

The reduction in carbohydrate content contributes to a lower glycemic impact, as products with lower carbohydrate density generally elicit a slower glucose response. These dry biscuits contain enough carbohydrates to provide energy quickly, but their balanced macronutrient profile makes them suitable for consumers looking for snacks with a lower glycemic index (Fathonah *et al*., 2019; Wee & Henry, 2020).

Texture Analysis

Texture analysis, particularly the hardness of biscuits, shows a trend of increasing hardness with the addition of catfish flour. It is 2.75 N for the control biscuits, 3.10 N when 2% catfish flour is added, 3.32 N when 4% catfish flour is added, and 3.43 N when 6% catfish flour is added. The higher the addition of catfish flour, the higher the texture of the biscuits. The increase in texture value is caused by the high protein content in fish flour, which forms a stronger protein network during baking and thereby enhances the structure of the biscuits. Protein-enriched bread products exhibit this effect. When protein is added, the structure gets denser because the bonds between molecules get stronger (Wani *et al*., 2017). Research on biscuits based on combinations of different types of flour shows varying hardness values. Kulthe *et al.* (2017) found that pearl millet flour gave them between 6.25 and 15.97 N; Bara *et al.* (2019) found that wheat flour gave them between 4.37 and 5.89 N; and Bakare *et al.* (2020) found that breadfruit flour and fish flour gave them between 1.2 and 2.1 N. The hardness value of the biscuits in this study still falls within those values.

A balanced and optimal formulation of ingredients is necessary because excessive hardness can negatively impact consumer acceptance. Several studies show that adding catfish flour improves the texture of the biscuits while keeping it within an acceptable range and maintaining the desired texture. Protein-enriched baked goods, such as dry biscuits, can benefit from the texture improvement provided by moderate protein addition without significantly sacrificing the desired bite quality (Navia *et al*., 2021; Sinthusamran *et al*., 2019; Muslihudin *et al*., 2021).

Color Analysis

The significance of color changes was verified by applying ANOVA to the L*, a*, and b* values, followed by Duncan's post-hoc test to identify significant differences in color parameters between the control samples and the treatment samples with varying levels of catfish flour (Table 3). This statistical analysis confirms that the addition of catfish flour significantly impacts the color characteristics of gluten-free biscuits.

Color parameters that include L* (lightness), a* (red-green spectrum), and b* (yellow-blue spectrum) are significantly influenced by the inclusion of catfish flour. Biscuits with a higher fish meal content showed a decrease in brightness (L* value), from 74.66 in the control to 70.82 in the 6% fish meal sample, indicating darker biscuits as the protein content increased. The darker coloration in fish meal-enriched biscuits is consistent with the research by Sharma *et al*. (2025), who observed that fish protein introduces natural pigments and amino groups that react during baking, creating a Maillard reaction that results in a darker color. The Maillard reaction, a non-enzymatic browning reaction between reducing sugars and amino acids, increases with higher protein content and heat exposure. This reaction produces melanoidins, which contribute to the darker color in fish meal-enriched biscuits.

The a* and b* values also show changes, with the a* value shifting slightly towards the

Table 3 Color and texture of gluten free biscuits
Tabel 3 Warna dan tekstur biskuit bebas gluten

Parameter	Addition of catfish flour (%)			
	0	2	4	6
L*	74.66±0.03^{c}	72.29±0.58^{b}	72.07±0.16^{b}	70.82±0.29^{a}
a*	1.73±0.32^{a}	2.16±0.06^{ab}	2.41±0.34^{b}	2.46±0.18^{b}
b*	40.20±0.38^{c}	38.99±0.53^{b}	38.75±0.32^{b}	37.69±0.25^{a}
Texture	2.75±0.16^{a}	3.10±0.11^{b}	3.32±0.14^{bc}	3.43±0.06^{c}

The letters indicate significant differences between groups according to the Duncan test (p <0.05)

red spectrum and the b* value towards the blue spectrum as the amount of fish flour increases. The shift in these color parameters is characteristic of baked products with added protein, which tend to have a warm hue after baking (Sinthusamran *et al*., 2019; Sharma *et al*., 2025). The color change due to the addition of fish flour can affect the appearance, which has implications for consumer perception of the biscuits. The darker the color of the biscuit, the greater its potential to make it unappealing. Siswanti *et al.* (2024) research confirms that consumers do not favor biscuits with dark colors. The addition of 6% fish flour in this study still resulted in a bright brown color.

Hedonic Test

According to the hedonic test on gluten-free biscuits that had catfish flour added (0, 2, 4, and 6%), there were no significant differences in the smell, taste, texture, or overall quality. However, there were significant differences in the color quality between the treatments with 4% and 6% catfish flour addition (Table 4). These results indicate that the panelists can accept the modification of the biscuit formulation with the addition of catfish flour, despite the visual changes (color) in the product. The overall average acceptance value remains within the category, indicating that the addition of catfish flour is still within the sensory acceptable limits.

Color

The color parameter showed that the addition of 2% catfish flour and control has the highest score (5.47), while the addition of 4 and 6% catfish flour (4.33) has a lower score. This indicates that the addition of fish flour in higher amounts causes a decrease in color preference, possibly due to the biscuits undergoing browning or pigment changes during baking as a result of the Maillard reaction. The high protein content will increase the likelihood of browning reactions, specifically Maillard reactions (Khotimah *et al*., 2023). This causes the brightness level of the product to decrease and the color of the resulting biscuits to become darker. This phenomenon has been reported in studies on the utilization of snakehead fish flour (Siswanti

Table 4 Hedonic test of gluten free biscuits
Tabel 4 Uji hedonik biskuit bebas gluten

Parameter	Addition of catfish flour (%)			
	0	2	4	6
Color	5.37±0.49^{a}	5.47±0.63^{a}	4.63±0.89^{b}	4.33±0.92^{b}
Aroma	5.03±0.93^{a}	4.93±0.87^{a}	5.10±0.88^{a}	5.03±0.85^{a}
Taste	5.03±0.85^{a}	4.90±0.61^{a}	5.00±0.95^{a}	4.97±0.81^{a}
Texture	4.50±1.04^{a}	4.73±1.34^{a}	4.87±1.25^{a}	4.47±1.04^{a}
Overall	4.88±0.70^{a}	4.90±0.79^{a}	4.87±0.83^{a}	4.77±0.75^{a}

The letters indicate significant differences between groups according to the Duncan test (p <0.05)

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et al., 2024) and swanggi fish flour (Astiana *et al*., 2023) in biscuit products, showing that the product color tends to be darker and less favored by panelists if the concentration is too high.

Aroma

The aroma parameter did not show significant differences, with scores ranging from 4.93 to 5.10. Panelists can still accept the biscuit aroma, even with the addition of catfish flour. Ingredients such as butter and milk powder can cover or reduce the characteristic aroma of fish protein. Biscuits with the addition of other ingredients that have strong flavors and aromas can neutralize the undesirable fishy smell (Muhlishoh *et al*., 2024). The same effect is also demonstrated in donut products that contain other ingredient formulations, namely wheat flour, yeast, and margarine, which prevent the fish flour's fishy aroma from being detected by the panelists (Saputra *et al*., 2024).

Taste

The taste parameter shows relatively stable results in all formulations, with a value range between 4.90 and 5.03. This indicates that the panelists can still accept the taste of the biscuits with the addition of catfish flour. The formulated biscuit flavor is sweet and savory. The sweet and savory flavors come from all the ingredients used. The addition of fish flour, which is rich in protein and contains free amino acids, can enhance the savory flavor without disturbing the original taste balance of the product (Manik, 2020). Biscuits that contain protein can affect the taste of the biscuits (Husain *et al*., 2023). Protein contains amino acids that play a very important role in food processing, as they can create a delicious taste and enhance the flavor of biscuits (Yuliantini *et al*., 2018). However, the concentration must still be monitored because the more fish flour is added, the more dominant the fish flour flavor becomes, which can lead to a decrease in panelists' acceptance (Bakhtiar *et al*., 2019).

Texture

The texture parameter shows a score of 4.47-4.87. This indicates that the texture of the biscuits with the addition of catfish flour is still acceptable to the panelists. Gluten-free biscuits tend to be more brittle and less firm. Formulation and mixing of several ingredients can be done to help the texture of the biscuits not to be brittle (Kohli *et al*., 2023). Additional protein can enhance a firmer texture in low-gluten products (Wani *et al*., 2010). The addition of catfish flour has a higher hardness value compared to biscuits without the addition of catfish flour (Bakare, 2020). However, attention must be paid to the concentration level so that the biscuits do not become too hard. This is explained in the research by Astiana *et al*. (2023), where the texture of biscuits with surimi flour fortification is harder compared to biscuits without fish surimi fortification, thereby reducing the panelists' acceptance of the biscuit texture.

Overall

Overall, the hedonic test showed that biscuits with the addition of catfish flour up to 6% were acceptable to the panelists, although there was a significant difference in the color attribute. This indicates that the addition of catfish flour is still acceptable and preferred by panelists and does not affect consumer consumption. Thus, biscuit formulations with the addition of catfish flour have the potential to be developed.

CONCLUSION

The addition of 6% catfish flour is the best treatment, characterized by biscuits with a moisture content of 5.59%, ash 1.63%, protein 8.57%, fat 28.46%, and carbohydrates 55.39%. The biscuits with the addition of 6% catfish flour are still acceptable in terms of texture and color and meet SNI 2973:2022 for the protein content parameter. The hedonic test indicated that the addition of catfish flour in all biscuit formulas was acceptable and preferred by panelists as a whole. So, catfish flour has proven beneficial in increasing the protein content of gluten-free biscuits made from arrowroot.

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