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SENSORY AND PHYSICOCHEMICAL PROPERTIES OF THREADFIN BREAM (*Nemipterus nemurus*) MEATBALLS FROM BREADFRUIT AND TAPIOCA FLOUR FORMULATIONS

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Abstract

Fish meatballs require fillers to produce high-quality meat products. Tapioca is often used as a filler in meatballs, but has a low nutritional content. Breadfruit flour can be used as an alternative meatball filler because it contains high amylose, amylopectin, and fiber contents. This study aimed to determine the best formulation of threadfin bream fish meatballs with the addition of breadfruit and tapioca flour based on sensory, physical, and chemical properties and compliance with SNI 7266:2014. The breadfruit and tapioca flour formulation consisted of six treatments (%): (0: 15), (3:12), (6:9), (9:6), (12:3), and (15:0). The parameters analyzed included sensory tests, ash content, moisture, hardness, springiness, and cohesiveness. The best treatment was continued with the analysis of the protein and crude fiber content. The results showed that the formulation of breadfruit and tapioca flour significantly affected the sensory, physical, and chemical properties of threadfin bream fish meatballs. The best formulation is the treatment of 3% breadfruit flour and 12% tapioca with an appearance score of 7.62 (smooth surface, no cavities, bright), aroma 7.75 (typical of fish), taste 8.00 (typical of fish meatballs), texture 7.83 (dense, compact, chewy), hedonic taste 7.63 (very much like), overall acceptance 7.39 (like), moisture 68.02%, ash 2.22%, crude fiber 0.71%, and protein 11.38% in accordance with SNI 7266:2014. This formulation also produced a hardness value of 295.50 N, springiness value of 12.57 mm, and cohesiveness value of 1.22 mm. The higher the concentration of breadfruit flour, the lower the sensory and physical values and the higher the ash content of kurisi fish meatballs.

Keywords: hedonic, proximate, quality standard, texture profile, threadfin bream

Sifat Sensori dan Fisikokimia Bakso Ikan Kurisi (*Nemipterus nemurus*) dengan Formulasi Tepung Sukun dan Tapioka

Abstract

Bakso ikan memerlukan bahan pengisi untuk menghasilkan kualitas produk akhir yang baik. Tapioka sering digunakan sebagai bahan pengisi dalam pembuatan bakso, namun memiliki kandungan nutrisi yang rendah. Tepung sukun dapat digunakan sebagai alternatif tambahan bahan pengisi bakso karena mengandung amilosa dan amilopektin yang tinggi serta serat yang tinggi. Penelitian ini bertujuan untuk menentukan formulasi bakso ikan kurisi dengan penambahan tepung sukun dan tapioka terbaik berdasarkan sifat sensori, fisik, kimia dan kesesuaian dengan SNI 7266:2014. Formulasi tepung sukun dan tapioka yang digunakan terdiri dari 6 perlakuan (%), yaitu (0:15); (3:12); (6: 9); (9:6); (12:3); dan (15:0). Parameter yang dianalisis meliputi uji sensori, kadar abu, air, *hardness*, *springiness*, dan *cohesiveness*. Perlakuan terbaik dilanjutkan analisis kadar protein dan serat kasar. Hasil penelitian menunjukkan bahwa

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formulasi tepung sukun dan tapioka berpengaruh nyata terhadap sifat sensori, fisik dan kimia bakso ikan kurisi. Formulasi terbaik adalah perlakuan tepung sukun 3% dan tapioka 12% dengan skor ketampakan 7,62 (permukaan halus, tidak berongga, cerah), aroma 7,75 (khas ikan), rasa 8,00 (khas bakso ikan), tekstur 7,83 (padat, kompak, kenyal), rasa secara hedonik 7,63 (sangat suka), penerimaan keseluruhan 7,39 (suka), kadar air 68,02%, abu 2,22%, serat kasar 0,71%, dan protein 11,38% yang sesuai dengan SNI 7266:2014. Formulasi ini juga menghasilkan nilai *hardness* 295,50 N, nilai *springiness* 12,57 mm, dan nilai *cohesiveness* 1,22 mm. Makin tinggi konsentrasi tepung sukun makin menurunkan nilai sensori dan fisik.

Kata kunci: hedonik, ikan kurisi, profil tekstur, proksimat, standar mutu

INTRODUCTION

Indonesia is one of the leading countries in the production of fishery commodities. However, this is not reflected in per capita fish consumption, which remains relatively low. Despite its significant fisheries potential, Lampung Province also exhibited low levels of fish consumption. In 2023, fish consumption in Lampung was recorded at 39.98 kg per capita (KKP, 2023). Promoting the diversification of fish-based food products could be an effective strategy for enhancing fish consumption and supporting food security.

Fish are a healthy source of animal protein and are popular among the public. Among the various types of fish available in the market, the threadfin bream (*Nemipterus nemurus* Bleeker) is notable for its accessibility. The threadfin bream, classified as a demersal fish, features an elongated, flattened body with a pinkish hue and a distinctive golden-yellow stripe running from head to tail (Jumiati *et al*., 2021). According to KKP (2024), the production of threadfin bream in Lampung reached 7,199.72 tons in 2023. It is commonly sold in various forms, including fresh, fermented, surimi, fish meal, fish balls, and dried salted products (Oktaviyani *et al*., 2016). The threadfin bream has been studied for its potential use in kamaboko manufacturing (Agustin *et al*., 2012), collagen and gelatin (Widiyanto *et al*., 2022). Fish meatballs are a popular processed product derived from threadfin bream (Nurilmala *et al*., 2007; Zahiruddin *et al*., 2008). Pradana (2018) has shown that combining tapioca and wheat flour affects the physical, chemical, and organoleptic properties of threadfin bream meatballs.

Fish meatballs represent a well-recognized form of diversification of fish products that are widely appreciated by the community. These meatballs are prepared by blending minced fish meat with spices, flour, and other additives, followed by grinding, mixing, shaping, and boiling (Muttaqin *et al*., 2016). It is common to incorporate components, such as fillers and binders, to enhance the quality and chewiness of fish meatballs. Tapioca flour is a filler widely used in meatball production to enhance product textural properties, but it is less nutritious since it contains high carbohydrates (Khotimah *et al*., 2024). Pratiwi & Hakiki (2021) reported that excessive tapioca can lead to a less desirable texture in milkfish meatballs. Aziza *et al*. (2015) revealed that the substitution of tapioca with gembili flour enhances fishball fiber content and reduces fat. These findings suggest that while tapioca is effective as a filler, it should be optimized with alternative flours to improve nutritional and sensory quality. Breadfruit flour, which is rich in starch and fiber, could be a potential additive for diversifying meatball products.

Breadfruit flour is derived from breadfruit, which is abundantly grown in Indonesia. Breadfruit, belonging to the Moraceae family, is recognized as a major fruit source (Santosa *et al*., 2018). Breadfruit flour is notably higher in fiber than tubers. For instance, every 100 g of cassava contains 0.3 g of fiber, whereas the same amount of breadfruit ranges from 5.4 to 10.31 g (Noor *et al*., 2019; Mehta *et al*., 2023). Moreover, breadfruit flour is rich in various essential minerals and vitamins, with a low calorie profile, making it suitable for low calorie diets. According to Mehta *et al*. (2023), 100 g of breadfruit flour contains 314 mg of calcium, 924 mg of phosphorus, 28.13 mg of iron, 0.42 mg of vitamin B1, 0.19 mg of vitamin B2, 11.49 mg of vitamin C, and 350 kcal.

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In 2023, breadfruit production in Indonesia was reported to be 156,626 tons (Badan Pusat Statistik [BPS], 2023). Despite this abundant production, the utilization of breadfruit remains limited among the local population. Incorporating breadfruit flour as an additional ingredient in food products is a viable approach to enhancing food diversification. Breadfruit flour is commonly used to produce snacks such as cakes and chips (Ginting *et al.,* 2020; Rabago, 2022), but its potential applications are much broader, including as a filler in meatball production (Syam *et al.,* 2019; Yulianto *et al.,* 2020). The addition of breadfruit flour is expected to improve the texture of fish meatballs.

Breadfruit flour contains high levels of amylopectin and amylose, which are crucial for the cohesiveness and texture of food products. According to Akanbi *et al.* (2009), breadfruit flour comprises 77.48% amylopectin and 22.52% amylose. Amylopectin helps maintain elasticity, while amylose acts as an adhesive in foods such as meatballs, soups, sausages, and nuggets, thereby enhancing texture. Syam *et al.* (2019) demonstrated that breadfruit flour could be an effective filler in the production of beef meatballs, with the best results observed at the 40% substitution level. However, the formulation of breadfruit flour and tapioca in threadfin bream meatballs has not been previously studied. Therefore, this study aimed to determine the best formulation of threadfin bream meatballs based on sensory, physical, chemical charateristics and compliance with SNI 7266:2014.

MATERIALS AND METHOD

Threadfin Bream Meatball Preparation

Fresh threadfin bream fillets were obtained from the Way Halim Market in Bandar Lampung. The fillers, including breadfruit flour (Lingkar Organik) and tapioca flour (Pak Tani Gunung), were purchased from Koga Market in Bandar Lampung. Other ingredients used for meatball production included cold water, shallots, garlic, salt (Daun), sugar (Gunung Madu), and ground pepper (Ladaku).

Threadfin bream meatballs were prepared as described by Ananda (2021) and Pradana (2018), with modifications. Initially, the fillets were separated from the skin. Threadfin bream meat (100 g) was minced using a chopper, along with 20 g of cold water, 5 g of shallots, and 5 g of garlic. The homogenized mixture was then combined with 2 g of pepper, 3 g of salt, and 2 g of sugar, and gradually mixed with breadfruit and tapioca flour until a homogeneous dough was obtained. The dough was shaped into balls, boiled in water at 100°C for 15 minutes, and drained. The cooked fish meatballs were then ready for sensory, physical, and chemical analysis. The formulations of threadfin bream meatballs are presented in Table 1.

Sensory Analysis

The study conducted a sensory analysis based on scoring tests referencing SNI 7266:2014 (Badan Standardisasi Nasional [BSN], 2014), which evaluates the appearance, aroma, taste, and texture, and hedonic test on taste and overall acceptance. The scoring test employed 12 trained panelists (students) selected based on their consumption preferences for processed fish products and their successful completion of a Sensory Evaluation course. Panelists' responses to the scoring test were collected using questionnaires based on SNI 7266:2014, which evaluated product descriptions with specific scores. A hedonic test was conducted on threadfin bream meatballs using 30 untrained panelists (students), following SNI 2346:2011 (BSN, 2011). The test evaluated taste and overall acceptance parameters, as taste is a primary attribute influencing consumer preference for meatballs, while overall acceptance reflects panelists' acceptability (Fadlan *et al.*, 2022). Panelist responses were recorded using hedonic questionnaires with a likert scale of 1 to 9, where 1 (extremely dislike), 2 (strongly dislike), 3 (dislike), 4 (somewhat dislike), 5 (neutral), 6 (somewhat like), 7 (like), 8 (strongly like), and 9 (extremely like).

Physical Analysis

Physical analysis, referring to Untoro *et al.* (2012), assessed the hardness, springiness,

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Table 1 Threadfin bream meatballs with breadfruit and tapioca flour formulations
Tabel 1 Formulasi bakso ikan kurisi dengan tepung sukun dan tapioka

Ingredient (%)	Formulation ratio of breadfruit and tapioca flour (%)					
	0:15	3:12	6:9	9:6	12:3	15:0
Threadfin bream meat	62	62	62	62	62	62
Breadfruit flour	0	3	6	9	12	15
Tapioca	15	12	9	6	3	0
Cold water	13	13	13	13	13	13
Shallot	3	3	3	3	3	3
Garlic	3	3	3	3	3	3
Pepper	1	1	1	1	1	1
Salt	2	2	2	2	2	2
Sugar	1	1	1	1	1	1
Total	**100**	**100**	**100**	**100**	**100**	**100**

and cohesiveness of threadfin bream meatballs using a texture analyzer (Brookfield AMETEK model CT3-4500-115CT3). Meatballs were prepared in a cube shape (3×3×3 cm) and placed below the 6 cm sharp probe before being tested. The machine uses the following test configuration: test speed of 2.5 mm/s, deformation of 7.0 mm, and trigger of 15.0 g. The values displayed for each texture profile were recorded.

Chemical Analysis

The ash content was determined using a laboratory furnace (Neytech Volcano D-550), while the moisture content was measured using an oven (Memmert), both employing the thermogravimetric method. The best treatments being further analyzed on the protein content (AOAC, 2019) and crude fiber according to SNI ISO 5498:2015 (BSN, 2015).

Determination of The Best Treatment

The best formulations were determined based on the effectiveness test following De Garmo *et al.* (1988). The parameters were grouped, assigned weights, and subsequently calculated for effectiveness (E) and result (R) values. The parameters used in determining the best formulation encompassed all parameters analyzed across treatments, including sensory tests (appearance, texture, taste, aroma, overall acceptance), texture profile analysis (hardness, springiness, cohesiveness), and chemical analyses (moisture content and ash content). The formulation with the highest result value was designated as the optimal formulation. Subsequently, the best formulation underwent further chemical analysis to determine its protein and crude fiber content.

Data Analysis

The study used a randomized block design (RBD) with one treatment factor and four replications. The treatment factors included six levels of breadfruit and tapioca flour concentrations. Statistical analysis involved variance analysis to evaluate treatment effects, followed by an honestly significant difference (HSD) test at a significance level of 5%, using IBM SPSS version 25.

RESULTS AND DISCUSSION

Sensory Evaluation

Appearance

Figure 1 indicates that the formulations of breadfruit and tapioca flour significantly affected the appearance of threadfin bream meatballs ($p<0.05$). The treatments (0:15), (3:12), and (6:9) were not significantly different but showed a significant difference with (9:6), (12:3), and (15:0). The threadfin

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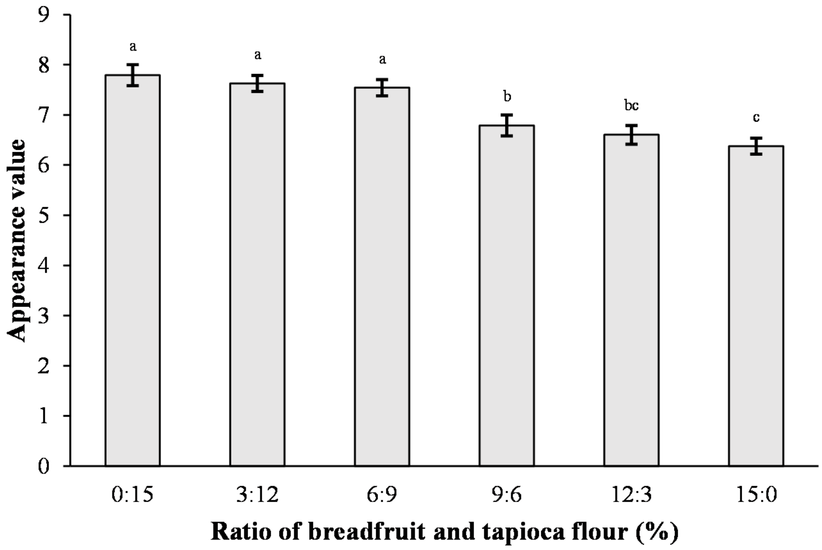

Figure 1 Appearance of threadfin bream meatballs with breadfruit and tapioca flour; Different letters indicating a significant difference (p<0.05)

Gambar 1 Ketampakan bakso ikan kurisi dengan tepung sukun dan tapioka; Huruf superskrip berbeda menunjukkan data signifikan berbeda (p<0.05)

bream meatballs from treatments (0:15), (3:12), and (6:9) exhibit a smooth, non-porous, and bright surface appearance. The treatment of (9:6) and (12:3) resulted in slightly rough, porous, and less bright surfaces, while treatment (15:0) led to a dull, rough, and porous appearance (Figure 2). These variations in appearance can be attributed to the different formulations of breadfruit flour used. The dull appearance observed in the fish meatballs was primarily due to the presence of polyphenol oxidase enzymes in breadfruit flour, which induced a yellowish-brown coloration. Saepudin *et al*. (2017) explained that the polyphenol enzyme in breadfruit is responsible for color changes due to browning reactions when exposed to air.

The surface appearance was also significantly influenced by the amylopectin content of breadfruit flour. Montolalu *et al*. (2017) stated that amylopectin in starch flour contributes to gel formation, and a higher amylopectin content enhances the water-binding capacity, leading to a smoother texture in meatballs. Amylopectin affects the expansion properties of starch granules, which begin to expand when hydrogen bonds are disrupted and amylopectin components are released, allowing the granules to retain and absorb more water (Yufidasari *et al*., 2018).

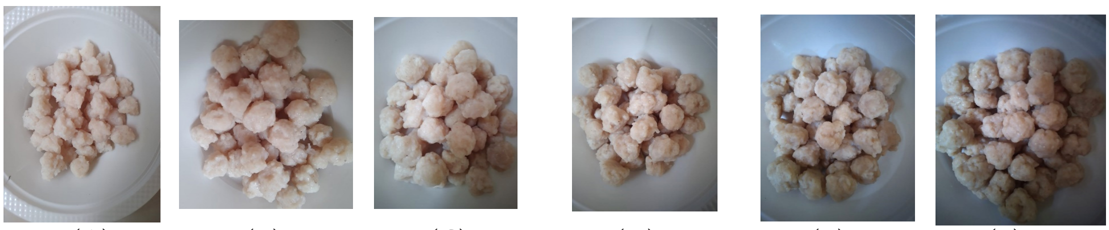
(A) (B) (C) (D) (E) (F)

Figure 2 Appearance of threadfin bream meatballs in various formulations of breadfruit:tapioca flour; A=(0:15), B=(3:12), C=(6:9), D=(9:6), E=(12:3), F=(15:0)

Gambar 2 Ketampakan bakso ikan kurisi pada formulasi tepung sukun:tapioka berbeda; A=(0:15), B=(3:12), C=(6:9), D=(9:6), E=(12:3), F=(15:0)

According to Akanbi *et al*. (2009), breadfruit flour contains 77.48% amylopectin, which is lower than the amylopectin content in tapioca (73.56-82.16%) (Onitilo *et al*., 2007). The lower amylopectin content in breadfruit flour contributes to a softer texture and a more porous appearance with visible cracks as the proportion of breadfruit flour increases. Riskayanti (2018) noted that the addition of breadfruit flour to chicken meatballs imparted a yellowish-brown hue and resulted in a less smooth surface. According to the Indonesian National Standard (SNI 7266:2014) for fish meatballs, the minimum acceptable appearance score is 7. Treatments (0:15), (3:12), and (6:9) met these appearance standards, while other treatments, although not meeting the standards, were still deemed acceptable by panelists and demonstrated good quality.

Aroma

Figure 3 shows that the breadfruit and tapioca flour formulations significantly affected the aroma of threadfin bream meatballs ($p<0.05$). The treatments (0:15), (3:12), and (6:9) were not significantly different but significantly differed with (15:0). The threadfin bream meatballs from treatments (0:15), (3:12), and (6:9) exhibit a distinctly fish-like aroma, while treatment (15:0) resulted in a moderately fish-like aroma. The breadfruit flour concentration at 15% slightly reduces the fishy aroma of the threadfin bream meatballs. According to Novrini (2020), breadfruit flour introduces a distinct "*langu*" aroma, which diminishes the fish-like aroma as its concentration increases. Tannins, which are phenolic compounds, contribute to flavor formation, including aroma development. They form complex bonds with proteins and other macromolecules, masking the fish-like flavor produced by volatile compounds in fish (Zhang *et al*., 2011). Trimethylamine oxide (TMAO), a nitrogen compound responsible for the typical fish aroma, is broken down into dimethylamine and trimethylamine, producing a characteristic fishy smell (Permanasari *et al*., 2014; Ratnasari *et al*., 2021). Therefore, higher concentrations of breadfruit flour decrease the fish-like aroma because tannins bind to fish proteins, which are essential for aroma development. Ananda (2021) observed that meatballs with 50% breadfruit flour exhibited a less distinct beef aroma, indicating that excessive breadfruit flour reduces the meatballs' aroma. According to SNI 7266:2014 (BSN, 2014), the minimum acceptable aroma score for fish meatballs is 7. The others treaments met this standard,

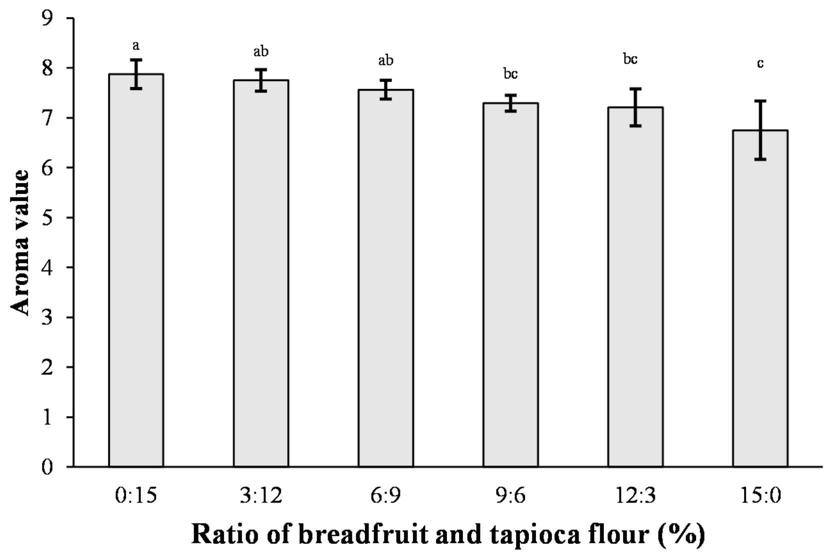

Figure 3 Aroma of threadfin bream meatballs with breadfruit and tapioca flour; Different letters indicating a significant difference ($p<0.05$)

Gambar 3 Aroma bakso ikan kurisi dengan tepung sukun dan tapioka; Huruf superskrip berbeda menunjukkan data signifikan berbeda ($p<0.05$)

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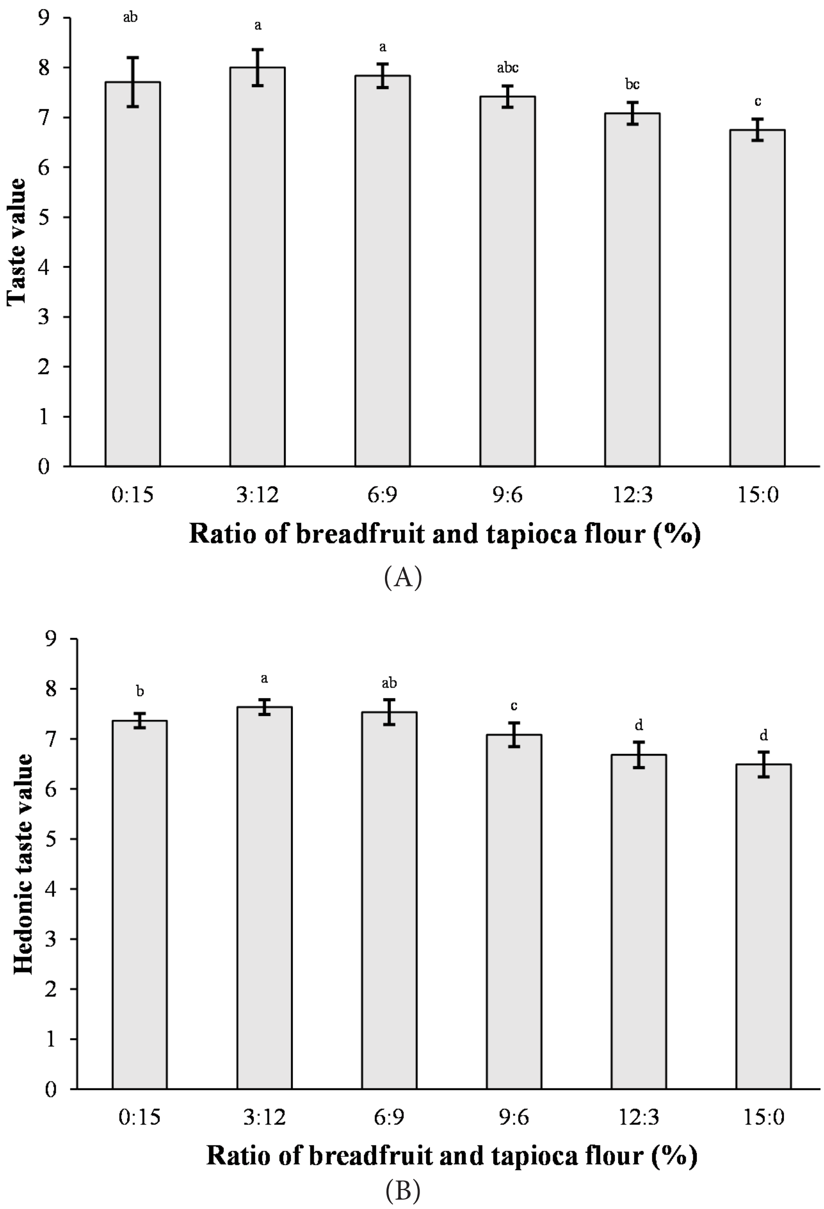

Figure 4 Taste scoring values (A) and hedonic taste (B) of threadfin bream meatballs with breadfruit and tapioca flour; Different letters indicating a significant difference ($p<0.05$)

Gambar 4 Rasa bakso ikan kurisi dengan tepung sukun dan tapioca melalui uji *skoring* sensori (A) dan hedonik (B); Huruf berbeda menunjukkan perbedaan signifikan ($p<0.05$)

whereas treatment (15:0) did not meet the standard but still maintained good quality and acceptability among the panelists. Fish meatballs with optimal aroma characteristics were those with breadfruit flour concentrations of 0%, 5%, and 10%, which retained their distinctive fish-like aroma.

Taste

Figure 4A showed that different formulations of breadfruit and tapioca flour significantly affect the score taste of threadfin bream meatballs ($p<0.05$). The treatments (0:15), (3:12), (6:9), and (9:6) were not significantly different. However, it is showed a significant difference with (15:0). The others treatments exhibit a distinctly fish-like taste, while treatment (15:0) led to a moderately fish-like taste. The addition of breadfruit flour can reduce the taste of fish meatballs due to the tannins present in breadfruit flour. Yusuf *et al.* (2022) reported that the aftertaste of breadfruit exhibits slight bitterness owing to tannin compounds. Tannins can impart astringency by forming cross-links with proteins or glycoproteins in the oral cavity, resulting in a dry, puckered sensation (Rosyidah & Ismawati, 2016). Riskayanti (2018) also found that increasing the breadfruit flour in chicken meatballs affects their taste and intensifies the breadfruit flavor. The SNI 7266:2014 standard requires a minimum taste score of seven for fish meatballs. Treatments (0:15), (3:12), (6:9), (9:6), and (12:3) met these standards, whereas (15:0) did not. Despite not meeting the standard, the distinctive taste of fish meatballs was still perceived by the panelists.

Figure 4B indicated that different formulations of breadfruit flour and tapioca significantly affected the hedonic taste of threadfin bream meatballs (p<0.05). The treatment (0:15) was not significantly different from (6:9) but significantly different from (3:12), (9:6), (12:3), and (15:0). The panelists very much liked the taste of threadfin bream meatballs from treatment (0:15), while they somewhat liked the taste of treatment (15:0). Generally, preferred fish meatballs retain the inherent fish flavor, whereas breadfruit flour imparts a slightly bitter taste, altering the taste profile (Ardianti *et al.*, 2014; Ginting *et al.*, 2020). Ananda (2021) found that beef meatballs without breadfruit flour had the highest average taste score, whereas those with the highest addition of breadfruit flour had the lowest score. According to the SNI 7266:2014 standards, treatments (0:15), (3:12), (6:9), and (9:6) meet the hedonic taste standards for threadfin bream meatballs, with panelists expressing a preference for these treatments. Treatments (12:3) and (15:0) did not meet the standards but were still partially liked by the panelists.

Texture

As shown in Figure 5, the concentration variation of breadfruit flour significantly affects the texture of threadfin bream meatballs ($p<0.05$). The treatments (0:15), (3:12), and (6:9) were not significantly different but showed a significant difference with (9:6), (12:3), and (15:0). The threadfin bream meatballs from treatments (0:15), (3:12), and (6:9) exhibit a firm, compact, and elastic texture, while the treatments (9:6), (12:3), and (15:0) showed a not firm, less compact, and less elastic texture. The concentration of breadfruit flour at 9% to 15% significantly reduces the texture score of threadfin bream meatballs. The amylose

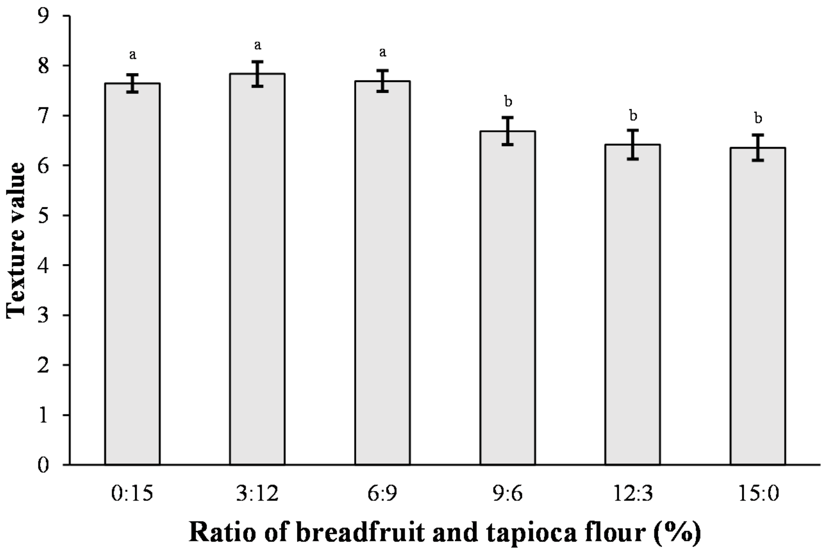

Figure 5 Texture of threadfin bream meatballs with breadfruit and tapioca flour; Different letters indicating a significant difference ($p<0.05$)

Gambar 5 Tekstur bakso ikan kurisi dengan tepung sukun dan tapioka; Huruf superskrip berbeda menunjukkan data signifikan berbeda ($p<0.05$)

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and amylopectin content in breadfruit flour is critical in determining meatball texture. Syam *et al*. (2019) reported that amylopectin contributes to adhesion, whereas amylose is crucial for hardness. This is consistent with Riskayanti (2018), who found that the smooth, non-soggy texture of chicken meatballs is due to the high amylose and amylopectin contents of breadfruit. The ability of meatballs to form a compact structure is primarily due to the cross-linking between starch and meat proteins. Huang & Bohrer (2020) explained that texture formation in emulsion products, such as meatballs, results from the cross-linking of myofibril proteins with starch, which forms disulfide bridges that facilitate gel formation, producing a chewy and resilient texture during heating.

A higher addition of breadfruit flour affected the texture of the fish meatballs. Breadfruit flour absorbs water and disrupts gelatinization processes, resulting in a less compact texture (Kaltari *et al*., 2016). Ananda (2021) reported that beef meatballs exhibit somewhat elastic and resilient textures, with average texture scores ranging from 4.07 to 4.27. According to SNI 7266:2014, the minimum acceptable texture score for fish meatballs is 7. Treatments (0:15), (3:12), and (6:9) met this standard, while the other treatments did not meet the standard but were still deemed acceptable by the panelists.

Overall acceptance

Figure 6 showed that different formulations of breadfruit and tapioca flour significantly affect the overall acceptance of threadfin bream meatballs ($p<0.05$). The treatments (0:15), (3:12), and (6:9) were not significantly different but showed a significant difference with (9:6), (12:3), and (15:0). The panelists liked and accepted the threadfin bream meatballs from treatments (0:15), (3:12), and (6:9), but the acceptance was significantly reduced to somewhat liked in (9:6), (12:3), and (15:0) treatments. The increasing concentration of breadfruit flour from 9% to 15% significantly lowered the overall acceptance of threadfin bream meatballs. Breadfruit flour is less favored due to browning during processing and its characteristic aroma, which cannot be entirely eliminated (Mehta et al., 2023). The most preferred fish meatballs are those with a smooth, non-porous, bright surface, a distinct fish aroma, a unique fish meatball flavor, and a

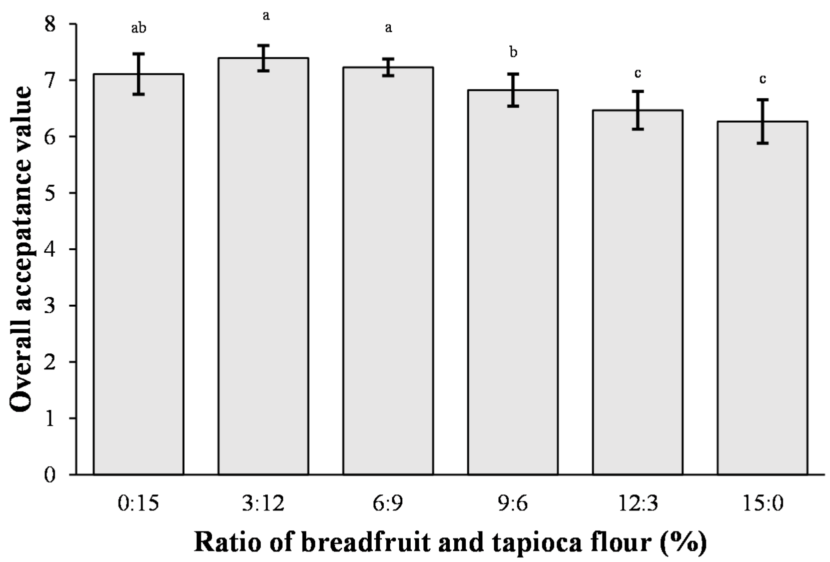

Figure 6 Overall acceptance of threadfin bream meatballs with breadfruit and tapioca flour; Different letters indicating a significant difference ($p<0.05$)

Gambar 6 Penilaian keseluruhan bakso ikan kurisi dengan tepung sukun dan tapioka; Huruf berbeda menunjukkan data signifikan berbeda ($p<0.05$)

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firm, compact, and elastic texture. Riskayanti (2018) reported that adding breadfruit flour to chicken meatballs affects their overall acceptance due to increased porosity, yellowish-brown hue, "langu" aroma, and slight bitterness. Ananda (2021) found that the highest average overall acceptance score for beef meatballs was observed in those with the lowest amounts of breadfruit flour. According to SNI 7266:2014 (BSN, 2014), fish meatballs should have an overall acceptance score of at least 7 to be considered acceptable. Treatments (0:15), (3:12), and (6:9) met these standards for overall acceptance, whereas the other treatments did not. However, fish meatballs were still favored by the panelists and deemed acceptable.

Physical Properties of Threadfin Bream Meatballs

The physical properties of threadfin bream meatballs were characterized by measurements of hardness, springiness, and cohesiveness, which numerically describe the texture of the product. Different formulations of breadfruit and tapioca flour significantly affected the hardness, springiness, and cohesiveness of threadfin bream meatballs ($p<0.05$). The result of physical properties analysis presented in Table 2.

Table 2 shows that the hardness values of threadfin bream meatballs from treatments (0:15) and (3:12) were not significantly different, but they were significantly different from those of (6:9), (9:6), and (12:3). The highest hardness value was observed in treatment (0:15), measuring 311.50 N. According to the texture scoring tests (Figure 5) and the SNI 7266:2014 standards, treatment (0:15) produced a firm, compact, and resilient texture. Conversely, the lowest hardness was recorded in (15:0) (208.25 N), indicating a less firm, compact, and resilient texture. Treatment (3:12), with a hardness of 295.50 N, exhibited a texture closely resembling that of the control, characterized by its firmness, compactness, and resilience. This suggests that the varying formulations of breadfruit and tapioca flour significantly affected the hardness of threadfin bream meatballs ($p<0.05$). The hardness of these meatballs was influenced by the fillers used, such as breadfruit and tapioca flour. Tapioca, with an amylose content ranging from 17.84 to 26.44% (Onitilo *et al*., 2007), contributes to a firmer and drier texture compared to breadfruit flour, which contains 22.52% amylose (Akanbi *et al*., 2009). Fillers with higher amylose content tend to produce harder products due to their propensity to dry out, as confirmed by Masita *et al*. (2017). Huang & Bohrer (2020) also reported similar results, where the hardness of cooked beef emulsions decreased at higher levels of breadfruit flour. Amylose, a straight-chain molecule, readily absorbs water and contributes to texture through gelatinization. Foods with a higher amylose content in their starch are typically drier and more absorbent, resulting in greater hardness.

Table 2 shows that the springiness value of threadfin bream meatballs from treatment (0:15) significantly differed with all treatments, while treatment (12:3) did not significantly differ with (9:6) and (15:0). The

Table 2 Physical characteristics of threadfin bream meatballs with breadfruit and tapioca flour

Tabel 2 Karakteristik fisik bakso ikan kurisi dengan tepung sukun dan tapioka

Formulations (%)	Hardness (N)	Springiness (mm)	Cohesiveness (mm)
0:15	311.50 ± 25.54^{a}	13.77 ± 0.31^{a}	1.38 ± 0.10^{a}
3:12	295.50 ± 24.85^{ab}	12.57 ± 0.29^{b}	1.22 ± 0.11^{ab}
6:9	265.19 ± 33.08^{bc}	11.20 ± 0.42^{c}	1.08 ± 0.11^{bc}
9:6	244.87 ± 33.55^{cd}	9.72 ± 0.57^{d}	0.98 ± 0.13^{c}
12:3	229.06 ± 32.57^{cd}	8.85 ± 0.58^{de}	0.72 ± 0.12^{d}
15:0	208.25 ± 13.49^{d}	8.10 ± 0.55^{e}	0.66 ± 0.11^{d}

Different letters in the same column indicating a significant difference ($p<0.05$)

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highest springiness value was recorded in (0:15) at 13.77 mm, indicating a firm, compact, and resilient texture. In contrast with 15:0 treatment had the lowest springiness value at 8.10 mm, reflecting a less firm, compact, and resilient texture. These differences in springiness values highlight the significant effect of various formulations of breadfruit and tapioca flour ($p<0.05$). The fiber content in breadfruit flour influences springiness, acting as a hydrocolloid capable of binding water, as described by Pontoluli *et al.* (2017). Fibers aid in water binding and interact with other macromolecules, such as proteins, enhancing elasticity by contributing to the structural properties of proteins that bind water and create elasticity. The high amylopectin content of the added flour also affects springiness values. Amylopectin enhances binding capacity and gel strength, thereby increasing elasticity (Suryono & Harijono, 2013). Breadfruit flour can improve water-binding capacity, aligning with Riskayanti (2018), who noted that the high amylopectin content in breadfruit flour helps to maintain elasticity. In this study, the springiness values decreased with the addition of breadfruit flour due to the higher amylopectin content in tapioca compared to that in breadfruit flour. Tapioca's amylopectin content ranges from 73.56% to 82.16% (Onitilo *et al.*, 2007), whereas breadfruit flour contains 77.48% amylopectin (Akanbi *et al.*, 2009).

Table 2 shows that the cohesiveness value of threadfin bream meatballs from treatments (0:15) and (3:12) were not significantly different but showed a significant difference with (9:6), (12:3), and (15:0). Cohesiveness was highest in treatment (0:15) (1.37 mm), indicating a firm, compact, and resilient texture. The lowest cohesiveness was observed in treatment (15:0) (0.65 mm), suggesting a less firm, compact, and resilient texture. This variation in cohesiveness is significantly affected by the formulation of breadfruit and tapioca flour ($p<0.05$). The cohesiveness of threadfin bream meatballs is affected by the amylose content in breadfruit flour. Fitriyani *et al.* (2017) observed that products made from high-amylose starch have denser structures than those made from lower-amylose starch. During cooking, meat proteins contract, and starch molecules contribute to the formation of a denser texture. Moisture content also influences cohesiveness, as breadfruit and tapioca flour affect the moisture content in the meatballs due to their amylose content, which readily absorbs water. Noor *et al.* (2019) reported that the water-holding capacity of breadfruit flour (1.5 g/g flour) is significantly higher than that of tapioca starch (0.8 g/g flour). This may contribute to increasing its cohesiveness, allowing it to withstand pressure better. Tapioca, with an amylose content ranging from 17.84 to 26.44% (Onitilo *et al.*, 2007), and breadfruit flour, with 22.52% amylose (Akanbi *et al.*, 2009), resulting in varying levels of cohesiveness. Lower amylose content in breadfruit flour leads to lower moisture content, thereby decreasing cohesiveness when added to the meatballs.

Table 3 Moisture and ash of threadfin bream meatballs with breadfruit and tapioca flour

Tabel 3 Kadar air dan abu bakso ikan kurisi dengan tepung sukun dan tapioka

Formulations (%)	Moisture (%)	Ash (%)
0:15	69.13±0.82^{a}	1.99±0.19^{c}
3:12	68.03±0.72^{ab}	2.22±0.27^{bc}
6:9	67.06±0.72^{b}	2.37±0.24^{bc}
9:6	66.78±0.63^{bc}	2.58±0.35^{ab}
12:3	65.55±0.62^{cd}	2.61±0.27^{ab}
15:0	64.99±0.40^{d}	2.77±0.33^{a}

Different letters in the same column indicating a significant difference ($p<0.05$)

Moisture and Ash Content of Threadfin Bream Meatballs

The chemical properties examined in this study include moisture content and ash content, which were compared to the Indonesian National Standard (SNI) for fish meatballs. The various formulations of breadfruit and tapioca flour significantly affected the moisture and ash content of threadfin bream meatballs ($p<0.05$). The results are shown in Table 3.

The lowest moisture content was recorded in treatment (15:0) at 64.99%, whereas the highest was recorded in treatment (0:15) at 69.13%. According to SNI 7266:2014, the optimal moisture content for fish meatballs reaches a maximum of 65%. Moisture content is influenced by the formulation of breadfruit and tapioca flour in meatballs. The size of starch granules, which are larger in tapioca than in breadfruit flour, tends to affect moisture content. Santoso *et al.* (2015) noted that larger starch granules gelatinize more easily and absorb more water. Breadfruit starch granule sizes range from 10 to 19 µm (Lubis *et al.*, 2006), whereas tapioca starch granules range from 17.4 to 35.9 µm. Larger tapioca starch granules lead to a higher moisture content in fish meatballs. The moisture content is also affected by the amylose content of the filler. Amylose readily absorbs water, and a higher amylose content increases the moisture content in the meatballs. The amylose content of tapioca ranges from 17.84 to 26.44% (Onitilo *et al.*, 2007), while breadfruit flour contains 22.52% amylose (Akanbi *et al.*, 2009). As the concentration of breadfruit flour increases, the moisture content decreases due to the lower amylose content of breadfruit flour. Ananda (2021) found that the moisture content in beef meatballs decreases with increased breadfruit flour concentration, with average values ranging from 70.69 to 71.95%. According to SNI 7266:2014, only the meatballs containing 15% breadfruit flour met the quality standard for maximum moisture content. However, this does not imply that other treatments were of inferior quality.

The lowest ash content was found in treatment (0:15) at 1.99%, while the highest was found in treatment (15:0) at 2.77%. This indicates that different formulations of breadfruit and tapioca flour significantly affect the ash content of threadfin bream meatballs. The increase in ash content is attributed to the higher ash content of breadfruit flour compared to tapioca. Breadfruit flour contains 1.58% ash (Sitohang *et al.*, 2015), while tapioca contains only 0.18% ash (Imaningsih, 2012). The ash content is related to the mineral content, purity, and cleanliness of the substance. According to Mehta *et al.* (2023), breadfruit flour contains minerals such as 314 mg of calcium, 924 mg of phosphorus, and 28.13 mg of iron. The addition of breadfruit flour led to an increased ash content in threadfin bream meatballs, consistent with Parapat *et al.* (2021), who found that higher ash content in snakehead fish hamburgers was associated with greater amounts of breadfruit flour, averaging between 2.22 and 2.62%. SNI 7726:2014 sets a maximum ash content limit of 2% for fish meatballs. In this study, only treatment P1 met this standard, although this does not imply that other treatments were of poor quality.

Determination of The Best Treatment

A recapitulation of the determination of the best treatment is presented in Table 4. By counting the total star notation on each treatment, it is known that treatment (3:12) was determined as the best treatment with 5 total stars, followed by without breadfruit flour and (6:9) with 4 stars and (15:0) with 1 star. The treatment 3% breadfruit flour: 12% tapioca showed a star notation at several parameters, such as appearance, taste, texture, taste (hedonic), and overall acceptance.

Protein and Crude Fiber Content of The Best Treatment

As shown in Table 5, the protein content of the best threadfin bream meatballs was 11.38%, representing an increase of 1.45% compared to meatballs without breadfruit flour. This protein content meets the SNI 7266:2014 standard. Although SNI 7266:2014 does not specify a standard for crude fiber in fish meatballs, comparing the crude fiber in the best treatment to the control revealed

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Table 4 The best treatment determination of threadfin bream meatballs with breadfruit and tapioca flour

Tabel 4 Perlakuan terbaik bakso ikan kurisi dengan tepung sukun dan tapioka

Parameter	Value	Treatments (%)											
		0:15		3:12		6:9		9:6		12:3		15:0	
		E	R	E	R	E	R	E	R	E	R	E	R
Appearance	0.11	1	0.11	0.883	0.097	0.825	0.091	0.293	0.032	0.163	0.018	0	0
Aroma	0.09	1	0.09	0.889	0.08	0.723	0.065	0.483	0.043	0.407	0.037	0	0
Taste	0.14	0.766	0.107	1	0.14	0.868	0.122	0.534	0.075	0.266	0.037	0	0
Taste (hedonic)	0.12	0.766	0.092	1	0.12	0.914	0.11	0.519	0.062	0.169	0.02	0	0
Texture	0.17	0.873	0.148	1	0.17	0.903	0.154	0.225	0.038	0.041	0.007	0	0
Overall acceptance	0.03	0.748	0.022	1	0.03	0.853	0.026	0.497	0.015	0.176	0.005	0	0
Hardness	0.08	1	0.08	0.845	0.068	0.551	0.044	0.355	0.028	0.202	0.016	0	0
Springiness	0.06	1	0.06	0.788	0.047	0.547	0.033	0.286	0.017	0.132	0.008	0	0
Cohesiveness	0.04	1	0.04	0.778	0.031	0.583	0.023	0.444	0.018	0.083	0.003	0	0
Moisture content	0.15	0	0	0.266	0.04	0.5	0.075	0.568	0.085	0.865	0.13	1	0.15
Ash content	0.01	1	0.01	0.705	0.007	0.513	0.005	0.244	0.002	0.205	0.002	0	0
Total	**1**		**0.76**		**0.83**		**0.75**		**0.42**		**0.28**		**0.15**

Table 5 Protein and crude fiber content of the best treatment of threadfin bream meatballs

Tabel 5 Kadar protein dan serat kasar perlakuan terbaik bakso ikan kurisi dengan tepung sukun dan tapioka

Parameter	Without breadfruit flour	3% breadfruit flour:12% tapioca	SNI 7662:2014
Protein	9.93±0.24	11.38±0.57	Min 7
Crude fiber	0.57±0.14	0.71±0.04	-

that the control treatment had 0.57% crude fiber, while the best treatment had 0.71%. The increase in protein and crude fiber content in threadfin bream meatballs can be attributed to the inclusion of breadfruit flour. According to Noor *et al.* (2019), breadfruit flour contains 5.74 g of protein and 5.44 g of crude fiber per 100 g, whereas tapioca contains only 0.3 g of fiber per 100 g. The formulation of 3% breadfruit flour and 12% tapioca as fillers resulted in a 0.14% increase in the crude fiber content of the threadfin bream meatballs.

CONCLUSION

Using 3% breadfruit flour and 12% tapioca to manufacture threadfin bream fish meatballs improved their taste, texture, and chemical (moisture and ash) properties in accordance with SNI 7266:2014 criteria. This formulation resulted in a widely accepted product with increased protein and fiber content.

REFERENCES

Agustin, T. I. (2012). Mutu fisik dan mikrostruktur kamaboko ikan kurisi dengan penambahan karaginan. *Jurnal Pengolahan Hasil Perikanan Indonesia*, 15(1), 17-26. https://doi.org/10.17844/jphpi.v15i1.5329

Akanbi, T., Nazamid, S., & Adebowale, A. A. (2009). Functional and pasting properties of a tropical breadfruit (*Artocarpus altilis*) starch from Ile-Ife, Osun State, Nigeria. *International Food Research Journal*, 16(2), 151-157.

Ananda, A. I. (2021). Sifat fisikokimia dan organoleptik bakso daging sapi dengan penambahan tepung sukun (*Artocarpus altilis*). [Skripsi]. Institut Pertanian Bogor.

Ardianti, Y., Widyastuti, S., Rosmilawati., Saptono., & Handito, D. (2014). Pengaruh penambahan karagenan terhadap sifat fisik dan organoleptik bakso ikan tongkol (*Euthynnus affinis*). *Agroteksos*, 24(3), 159- 166.

Association of Official Agricultural Chemists. (2019). Official Methods of Analysis of The Association of Official Analytical of Chemist 21st Edition. Benjamin Franklin Station.

Aziza, T., Affandi, D.R., & Manuhara, G.J. (2015). Bakso ikan tongkol (*Euthynnus affinis*) dengan filler tepung gembili sebagai fortifikan inulin. *Jurnal Teknologi Hasil Pertanian*, 8(2), 77-83. https://doi.org/10.20961/jthp.v0i0.12894

Badan Pusat Statistik. (2023). Produksi Tanaman Buah-buahan. https://www.bps.go.id/id/statistics-table/2/NjIjMg==/produksi-tanaman-buah-buahan.html.

Badan Standaridsasi Nasional. (2011). Petunjuk Pengujian Organoleptik dan atau Sensori Pada Produk Perikanan. SNI 2346:2011.

Badan Standardisasi Nasional. (2014). Bakso Ikan. SNI 7266:2014.

Badan Standardisasi Nasional. (2015). Produk Pangan Pertanian – Penentuan Kadar Serat Kasar – Metode Umum. SNI ISO 5498:2015.

De Garmo, E. P., Sullivan, W. G., & Bontadelli, J. A. (1988). Engineering Economy. 8th Ed. Macmillan.

Fadlan, M., Nurhayati, A., Maulina, I., & Rizal, A. (2022). Analysis of consumer preferences in selecting processed fish products (case study in Bendungan Hilir Market, Central Jakarta, Indonesia). *Asian Journal of Fisheries and Aquatic Research,* 16(2), 8-15. https://doi.org/10.9734/ajfar/2022/v16i230367

Fitriyani, E. (2017). Tepung ubi jalar sebagai bahan filler pembentuk tekstur bakso ikan. *Jurnal Galung Tropika*, 6(1), 19-32. https://doi.org/10.31850/jgt.v6i1.197

Ginting, W. M., Meriahta, D., & Manurung, J. (2020). Formulasi tepung sukun dan formula tempe dalam pembuatan biskuit pada balita. *Ghidza: Jurnal Gizi dan Kesehatan*, 4(2), 131-142. http://dx.doi.org/10.22487/ghidza.v4i2.149

Huang, S., & Bohrer, B. M. (2020). The effect of tropical flours (breadfruit and banana) on structural and technological properties of beef emulsion modeling systems. *Meat Science*, 163(5), 1-11. https://doi.org/10.1016/j.meatsci.2020.108082

Imaningsih, N. (2012). Profil gelatinisasi beberapa formulasi tepung-tepungan untuk pendugaan sifat pemasakan. *Penelitian Gizi Makan*, 35(1), 13-22.

Jumiati, S., Rahmaningsih, & Sudianto, A. (2021). Mutu kerupuk limbah insang ikan kurisi (*Nemipterus japonicus*) ditinjau dari analisis proksimat. *Jurnal Teknologi Pangan*, 15 (1), 1-11. https://doi.org/10.33005/jtp.v15i1.2715

Kaltari, B. I., Setyowati, S., & Dewi, D. P. (2016). Pengaruh variasi pencampuran tepung talas bogor (*Colocasia esculenta* L. Schott) dan kacang merah (*Phaseolus vulganis* L.) terhadap sifat fisik, tingkat kesukaan, kadar protein dan kadar serat pada *cookies* talas rendah protein. *Jurnal Nutrisia*, 18(1), 51-57. https://doi.org/10.29238/jnutri.v18i1.84

Kementerian Kelautan dan Perikanan Republik Indonesia. (2023). Data Angka Konsumsi Ikan. https://statistik.kkp.go.id/home.php?m=aki&i=209#panel-footer.

Kementerian Kelautan dan Perikanan Republik Indonesia. (2024). Produksi Perikanan. https://statistik.kkp.go.id/home.php?m=prod_ikan_prov&i=2#panel-footer.

Khotimah, K., Kusumaningrum, I., & Afiah, R. N. (2024). Profil tekstur dan uji hedonik bakso ikan lele dengan penambahan tepung ubi kelapa (*Dioscorea alata*). *Jurnal Pengolahan Hasil Perikanan*

This work is licensed under CC BY 4.0.

Indonesia, 27(8), 693-705. http://dx.doi.org/10.17844/jphpi.v27i8.50811

Lubis, Y. M., Kumalaningsih, S., & Susanto, T. (2006). Tepung komposit berbasis tepung sukun (*Artocarpus artilis*) hasil modifikasi alkali untuk pembuatan biskuit. *Jurnal Teknologi Pertanian*, 7(3), 173-183.

Masita, S., Wijaya, M., & Fadilah, R. (2017). Karakteristik sifat fisiko-kimia tepung sukun (*Artocarpus altilis*) dengan varietas Toddo'Puli. *Jurnal Pendidikan Teknologi Pertanian*, 3(1), 234-241. http://dx.doi.org/10.26858/jptp.v3i0.5722

Mehta, K. A., Quek, Y. C. R., & Henry, C. J. (2023). Breadfruit (*Artocarpus altilis*): Processing, nutritional quality, and food applications. *Frontiers in Nutrition,* 10(3), 1-13. https://doi.org/10.3389/fnut.2023.1156155

Montolalu, S., Lontaan, N., Sakul, S., & Mirah, A. D. (2017). Sifat fisiko-kimia dan mutu organoleptik bakso broiler dengan menggunakan tepung ubi jalar (*Ipomoea batatas* L.). *ZOOTEC*, 32(5), 1-13. https://doi.org/10.35792/zot.32.5.2013.986

Muttaqin, B., Surti, T., & Wijayanti, I. (2016). Pengaruh konsentrasi *egg white powder* (EWP) terhadap kualitas bakso dari ikan lele, bandeng, dan kembung. *Jurnal Pengolahan dan Bioteknologi Hasil Perikanan*, 5(3), 9-16.

Noor, S. N. M., Zakaria, Z., & Hussin, N. (2019). Physicochemical and functional properties of breadfruit flour, commercial wheat flour and starches. *Bioscience Research,* 16(SI2), 203-212.

Novrini, S. (2020). Pengaruh persentase tepung sukun dalam campuran tepung dan gula terhadap mutu *cookies* sukun. *Agriland: Jurnal Ilmu Pertanian*, 8(1), 61-65. https://doi.org/10.30743/agr.v8i1.2590

Nurilmala, M., Suptijah, P., & Nurfianti, D. (2007). Penggunaan kitosan sebagai pembentuk gel pada bakso ikan kurisi (*Nemipterus nematophorus*). *Jurnal Pengolahan Hasil Perikanan Indonesia*, 10(1), 35-46. https://doi.org/10.17844/jphpi.v10i1.968

Oktaviyani, S., Boer, M., & Yonvitner, Y. (2016). Aspek biologi ikan kurisi (*Nemipterus japonicus*) di Perairan Teluk Banten. *Bawal Widya Riset Perikanan Tangkap*, 8(1), 21-28. http://dx.doi.org/10.15578/bawal.8.1.2016.21-28

Onitilo, M. O., Sanni, L. O., Oyewole, O. B., & Maziya-Dixon, B. (2007). Physicochemical and functional properties of sour starches from different cassava varieties. *International Journal of Food Properties*, 10(3), 607-620. http://dx.doi.org/10.1080/10942910601048994

Parapat, C. S., Evnaweri, E., & Ratnasari, I. (2021). Kajian sifat fisika kimia hamburger ikan gabus dengan substitusi tepung sukun. *Journal of Tropical Fisheries*, 16(1), 9-22. https://doi.org/10.36873/jtf.v16i1.7803

Permanasari, I. A., Ibrahim, R., & Rianingsih, L. (2014). Pengaruh perbedaan jenis viscera ikan sebagai bahan baku dan penambahan enzim tripsin terhadap mutu kecap ikan. *Jurnal Pengolahan dan Bioteknologi Hasil Perikanan*, 3(2), 82-89.

Pontoluli, D. F., Assa, J. R., & Mamuaja, C. F. (2017). Karakteristik sifat fisik dan sensoris mie basah berbahan baku tepung sukun (*Arthocarpus altilis*) dan tepung ubi jalar ungu (*Ipomea batatas i*). *Jurnal Unsrat*, 1(8), 1-12. https://doi.org/10.35791/cocos.v1i8.17831

Pradana, A. V. Y. (2018). Pengaruh kombinasi tepung tapioka dan tepung terigu terhadap sifat fisikokimia dan organoleptik bakso ikan kurisi *(Nemipterus japonicus)*. [Skripsi]. Universitas Brawijaya.

Pratiwi, T., & Hakiki, D.N. (2021). The effect of variation of tapioca flour on the level of likes of milkfish presto (*Channos channos* Forsk) meatballs. *FOOD SCIENTIA: Journal of Food Science and Technology*, 1(2), 131-141. https://doi.org/10.33830/fsj.v1i2.2075.2021

Rabago, C.C. (2022). Utilization of breadfruit (*Artocarpus altilis*) on tart dough production. *Science International (Lahore)*, 34(6), 75-79.

Ratnasari, D., Wening, D. K., Dewi, Y., & Qomariyah, R. N. (2021). Bakso sapi ikan kembung sebagai alternatif jajanan sehat tinggi protein untuk anak sekolah dasar. *Jurnal Ilmiah Gizi Kesehatan (JIGK)*, 3(1), 9-16. https://doi.org/10.46772/jigk.v3i01.560

Riskayanti. (2018). Pengaruh penambahan tepung sukun (*Artocarpus communis*) terhadap kualitas bakso daging ayam. [Skripsi]. UIN Alaudin Makassar.

Rosyidah, A. Z., & Ismawati, R. (2016). Studi tentang tingkat kesukaan responden terhadap penganekaragaman lauk pauk dari daun kelor (*Moringa oleivera*). *E-journal Boga*, 5(1), 17-22.

Saepudin, L., Setiawan, Y., & Sari, P. D. (2017). Pengaruh perbandingan substitusi tepung sukun dan tepung terigu dalam pembuatan roti manis. *Agroscience*, 7(1), 227-243.

Santosa, H., Handayani, N. A., Fauzi, A. D., & Trisanto, A. (2018). Pembuatan beras analog berbahan dasar tepung sukun termodifikasi *heat moisture treatment*. *Jurnal Inovasi Teknik Kimia*. 3(1), 37-45. http://dx.doi.org/10.31942/inteka.v3i1.2124

Santoso, B., Pratama, F., Hamzah, B., & Pambayun, R. (2015). Karakteristik fisik dan kimia pati ganyong dan gadung termodifikasi metode ikatan silang. *Jurnal Agritech*, 35(3), 233-279. https://doi.org/10.22146/agritech.9337

Sitohang, K. A., Lubis, Z., & Lubis, L. M. (2015). Pengaruh perbandingan jumlah tepung terigu dan tepung sukun dengan jenis penstabil terhadap mutu *cookies* sukun. *Jurnal Rekayasa Pangan dan Pertanian*, 3(3), 308-315.

Suryono, M., & Harijono, Y. (2013). Pemanfaatan ikan tuna (*Yellowfin tuna*), ubi jalar (*Ipomoea batatas*) dan sagu (*Metroxylon sago sp.*) dalam pembuatan kamaboko. *Jurnal Teknologi Pertanian*, 14(1), 9-20.

Syam, J., Irmawaty, I., & Kasyim, K. (2019). Substitusi tepung sukun (*Artocarpus altilis* [parkinson.] Fosber) sebagai *filler-binder* dalam bakso daging sapi. *Jurnal Ilmu Dan Industri Peternakan*, 5(1), 12-20. https://doi.org/10.24252/jiip.v5i1.11099

Untoro, N. S., Kusrahayu, K., & Setiani, B. E. (2012). Kadar air, kekenyalan, kadar lemak dan citarasa bakso daging sapi dengan penambahan ikan bandeng presto (*Channos channos* Forsk). *Animal Agriculture Journal*, 1(1), 567-583.

Widiyanto, Uju, & Nurilmala, M. (2022). Karakteristik kolagen dari kulit dan sisik ikan coklatan, swanggi, dan kurisi sebagai bahan gelatin. *Jurnal Pengolahan Hasil Perikanan Indonesia*, 25(3), 512-527. http://dx.doi.org/10.17844/jphpi.v25i3.43598

Yufidasari, H. S., Nursyam, H., & Ardianti, B. P. (2018). Penggunaan bahan pengemulsi alginat dan substitusi tepung kentang pada pembuatan bakso ikan gabus (*Channa striata*). *Journal of Fisheries and Marine Research*, 2(3), 178-185. https://doi.org/10.21776/ub.jfmr.2018.002.03.6

Yulianto,M.K.D.,Evnaweri,&Sulistyaningrum, T.W. (2020). Substitution of breadfruit flour on little tuna sempol. *Journal of Tropical Fisheries*, 15(2), 50-60. https://doi.org/10.36873/jtf.v15i2.7797

Yusuf, I. E., Swamilaksita, P. D., Ronitawati, P., Fadhilla, R., & Dewanti, L. P. (2022). Pengembangan tepung sukun dan tepung kacang tunggak dalam pembuatan kue mangkok. *Jurnal Pangan dan Gizi*, 12(1), 71-82. https://doi.org/10.26714/jpg.12.1.2022.71-82

Zahiruddin, W., Erungan, A. C., Wiraswanti, I. (2008). Pemanfaatan karagenan dan kitosan dalam pembuatan bakso ikan kurisi(*Nemipterus nematophorus*) pada penyimpanan suhu dingin dan beku. *Jurnal Pengolahan Hasil Perikanan Indonesia*, 11(1), 40-52. https://doi.org/10.17844/jphpi.v11i1.930

Zhang, J., Wu, W. Z., & Mi, Q. (2011). Phenolic compounds from *Canna edulis* Kerr. and their antioxidant activity. *Food Science and Technology*, 44, 2091-2096. http://dx.doi.org/10.1016/j.lwt.2011.05.021