Available online: journal.ipb.ac.id/index.php/jphpi


# CHARACTERISTICS OF DRY NOODLES BASED ON SAGO FLOUR ENRICHED WITH SKIPJACK TUNA (*Katsuwonus pelamis*)

**Christina Litaay[1]*, Joko Santoso[2], Bambang Hariyanto[3], Ashri Indriati[1], Moeso Andrianto[1]*, Pradeka Brilyan Purwandoko[1], Nurhaidar Rahman[1], Indriawati[4], Sandi Sufiandi[4]**

[1]Research Center for Appropriate Technology, National Research and Innovation Agency
Ks. Tubun street No.5, Cigadung, Subang, West Java Indonesia 41213
[2]Department of Aquatic Product Technology, IPB University
Agatis street IPB Dramaga , Bogor, West Java Indonesia 16680
[3]Food Technology, Faculty of Food and Health Technology, Sahid University
Prof. Dr. Supomo street No. 84 Tebet South Jakarta, Indonesia 12870
[4]Directorate of Laboratory Management, Research Facilities, and Science and Technology Park
National Research and Innovation Agency
Raya Bogor street, Cibinong West Java Indonesia 16911

Submitted: 21 May 2024/Accepted: 9 December 2024
*Korespondensi: christina_litaay@yahoo.com, moesoandrianto@gmail.com

**How to cite (APA Style 7th)**: Litaay, C., Santoso, J., Hariyanto, B., Indriati, A., Andrianto, M., Purwandoko, P. B., Rahman, N., Indriawati, & Sufiandi, S. (2024). Characteristics of dry noodles based on sago flour enriched with skipjack tuna (*Katsuwonus pelamis*) flour. *Jurnal Pengolahan Hasil Perikanan Indonesia,* 27(12), 1181-1194. http://dx.doi.org/10.17844/jphpi.v27i12.55616

**Abstract**

Indonesia is one of the countries with the largest consumption of instant noodles. The demand for wheat imports has increased along with the increased consumption of noodles made from wheat flour. Sago flour is recommended for use as a raw material for noodles. The nutritional content of fish can increase the nutritional value of noodle products. This study aimed to determine the optimal concentration of skipjack tuna flour for sago flour-based dry noodles based on their lightness value and consumer preferences. The study included five treatments for sago-based dry noodles: control, skipjack tuna flour 2, 4, 6, and 8%. Dry noodles were then analyzed for lightness value and organoleptic. The best treatment then analyzed chemical composition (protein and ash content) and microstructure. The addition of skipjack tuna flour had a significant effect ($p<0.05$) on the lightness, aroma, and overall parameters. The lightness, aroma, and overall value of the 8% skipjack tuna flour were better than the control and other treatment noodles. Dry noodles with the addition of 8% skipjack tuna flour had a fragrant aroma, slightly less clear color, a delicious noodle taste, and a texture close to chewy; therefore, it was still acceptable to panelists. The noodle treatment with the incorporation of 8% skipjack tuna flour produced a high protein content of 5.56% (dry weight) and ash content of 1.12% (dry weight). Noodles with skipjack tuna flour (8%) have slightly truncated elliptical granules, and wheat noodles have elliptical granules.

Keywords: ash content, fish-based protein, fortification, lightness value, microstructure

## Karakteristik Mi Kering Berbasis Tepung Sagu yang Diperkaya Tepung Ikan Cakalang (*Katsuwonus pelamis*)

**Abstract**

Indonesia merupakan salah satu negara dengan konsumsi mi instan terbesar. Permintaan impor gandum meningkat seiring dengan meningkatnya konsumsi mi berbahan tepung terigu. Tepung sagu direkomendasikan untuk digunakan sebagai bahan baku mi. Kandungan gizi ikan dapat meningkatkan nilai gizi produk mi. Penelitian ini bertujuan untuk menentukan konsentrasi tepung ikan cakalang yang optimal untuk mi kering berbahan tepung sagu berdasarkan karakteristik kecerahan dan kesukaan konsumen. Mi kering berbahan dasar sagu terdiri dari lima perlakuan, yaitu kontrol, tepung ikan cakalang 2, 4, 6, dan 8%. Parameter yang dianalisis meliputi *lightness* dan organoleptik. Perlakuan terbaik kemudian dianalisis kadar protein, abu, dan mikrostruktur. Penambahan tepung ikan cakalang memberikan pengaruh yang nyata ($p$<0,05) terhadap parameter lightness, aroma, dan keseluruhan. *Lightness*, aroma, dan nilai keseluruhan mi tepung ikan cakalang 8% lebih baik dibandingkan dengan kontrol dan perlakuan lainnya. Mi kering dengan penambahan tepung ikan cakalang 8% memiliki aroma harum, warna agak kurang bening, rasa mi enak, dan tekstur mendekati kenyal sehingga masih dapat diterima panelis. Perlakuan mi dengan penambahan tepung ikan cakalang 8% menghasilkan kadar protein tinggi, yaitu 5,56% (bk) dan kadar abu 1,12% (bk). Mi dengan penambahan tepung ikan cakalang 8% memiliki butiran elips agak terpotong, sedangkan mi gandum memiliki butiran elips.

Kata kunci: fortifikasi, kadar abu, mikrostruktur, nilai kecerahan, protein berbasis ikan

## INTRODUCTION

Indonesia is one of the countries with the largest consumption of instant noodles worldwide, where in 2020 a total consumption of 12,640 million servings occurred (World Instant Noodle Association, 2021). The growing consumption of noodles in Indonesia suggests that noodle products are highly favored by consumers. Indonesians have a preference for consuming a variety of noodles. According to Okoye *et al.* (2008), the preparation of noodles involves a dough without yeast, followed by the stretching, extrusion, and cutting of noodle strands into diverse shapes. Noodles are generally prepared from semolina, wheat flour, and water. In addition, there are raw materials, such as mocaf flour, tapioca flour, and corn flour (Lena *et al.*, 2022; Rahmawati *et al.*, 2024). In addition, noodles are a popular product because of their long shelf life and low cost (Fradique *et al.*, 2013).

The demand for wheat imports has increased along with the increased consumption of noodles made from wheat flour. This could potentially reduce the country's foreign exchange reserves due to the increased demand for noodles, which in turn leads to an increase in the volume of wheat imports and the consumption of gluten-containing wheat flour. Gluten is a cohesive mass consisting of gliadin and glutenin, which influences chewy cooking properties and elasticity so that the dough does not break easily (Wrigley *et al.*, 2006). Sago is a food commodity that generates significant amounts of carbohydrates within stable and sustainable ecosystem dynamics (Bantacut, 2011). According to Mawaddah *et al.* (2021), sago starch has a high swelling capacity of 97%. The nutritional composition of sago starch is moisture content 40.21%, protein <0.10%, fat 0.15%, ash 0.20%, and carbohydrate 80.45% (Mustafa *et al.*, 2019). Researchers recommend using sago flour as a raw material for noodles (Litaay *et al.*, 2023) and suggest its potential as a main food ingredient substitute for wheat flour (Suparmi *et al.*, 2021; Pari *et al.*, 2024).

Sago offers several advantages, including being gluten-free, having a high-resistance starch content, a low glycemic index, providing high nutrition (calcium, phosphorus, iron, and high carbohydrate content), and serving as a viable replacement for wheat flour (10–20%). Sago's high carbohydrate content contrasts with its low protein content, necessitating the addition of protein sources, such as fish, to enhance the protein content of noodles (Litaay *et al.*, 2022b). Gluten-free noodles or pasta incorporate several proteins, including rice protein, casein, and egg white powder (Park & Kim, 2023). The incorporation of animal proteins, such as fish, is useful for increasing the nutritional content of sago-based products (Novitasari, 2020; Litaay *et al.*, 2022b). The nutritional content of fish can increase the nutritional value of noodle products. According to Brito *et al.* (2019), fish are nutritionally beneficial to health. Low fish consumption can affect stunting, health, and food security (Litaay *et al.*, 2021).

Functional foods are being increasingly developed in line with the increasing demand for fish protein ingredients (Thorkelsson *et al.*, 2009). A lot of different researchers have used fish in food products, such as catfish flour in dry noodles (Hastuti *et al.*, 2023), tilapia fish and snakehead fish (Fitriani, 2018), seaweed flour (Murniyati *et al.*, 2010), skipjack flour added to instant taro porridge (Yulianti, 2018), eel flour flakes (Mayasti *et al.*, 2022), lemuru biscuits (Asare *et al.*, 2018), crackers (Junianto *et al.*, 2019), wet noodles made from long-jawed mackerel, mackerel tuna, and pangas catfish flour (Amalia *et al.*, 2024), and noodles made with anchovy meal, mackerel, and tuna.

Skipjack tuna is one of Indonesia's leading commodities, with its total export valuation in early 2023 reaching US$330,050, or the equivalent of IDR 5.1 billion. The export target for skipjack tuna reaches around 3,500 tons. The catch of skipjack tuna in 2023 was 29,488.5 tons (Budiman, 2024). The protein content of skipjack tuna is 25.29% (db) (Nurjanah *et al.*, 2015), and after processing into flour, it increases to 82.86% (db) (Litaay, 2012; Litaay & Santoso, 2013). Skipjack tuna has a chemical composition of 20.15% protein, 1.94% ash, 73.03% moisture, 3.39% fat, and 2.35% carbohydrate (Intarasirisawat *et al.*, 2011). The protein in skipjack tuna consists of 9 essential amino acids (tyrosine, histidine, valine, threonine, isoleucine, methionine, lysine, phenylalanine, leucine) and 6 non-essential amino acids (glutamic acid, glycine, alanine, aspartic acid, serine, arginine) (Yusida *et al.*, 2014; Putri, 2018). Skipjack tuna has the potential to diversify local food, for instance, by processing it into flour and incorporating it into various food matrices. Skipjack tuna flour had protein and fat content of 82.86±0.42% and 1.10±0.00%, respectively, on a dry basis (Litaay, 2012; Litaay & Santoso, 2013). The high nutritional content of skipjack tuna remains underutilized. According to Lahagu *et al.* (2023), the potential for developing the nutritional value and benefits of skipjack tuna remains limited due to its limited utilization. The use of Skipjack's fish meal can enrich the protein content of noodles. This study aimed to determine the optimal concentration of skipjack tuna flour for sago flour-based dry noodles based on their physicochemical characteristics and consumer preferences.

## MATERIALS AND METHODS

### Production of Skipjack Tuna Flour

Skipjack tuna (*Katsuwonus pelamis*) was obtained from a local market in Tulehu, Salahutu Village, Central Maluku Regency, Indonesia. Skipjack tuna fish flour was prepared according to the method described by BSN (2013) with modification. The process of preparing fish meal involves washing the fish with clean water to remove dirt, followed by removing the head, gills, stomach contents, tail, and scales. The next process is filleting (separating from the skin and bones) the fish meat, which will be immersed in 0.8% sodium bicarbonate immersion for 6 hr. The next stage is boiling for 10 min at 80°C, then pressing (Press-Tokyo Jepang) for 10 min, drying (Heraeus) at 50°C for 5 hr, and sifting (60 mesh sieve).

### Production of Dry Noodles

The preparation of dry noodles was referred to BSN (2015) with modification. Sago flour was obtained from a local market in Ambon City (Maluku, Indonesia), which is produced by a home industry. The sago flour (*Metroxylon* sp.) had a carbohydrate content of 83.35% on a dry basis before the experiment. Table 1 presents the formulation for making dry noodles. The dry noodle formulation is made based on the percentage of sago flour, namely 2, 4, 6, and 8%. All dry ingredients (sago flour and skipjack tuna flour) were mixed in a mixer (Philips HR 1559/10, China) at a speed of 1 for 15 min, and then water and salt were added slowly. The dough is mixed in a mixer for 15 min, and then the starch is pregelatinized for 30 min by steaming the dough (60°C). Next, the noodle strands were formed at an extruder and then tempered at room temperature (27°C) for 48 hr. Dry noodles were then analyzed for lightness value and organoleptic. The best treatment then analyzed chemical composition (protein and ash content) and microstructure.

### Lightness Analysis (Gaurav, 2003)

Color lightness testing was identified using the Minolta Chroma Meter (type CR 200, Japan). The instrument uses white as the

http://dx.doi.org/10.17844/jphpi.v27i12.55616

Table 1 Dry noodle formulation with different concentrations of skipjack tuna flour
Tabel 1 Formulasi mi kering dengan perbedaan konsentrasi tepung ikan cakalang

| Ingredients | Skipjack tuna flour addition to dry noodles (%) | | | | |
|---|---|---|---|---|---|
| | 0 | 2 | 4 | 6 | 8 |
| Sago flour (g) | 78.74 | 77.52 | 76.34 | 75.19 | 74.07 |
| Skipjack tuna flour (g) | 0.00 | 1.55 | 3.05 | 4.51 | 5.93 |
| Salt (g) | 1.57 | 1.55 | 1.53 | 1.50 | 1.48 |
| Water (mL) | 19.69 | 19.38 | 19.08 | 18.80 | 18.52 |

standard color to calibrate the chromameter. Place the sample for use in a flat container. The analysis of color lightness was carried out by reading the color scale on a color reader with the parameter lightness (L).

## Organoleptic Analysis (Soekarto & Hubeis, 2000)

A scoring test was used to determine organoleptic/sensory quality characteristics. The test was performed using dry sago noodles, which were boiled according to the cooking time provided in wet form and coded according to the treatment. The panelists were asked to perform the assessment. The assessment was carried out by 20 untrained panelists (11 women and 9 men), including texture, odor, taste, and color, using the organoleptic test assessment criteria. Table 2 presents the organoleptic test assessment criteria.

## Protein Content Analysis (AOAC, 2005)

A sample of 0.1-0.5 g of noodles was placed in a 100 mL Kjeldahl flask (Pyrex, China), and K2SO4 (1.9 mg), HgO (40 mg), and $H_2SO_4$ (2 mL) were added. Next, the heating process was performed for 1-1.5 hours until the solution was clear. The solution was then added to distilled water (1-2 mL) and 40% NaOH (20 mL) and then distilled. The results were put into a Pyrex 125 mL Erlenmeyer flask along with 5 mL of $H_3BO_0$ and 2–4 drops of indicator. Next, 8–10 mL of $NaOH\text{-}Na_2S_2O_3$ was added. Distillation was stopped when the volume was 15 mL, dilution was carried out to 50 mL, and titration was performed with HCl (0.02 N) until the color was pink. We calculated the total nitrogen content using Formulas 1 and 2.

$$N\ (\%) = \frac{(A\text{-}B) \times NHCl \times 14}{\text{sample (mg)}} \times 100$$

$$\text{Protein}\ (\%) = N \times \text{conversion factor}\ (6.25)$$

Table 2 Organoleptic test assessment criteria
Tabel 2 Kriteria penilaian organoleptik

| Scale | Aroma | Color | Taste | Texture |
|---|---|---|---|---|
| 1 | Very less fragrant | Very less bright | Very less delicious | Very less chewy |
| 2 | Less fragrant | Less bright | Less delicious | Less chewy |
| 3 | Slightly less fragrant | A slightly less bright yellow/brownish | A bit less delicious | A slightly less chewy |
| 4 | Fragrant | Bright yellow | Delicious | Chewy |
| 5 | Slightly more fragrant | A bit brighter | A bit more delicious | Slightly chewier |
| 6 | More fragrant | Brighter | More delicious | Chewier |
| 7 | Very more fragrant | Very brighter | Very more delicious | Very chewier |

Note:
A = sample titration (mL)
B = titration blank (mL)
N = nitrogen (%)

### Ash Content Analysis (AOAC, 2005)

Ash content was measured by a dry ashing method. The cup was dried in an oven (Heraeus, Spain) at 100-105°C for 30 min and cooled for ±30 min, then weighed. A total of 5 g of sample was put into a cup, then burned at a temperature of 400°C, then 550°C, for 12-24 hours until the weight was constant. The cup was cooled for 30 min in a desiccator (scn simax, UK) and weighed. Calculation of ash content based on:

$$\text{Ash (\%)} = \frac{\text{(A-B)}}{\text{C}} \times 100$$

Note:
A = final weight (g)
B = weight of empty cup (g)
C = sample weight (g)

### Microstructure Analysis (Toya *et al.*, 1986)

The microscopic structure of sago noodles with the incorporation of fish protein was observed using SEM S-4800 (Hitachi, Madrid, Spain). The sample is sprinkled on the specimen holder, which is covered with double sticky tape, then coated with a gold-platinum thickness of 400 Å (JFC-1100) in an ion sputter machine. The sample that has been coated with palladium gold is then inserted into the SEM machine for shooting at 150× magnification for granule differences and 500× magnification for the inner section structure. The results show a three-dimensional image of the surface of the granules and the inside cross-section of the sago noodles incorporating fish protein. The observed samples included noodles without fish protein (control), noodles with 8% fish protein, commercial sago noodles, and wheat noodles.

### Statistical Analysis

Data were analyzed using the one-way ANOVA method. The study design used a completely randomized design (CRD) with one treatment, namely the concentration of skipjack tuna flour (Steel & Torrie, 1993). Data on protein and ash that were significant ($p<0,05$) were further analyzed using the Duncan test. Organoleptic results were analyzed using the Kruskal-Wallis nonparametric statistical test (Mattjik & Sumertajaya, 2006). Data on aroma, color, taste, and texture that were significant ($p<0,05$) were further analyzed using the multiple comparison test. Data were analyzed in three replications. Data were processed using IBM SPSS Statistics 20 (IBM Corp., USA).

## RESULTS AND DISCUSSION

### Organoleptic and Lightness Characteristics

The addition of skipjack tuna flour had a significant effect ($p<0.05$) on the lightness of noodles. The control treatment was not significantly different from the 2, 4, and 6% skipjack tuna flour treatments, but it was significantly different from the 8% treatment. The addition of 8% skipjack tuna flour yielded the highest lightness value (48.34), suggesting that the noodles tended to be bright or white in color. The more skipjack tuna flour added to sago starch, the more significant was the effect of skipjack tuna flour on increasing the lightness value. Table 3 presents the lightness values.

Irsalina *et al.* (2016) showed that noodles supplemented with 20% motan fish flour (*Thynnichthys thynnoides*) decreased the lightness value. Supplementation with bean by-products significantly decreases the lightness value of dry noodles (Sofi *et al.*, 2019). Meanwhile, noodles in the treatment without skipjack tuna flour had the lowest color lightness value of 42.49. This result is in line with the research of Hidayat & Rosidah (2022), where the lightness value of corn tortillas without the addition of snakehead fish bone flour was 55.58 and increased to 63.08 with the addition of 6% snakehead fish bone flour. The difference in color lightness occurs due to differences in the concentration of skipjack tuna flour and the reaction between the proteins and reducing sugars. The lightness value rose as the concentration of skipjack tuna flour in the noodle dough increased.

Table 3 Hedonic and lightness value of noodles based on sago flour and skipjack tuna flour
Tabel 3 Penilaian hedonik dan kecerahan mi berbasis tepung sagu dan tepung cakalang

| Skipjack tuna flour (%) | Lightness | Aroma | Color | Taste | Texture | Overall |
|---|---|---|---|---|---|---|
| 0 | 42.49±0.37[b] | 2.65±0.75[b] | 4.15±1.42[a] | 3.25±0.79[a] | 4.35±1.46[a] | 3.60±0.79[b] |
| 2 | 42.64±0.01[b] | 4.10±0.64[a] | 3.45±0.83[a] | 3.75±0.64[a] | 4.10±1.02[a] | 3.85±0.27[a] |
| 4 | 42.58±0.06[b] | 3.35±0.67[ab] | 3.50±0.83[a] | 3.70±0.80[a] | 4.05±1.10[a] | 3.65±0.26[b] |
| 6 | 43.41±0.28[ab] | 3.55±0.69[ab] | 3.55±0.94[a] | 4.00±0.92[a] | 3.85±0.75[a] | 3.74±0.19[a] |
| 8 | 48.34±0.25[a] | 4.00±1.30[a] | 3.75±1.02[a] | 4.05±1.10[a] | 3.80±1.01[a] | 3.90±0.13[a] |

The percentage of skipjack tuna flour in the noodles influenced their lightness value. The increase in the lightness value of the noodles was because the deproteinization process occurred perfectly. According to Hidayat and Rosidah (2022), an imperfect deproteinization process can result in a Maillard reaction.

## Aroma

Aroma is also an important factor in determining the level of consumer acceptance of a product because before eating, consumers usually first smell the product to judge whether the product is appropriate to be eaten, and the difference in the concentration of skipjack tuna flour significantly affected the assessment of noodle aroma ($p<0.05$). The control treatment was not significantly different from the 4% and 6% skipjack tuna flour treatments but was significantly different from the 2% and 8% treatments (Table 3). The results showed that the 2% and 8% treatments had a preference value of 4.10 and 4.00 (fragrant aroma), and the control treatment had a value of 2.65 (less fragrant aroma). The addition of skipjack tuna flour to sago noodle products demonstrated its ability to influence the aroma, owing to the distinct aroma of skipjack fish. Zuhri *et al.* (2014) stated that the higher the concentration of catfish flour, the lower the panelists' preferred level of aroma noodles. The study's results revealed that the panelists preferred the distinctive aroma of skipjack tuna, which enhanced the aroma value of dry noodles containing skipjack tuna flour over control noodles. Fish protein and nitrogen components, namely guanidine and aroma, contribute to the distinctive odor of fish. The addition of skipjack tuna flour to noodles resulted in a higher aroma value compared to the control, likely due to the unique aroma of skipjack tuna. Setiawan *et al.* (2013) stated that the addition of snakehead fish meat residues affects the aroma of snakehead fish crackers.

## Color

Color is an important component in determining the quality or degree of acceptance of a food product, as an attractive color can determine the degree of acceptance or fondness. If the color gives the impression that the food is not attractive or has deviated from the color that the consumer feels it should have, the consumer will tend to reject it. The assessment of noodle color was not significantly affected by the difference in the concentration of skipjack tuna flour ($p>0.05$) (Table 3). The results of the panelists' test on the color of dry noodles ranged from 3.45 to 4.15, with a slightly less bright yellow/ brownish to bright yellow scale. The addition of 20% tuna flour to cooked dry noodles did not affect panelists' preference for color attributes (Canti *et al.*, 2020). Fish flour addition and pigment degradation during the pre-gelatinization process lead to color change. Noodles with different concentrations of skipjack tuna flour did not affect the color results. Skipjack tuna has a myoglobin content that causes the meat to turn reddish-brown. Chaijan & Panpipat (2009) stated that high myoglobin content can cause meat to turn reddish-brown. Color indicates a chemical change in the food, such as reddish-brown, yellow, white, or reddish-yellow to the color of sago noodles. Color change occurs because of enzymes that encounter air during the drying process (Julianti *et al.*, 2011).

## Taste

Taste is an important factor in determining consumers' decisions to accept or reject food. If the taste is poor, consumers will reject the product even if the other parameters are good. We recognize four basic types of flavors: sweet, salty, sour, and bitter, while other tastes are a combination of these basic tastes (Fellows, 2001). The assessment of noodle taste was not significantly affected by the difference in the concentration of skipjack tuna flour ($p$>0.05) (Table 3). The panelists tested the taste of dry noodles and found that 6% and 8% were delicious, while 0, 2, and 4% were slightly less delicious. The taste of noodles with the addition of skipjack tuna flour was acceptable to the panelists and was not significantly different from that of noodles without the addition of skipjack tuna flour. Noodles without skipjack tuna flour had a low taste value because they tasted bland. The addition of skipjack tuna flour to sago noodles resulted in a distinctive taste, according to the panelists' preferences. Dry noodles with 20% tuna fish meal did not affect the taste value (Canti *et al.*, 2020). The taste of dry noodles with a concentration of 5% catfish protein added had the highest score, and the taste of the noodle product was the most liked by panelists (Zuhri *et al.*, 2014).

## Texture

Texture is also a parameter that determines the product selection. The assessment of noodle texture was not significantly affected by differences in the concentration of skipjack tuna flour ($p$>0.05), as shown in Table 3. The panelists' test for the texture of dry noodles ranged from 3.80 to 4.35, with a slightly less chewy to chewy scale. The greater the amount of skipjack tuna flour, the less chewy the noodles are. This result aligns with Marsaoly & Mahmud's (2020) assertion that adding a higher concentration of fishbone mel lowers the panelists' preference level. The addition of fish flour at high concentrations reduces texture acceptance (Iman, 2017). Lawless & Heymann (1998) stated that the addition of proteins reduces the level of elasticity of the product. The presence of protein in raw materials leads to a decrease in product development, and this reduction varies depending on the type and amount of protein present in the raw material. The difference in skipjack tuna flour concentration did not significantly affect the texture of the noodles due to the influence of amylose and amylopectin content. The noodles were made from sago flour containing 73% amylopectin and 27% amylose. Low amylose content can cause a weaker gel structure (Sandhu *et al.*, 2010).

## Overall

Based on the overall sensory results, the control dry noodles were not significantly different from the dry noodles supplemented with 4% skipjack tuna flour but were significantly different from the dry noodles supplemented with 2, 6, and 8% skipjack tuna flour. Dry noodles with the addition of skipjack tuna flour provided better aroma and taste values than the control noodles (0%); therefore, they were acceptable to the panelists. The aroma and taste assessments of the dry control noodles showed low panelist acceptance. Debbarma *et al.* (2017) found that panelists accepted dry noodles with 20% patin fish addition in terms of aroma, color, texture, and taste attributes. Panelists prefer the color, taste, aroma, and texture of dry noodles with 20% skipjack tuna flour (Yulianti, 2018). Panelists prefer the addition of 20% catfish flour to dry mocafwheat flour noodles in terms of texture, aroma, color, and taste attributes, according to Agustia *et al.* (2019). The addition of 20% skipjack tuna flour to dry noodles is still acceptable to panelists because it produces dry noodles with a slightly fishy aroma, yellow color, and slightly chewy texture (Canti *et al.*, 2022).

## The Best Treatment

The best-treated noodles were those containing 8% skipjack tuna flour. This was based on the results of the brightness and organoleptic tests, where the lightness value of the 8% skipjack tuna flour concentration was better than that of the control noodles and other treatment noodles. In addition, as seen from the organoleptic results, the noodles with 8% skipjack tuna flour were superior in terms

http://dx.doi.org/10.17844/jphpi.v27i12.55616

of aroma and overall parameters. Noodles with the addition of 8% skipjack tuna flour had better organoleptic qualities than the control treatment. Dry noodles with the addition of 8% skipjack tuna flour had a fragrant aroma, slightly less clear color, a delicious noodle taste, and a texture close to chewy; therefore, it was still acceptable to panelists.

## Protein and Ash Content of Noodles

The results of the study showed that the protein content of the best treatment of noodles with 8% skipjack tuna flour was significantly different from those without skipjack tuna flour and commercial noodles, while the ash content was not significantly different from those without skipjack tuna (Table 4). The noodle treatment that included 8% skipjack tuna flour yielded a high protein content of 5.56%, while the ash content was 1.12% (dw).

The protein content increases with the highest fish flour concentrations. This demonstrates that the incorporation of more fish-based protein leads to an increase in the protein content of the noodles. This phenomenon is consistent with several studies, including the physicochemical properties of rainbow trout (Corapci & Guneri, 2020), dry noodles fortified with anchovy flour (Litaay *et al.*, 2021), and cod fish protein powder for pasta (Desai *et al.*, 2018). When tilapia fish flour is added to noodles, the protein content increases to 13.04%, compared to a control of 11.32% (Kencana *et al.*, 2018). Additionally, adding 5% fish flour to instant noodle products can increase the protein content by 10.47% (Agustini & Haryati, 2007). The protein content of spaghetti enriched with chickpeas *(Cicer arietinum)* is 30% by 17.4% (Wood, 2009), and the protein content of corn flakes with 10% anchovy flour (*Stolephorus commersini*) is 13.30% (Rahmi *et al.*, 2018). Pasta products incorporating protein-rich semolina (*Semola rimacinata*) raw materials produce high protein (Marconi & Messia, 2021). Therefore, the incorporation of fish-based protein can enhance the nutritional value of noodles made from local non-gluten sago, known for its higher protein content. SNI 01-3551-2000 (BSN, 2000) mandates a minimum protein content of 4.0% for non-wheat noodles.

In comparison, commercial sago noodles show a relatively low ash content (0.82% db) compared to 8% skipjack tuna flour noodles (1.12% db). Noodles with the addition of 8% skipjack tuna flour concentration have a higher protein content compared to noodles without skipjack tuna flour. Litaay *et al.* (2022a) stated noodles enriched with 9% anchovy flour had the highest ash content compared to control noodles. Also, adding 20% eel fish meal (*Anguilla bicolor*) and 14.20% motan fish meal (*Thynnichthys thynnoides*) made the ash content go up by 2.59% and 14.20%, respectively (Irsalina *et al.*, 2016). These findings illustrate the importance of the fish-based protein incorporation process, which significantly influences the ash content in enriching noodles. Based on SNI 01-3551-2000 (BSN, 2000), noodles do not yet have ash content standards.

Table 4 Protein and ash content of noodles without skipjack tuna flour, best treatment, and commercial

Tabel 4 Kadar protein dan abu mi tanpa tepung tuna, perlakuan terbaik, dan komersial

| Sample | Protein content (%) | Ash content (%) |
|---|---|---|
| Without skipjack tuna flour | 0.24±0.00[b] | 0.56±0.11[a] |
| 8% skipjack tuna flour | 5.56±0.03[a] | 1.12±0.09[a] |
| Commercial product | 0.25±0.00[b] | 0.82±0.21[a] |
| Dry noodles* | 4.00 | - |

*BSN (2000); The followed different letter showed statistically significant difference ($p<0.05$); Standard deviation was calculated on three replicates.

## Noodle Microstructure

The addition of skipjack tuna flour to sago-based noodles affected the shape of the resulting noodle granules (Figure 1). The microstructure test revealed similarities between the control noodle granules, without the addition of skipjack tuna flour, and commercial noodles at 150× magnification, with oval-shaped granules. The noodle granules with the addition of skipjack tuna flour (8%), which have slightly truncated elliptical granules, differ from the elliptical granules in wheat noodles. According to Suarni (2008), a smaller particle size results in a smoother and softer product texture.

Figure 2 shows the internal structure at 500x magnification; that is, control noodles without the addition of skipjack tuna flour have a compact and smooth internal structure, whereas commercial sago noodles are more compact and smoother. This contrasts with the internal structure of noodles that have been added to 8% skipjack tuna flour, which exhibits a compact and slightly rough internal structure, while the internal structure of wheat noodles is smoother but less compact. Wheat noodles, which contain gluten, contribute to this difference by making the surface appear shiny. The noodles containing anchovy meal (7%) had a compact and slightly coarse

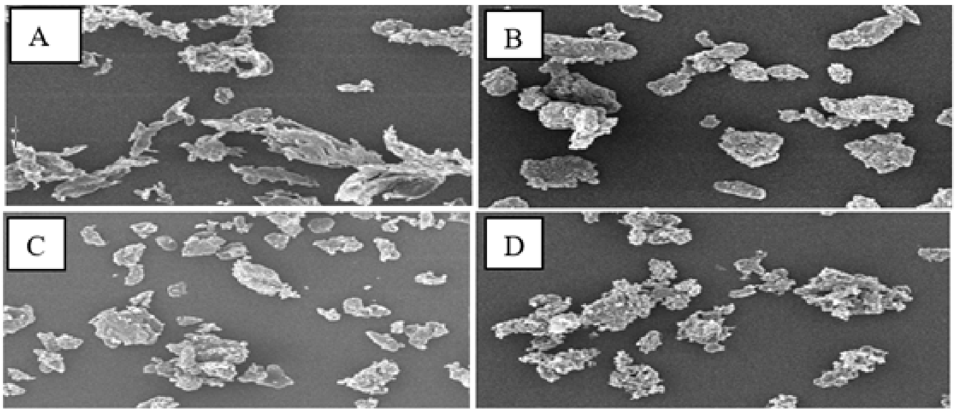


Figure 1 Microscopic structure of sago noodle granules (A) control; (B) with addition of 8% skipjack tuna flour; (C) commercial sago noodles; (D) wheat noodles

Gambar 1 Struktur mikroskopis butiran mi sagu (A) kontrol; (B) mi dengan tepung ikan cakalang 8%; (C) mi sagu komersial; (D) mi terigu

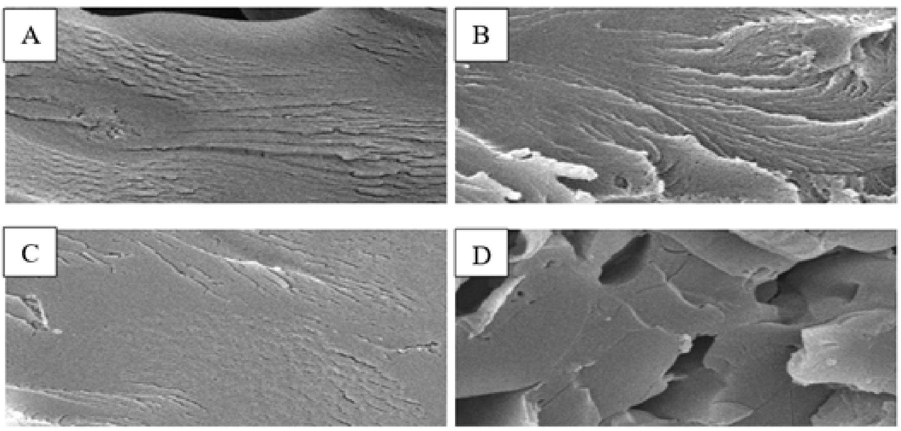


Figure 2 Internal structure of the noodles (A) control; (B) with addition of 8% skipjack tuna flour; (C) commercial sago noodles; (D) wheat noodles

Gambar 2 Struktur bagian dalam mi (A) kontrol; (B) mi dengan tepung ikan cakalang 8%; (C) cakalang 8%; (C) mi sagu komersial; (D) mi terigu internal structure. These results are consistent with those of Fitriani (2004), who found that wheat noodles have a shinier surface than corn noodles that look rough.

The interaction of free amino groups from amino acids or proteins and reducing sugars from starch (polysaccharides) shows covalent bonds, which play an important role in the structure of the product. Product structure depends on the strength of protein-polysaccharide interactions (Hemar *et al.*, 2002). The interaction between protein and polysaccharides influences the structure of food; besides that, the pregelatinization process can absorb a certain amount of water. When fish-based protein is added to noodle products, it results in a compact and slightly rough internal structure. This is because fishmeal could bind water. Fishmeal is hygroscopic, which can bind water and improve the internal structure of the product, thereby reducing loose zones and making it more compact and denser (Maruddin *et al.*, 2018; Valentina *et al.*, 2021).

## CONCLUSION

The optimal concentration for dried noodles made from sago is achieved by adding 8% skipjack tuna flour to the noodles. The lightness value of the 8% skipjack tuna flour concentration was better than that of the control noodles and other treatment noodles. In addition, as seen from the organoleptic results, the noodles with 8% skipjack tuna flour were better in terms of aroma, taste, and overall parameters. The noodle treatment with 8% skipjack tuna flour produced a high protein content of 5.56% (dw) and ash content of 1.12% (dw).

## ACKNOWLEDGEMENT

The funding for this research was provided by The Directorate General of Higher Education, Ministry of Research, Technology and Higher Education, Republic of Indonesia, awarded to Dr. Christina Litaay.

## REFERENCES

Agustia, F.C., Soebardjo, Y.P., & Ramadhan, G.R. (2019). Development of mocaf-wheat noodle product with the addition of catfish and egg-white flours as an alternative for high-animal-protein noodles. *Jurnal Aplikasi Teknologi Pangan*, 8(2), 47-51. http://doi.org/10.17728/jatp.2714

Agustini, T.W., & Haryati, S. (2007). The effect of different substitution meals to physical and chemical quality of instant noodles. *Journal of Control Development*, 11(1), 20-30.

Asare, S. N., Ijong, F. G., Rieuwpassa, F. J., & Setiawati, N. P. (2018). Penambahan hidrolisat protein ikan lemuru (*Sardinella lemuru*) pada pembuatan biskuit. *Jurnal Ilmiah Tindalung*, 4(1), 10-18.

[AOAC] Association of Official Analytical Chemist. (2005). Official methods of analysis of the Association of Official Analytical Chemists (18th ed.). Arlington.

Amalia, A. R., Sumartini, Azka, A., Ratrinia, P. W., Suryono, M., Saputra, E. N., & Hasibuan, N. E. (2024). Karakteristik fisikokimia mi basah substitusi jenis ikan berbeda dengan penambahan *egg white powder*. *Jurnal Pengolahan Hasil Perikanan Indonesia*, 27(11), 1021-1034. http://dx.doi.org/10.17844/jphpi.v27i11.52207

Bantacut, T. (2011). Sagu: sumber daya untuk penganekaragaman pangan pokok. *Jurnal Pangan*, 20(1), 27-40.

Brito, B. M., Lira, G. M., Pinheiro, A. G. A., Santana, C. M. A. S., & Amaral, I. L. (2019). Effect of cooking with interesterified margarine in the chemical composition of fish. *Food Science and Technology (Campinas)*, 39(Suppl. 2), 640-645. http://dx.doi.org/10.1590/fst.29618

Budiman, I. (2024). Tingkat pemanfaatan sumber daya ikan cakalang (*Katsuwonus pelamis*) di WPP_NRI 573 yang didaratkan di Pelabuhan Perikanan Samudra Nizam Zachman Jakarta. [Skripsi]. Universitas Satya Negara Indonesia.

[BSN] Badan Standardisasi Nasional. (2000). Dry Noodles. SNI 01-3551-2000.

[BSN] Badan Standardisasi Nasional. (2013). Fish Meal-Raw Material for Feed. SNI

2715:2013.

Chaijan, M., & Panpipat, W. (2011). Post harvest discoloration of dark-fleshed fish muscle: a review. *Walailak Journal of Science and Technology (WJST)*, 6(2), 149–166.

Canti, M., Fransiska, I., & Lestari, D. (2020). Dry noodles characteristics of substitution wheat flour with pumpkin and tuna flour. *Jurnal Aplikasi Teknologi Pangan*, 9(4), 181-187. http://doi.org/10.17728/jatp.6801

Canti, M., Hadi, T.C., & Lestari, D. (2021). Instant noodles from pumpkin (*Cucurbita Moschata* D.) and anchovy flour (*Stolephorus commersini*) as an alternative emergency food. *Jurnal Gizi Pangan,* 16(Supp.1), 37-44.

Corapci, B., & Guneri, N. (2020). Comparative assessment of nutritional composition and physicochemical properties of fresh, freeze-dried and rehydrated rainbow trout (*Oncorhynchus mykiss* walbaum, 1792) mince. *Food Science and Technology (Campinas)*, 40(Suppl. 1), 163-169. http://dx.doi.org/10.1590/fst.08419

Da Silva, T. F., & Conti-Silva, A. (2018). Potentiality of gluten-free chocolate cookies with added inulin/oligofructose: chemical, physical and sensory characterization. *LWT - Food Science and Technology,* 90, 172-179.

Debbarma, J., Viji, P., Rao, B. M., & Prasad, M. M. (2017). Nutritional and physical characteristics of noodles incorporated with green seaweed (*Ulva reticulata*) and fish *(Pangasianodon hypophthalmus)* mince. *Indian Journal of Fisheries,* 64(2), 90-95. http:// dx.doi.org/10.21077/ijf.2017.64.2.58918-14

Desai, A., Brennan, M. A., & Brennan, C. S. (2018). The effect of semolina replacement with protein powder from fish (*Pseudophycis bachus*) on the physicochemical characteristics of pasta. *LWT Food Science and Technology*, 89, 52-57. http://dx.doi.org/10.1016/j.lwt.2017.10.023

Fellows, P. (2001). Food Processing Technology Principle and Practice. Ellis Hordwoad.

Fitriani, F. (2018). The effect of adding three types of fish on the level of preference for dry noodle protein content. *Jurnal Proteksi Kesehatan*, 7(2), 79-86. https://doi.org/10.36929/ jpk.v7i2.138

Fradique, M., Batista, A. P., Nunes, M. C., Gouveia, L., Bandarra, N. M., & Raymundo, A. (2013). Isochrysis galbana and *Diacronema vlkianum* biomass incorporation in pasta products as PUFA's source. *Lebensmittel-Wissenschaft + Technologie*, 50(1), 312-319. http:// dx.doi.org/10.1016/j.lwt.2012.05.006

Gaurav, S. (2003). Digital Color Imaging Handbook. CRC Press.

Hastuti, S. U. D., Hardiani., Hodijah, S., Yulmardi, Rahmadi, S. (2023). Peningkatan value added ikan lele menjadi produk mi di Desa Mekar Sari Kecamatan Maro. *Jurnal Pengabdian kepada Masyarakat*, 3(2),107- 116.

Hemar, Y., Hall, C.E., Munro, P.A., & Singh, H. (2002). Small and large deformation rheology and microstructure of κ-carrageenan gels containing commercial milk protein products. *Journal International Dairy*, 12(4), 371-381. https://doi.org/10.1016/ S0958-6946(02)00032-8

Hidayat, Y. S., & Rosidah, U. (2022). The effect of snakehead fish bones flour (*Channa striata*) on physical and chemical properties of corn tortilla. *In*: Herlinda, S *et al.* (*Eds.*), Proceedings of the 10th National Seminar.

Iman, M. (2017). Fortification of tilapia meat against characteristics of small organoleptics and nutritional content. *Journal of Marine Fisheries*, 8(2), 161-167.

Intarasirisawat, R., Benjakul, S., & Visessanguan, W. (2011). Chemical compositions of the roes from skipjack, tongol, and bonito. *Journal Food Chemistry*, 124(4), 1328-1334. https://doi. org/10.1016/j.foodchem.2010.07.076

Irsalina, R., Lestari, S. D., & Herpandi. (2016). Physicochemical and sensory characteristics of dry noodle minnows carp (*Thynnichthys thynnoides*) fish meal addition. *FishtecH - Jurnal Teknologi Hasil Perikanan*, 5(1), 32-42.

Julianti, E., Lubis, Z., Ridwansyah., Era, Y., & Suhaidi, I. (2011). Physicochemical and functional properties of fermented starch from flour cassava varieties. *Asian Journal Agric Research,* 5(6), 292-299. https://doi. org/10.3923/ajar.2011.292.299

Junianto, Khan, A. M. A., & Rostini, I. (2019). Fortikasi protein pada kerupuk melarat dengan tepung hidrolisat protein daging ikan nila (*Oreochromis niloticus*). *Jurnal Pengolahan Hasil Perikanan Indonesia*, 22(1), 111-118. https://doi.org/10.17844/jphpi.v22i1.25884

Kencana, I. P., Darmanto, Y. S., & Sumardianto. (2018). Effect of minced fish mackerel (*Rastrelliger* sp.), tilapia (*Oreochromis niloticus*), and milkfish (*Chanos chanos* forsk) addition on characteristic mocaf substituted dry noodles. *Jurnal Ilmu Pangan dan Hasil Pertanian*, 2(1), 53-62. https://doi. org/10.26877/jiphp.v2i1.2300

Lahagu, O., Breemer, R., & Palijama, S. (2023). The effect of concentration of skipjack tuna *(Katsuwonus pelamis)* powder and drying time on the chemical characteristics of purple sweet potato (*Ipomoea batatas L*) tortilla chips. *Jurnal Agrosilvopasture-Tech*, 2(1), 54-61. https://doi.org/10.30598/j.agrosilvopasture-tech.2023.2.2.548.

Lawless, H. T., & Heymann, H. (1998). Sensory Evaluation of Food. Kluwer Academic.

Lena, O., Purwandhani, S.N., Masrukan., & Darmawan, E. (2022). Pembuatan mi kering dengan substitusi tepung jagung (*Zea mays*). *Agrotech,* 4(2), 1-9. https://doi.org/10.37631/agrotech.v1i1.

Litaay, C. (2012). Fortification Fish Meal Skipjack Tuna *(Katsuwonus pelamis)* on the Characteristic of Sago Noodles [Tesis]. Institut Pertanian Bogor.

Litaay, C., & Santoso, J. (2013). The effects of different immersion method and time on the physico-chemical characteristics of skipjack tuna (*Katsuwonus pelamis*) fish meal. *Jurnal Ilmu dan Teknologi Kelautan Tropis,* 5(1), 85-92.

Litaay, C., Pelasula, D. D., Horhoruw, S. M., & Arfah, H. (2021). Effect of bait availability on pole and line fisheries and the impact on the amount of fish consumption. IOP Conference Series: Earth and Environmental Science. http://dx.doi. org/10.1088/1755- 1315/763/1/012048

Litaay, C., Indriati, A., Mayasti, N. K. I., Sriharti, Tribowo, R. I., Andriansyah, R. C. E., & Daryanto, A. A**.** (2022a, September 06-07). Characteristics of sago noodles high in protein and calcium [Conference session]. 5th EMBRIO International Symposium: Sustainable Development Of Fisheries And Marine Resource Amidst Covid-19 Era And Beyond. IOP Conference Series: Earth and Environmental Science. https://doi. org/ 10.1088/1755-1315/1033/1/012061

Litaay, C., Indriati, A., Sriharti., Mayasti, N. K. I., Tribowo, R. I., Andriana, Y., & Andriansyah, R. C. E. (2022b). Physical, chemical, and sensory quality of noodles fortification with anchovy (*Stolephorus* sp.) flour. *Food Science and Technology Campinas*, 42, 1-7. https://doi.org/10.1590/fst.75421

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. http://dx.doi. org/10.17844/jphpi.v26i1.45159

Marconi, E., & Messia, M. C. (2021). Pasta from non traditional materials. *Cereal Foods World*, 46, 522-530.

Marsaoly, M & Mahmud, M. (2020). Making sago plates using tuna (*Thunnus albacores*) bone meal substitution. *Global Health Science*, 5(1), 28-33.

Maruddin, F., Ratmawati, Fahrullah, & Taufik, M. (2018). Characteristics of edible film based dangke whey with carrageenan addition. *Jurnal Veteriner*, 19(2), 291-297. https://doi.org/10.19087/jveteriner.2018.19.2.291

Mattjik, A. A., & Sumertajaya, I. M. (2006). Perancangan Percobaan. Bogor: IPB Press.

Mayasti, N. K. I., Litaay, C., Indriati, A., Ekafitri, Riyanti, Sriharti., Tribowo, R. I. (2022), Quality evaluation of flake from adlay (*Coix lacryma-jobi* L) flour enriched with eel flour. AIP Conference Proceedings. https://doi.org/10.1063/5.0109960

Mawaddah, N., Mukhlishah, N., Rosmiati., & Mahi, F. (2021). Flowering power test and organoleptic test of skipjack tuna crackers with different starch. *Jurnal Pertanian Berkelanjutan*, 9(3), 181-187.

Murniyati, Subaryono, & Hermana, I. (2010). Processing noodles fortified with fish and seaweed as a source of protein, crude fiber and iodine. *Jurnal Pascapanen dan Bioteknologi Kelautan dan Perikanan*, 5(1), 65-75. https://doi.org/10.15578/j.jpbkp.v5i1.427

Mustafa, K. M., Baini, R., Lim, S. F., Rahman, M. R., Mohamaddan, S., & Hussain, H. (2019). Drying effect on the properties of traditionally processed sago starch. *International Food Research Journal*, 26(6), 1861-1869.

Novitasari, R. (2020). Study on the use of natural resources in inhil district in manufacturing sago noodles of fortification fish and eggs. *Jurnal Selodang Mayang*, 6(3), 195-200. https://doi.org/10.47521/selodangmayang.v6i3.185

Nurjanah, Suseno, S. H., Hidayat, T., Paramudhita, P. S., Ekawati, Y., & Arifianto, T. B. (2015). Changes in nutritional composition of skipjack (*Katsuwonus pelamis*) due to frying process. *International Food Research Journal*, 22(5), 2093–2102.

Okoye, J., Nkwocha, A., & Ogbonnaya. (2008). Production, proximate composition, and consumer acceptability of biscuits from wheat/ soybean flour blends. *Continent Journal Food Science Technology*, 2, 6-13.

Pari, R. F., Setyaningsih, I., Ramadhan, W., Tarman, K., Hardiningtyas, S. D., Nurhayati, T., Desniar, Uju, & Aini, K. (2024). Karakteristik kimia, mikrob dan daya terima kukis sagu yang diperkaya spirulina dan rumput laut. *Jurnal Pengolahan Hasil Perikanan Indonesia*, 27(9), 782-797. http://dx.doi.org/10.17844/jphpi.v27i9.44664

Park, J., & Kim, H. S. (2023) Rice-based gluten-free foods and technologies. *Foods*, 12, 1-16. https://doi.org/10.3390/foods12224110

Putri, E. B. P. (2018). Analysis of protein and vitamin C contents on cookies substituted by skipjack fish (*Katsuwonus* sp.) and goji berry (*Lycium barbaru*m L.). *Ilmu Gizi Indonesia*, 2(1), 33–38.

Rahmawati, R., Asmoro, N.W., & Handayani, C.B. (2024). Karakteristik mie basah dari tepung mocaf (*modified cassava flour*) dan tapioka dengan penambahan variasi tepung porang (*Amorphophallus muelleri* Blume). *Jurnal Ilmu Pangan dan Hasil Pertanian*, 8(1), 86-99. https://doi.org/10.26877/jiphp.v8i1.19279

Rahmi, Y., Widya, N. R., Anugerah, P. N., & Tanuwijaya, L. K. (2018). Anchovy fish flour (*Stolephorus Commersini* LAC.) as a source of calcium and protein in corn flakes alternative breakfast for school-aged children. *Jurnal Nutrire Diaita,* 10(1), 34- 44.

Sandhu, K. S., Kaur, M., & Mukesh. (2010). Studies on noodle quality of potato and rice starches and their blends in relation to their physicochemical, pasting and gel textural properties. LWT - *Food Science and Technology*, 43(8), 1289–1293. https://doi.org/10.1016/j.lwt.2010.03.003.

Setiawan, D. W., Sulistiyati, T. D., & Suprayitno, E. (2013). Pemanfaatan residu daging ikan gabus (*Ophiocephalus striatus*) dalam pembuatan kerupuk ikan beralbumin. *THPi Student Journal*, 1(1), 21-32.

Soekarto, S.T., & Hubeis, M. (2000). Metodologi Penelitian Organoleptik. IPB Press.

Sofi, S. A., Singh, J., Chhikara, N., & Panghal, A. (2019). Effect of incorporation of germinated flour and protein isolate from chickpea on different quality characteristics of rice-based noodle. *Cereal Chemistry*, 90, 1-10. https://doi.org/10.1002/cche.10192

Stell RGD, Torrie JH. (1993). *Principles and Procedures of Statistics Indeks*. Sumantri

http://dx.doi.org/10.17844/jphpi.v27i12.55616

B, Penerjemah. Jakarta: PT Gramedia Pustaka Utama.

Suarni. (2008). Composite flour of sorghum, corn, and rice for making cakes. [Treatise on Research on Corn and Other Cereals]. Corn and Cereal Research Institute, Maros. 6, 55-60.

Suparmi, Sumarto, Sari, N. I., & Hidayat, T. (2021). Pengaruh kombinasi tepung sagu dan tepung udang rebon terhadap karakteristik kimia dan organoleptik makaroni. *Jurnal Pengolahan Hasil Perikanan Indonesia*, 24(2), 218-226. http://dx.doi.org/10.17844/jphpi.v24i2.35059

Thorkelsson, G., Slizyte, R., Gildberg, A., & Kristinsson, H. G. (2009). Fish proteins and peptides. Processing methods, quality and functionality. In: Luten JB, editor. *Marine functional foods.* Wageningen University Press. pp. 115–133.

Tournier, C., Sulmont-Rosse, C., & Guichard, E. (2007). Flavour perception: aroma, taste, and texture interaction. *Food*, 1(2), 246-257.

Toya, T., Jotaki, R., & Kato, A. (1986). *Specimen Preparation in EPMA and SEM*. JEOL Training Center EP Section.

Valentina, A., Masirah., & Lailatussifa, R. (2021). The effect of fortification of different types of fish on the level of preference and physical characteristics of wet noodles. *Jurnal Chanos chanos*, 19(1), 125-134. http:// dx.doi.org/10.15578/chanos.v19i1.9610

Wood, J. A. (2009). Texture, processing and organoleptic properties of chickpea-fortified spaghetti with insights to the underlying mechanisms of traditional durum pasta quality. *Journal of Cereal Science*, 49(1), 128-133. http://dx.doi.org/10.1016/j.jcs.2008.07.016

World Instant Noodles Association. (2021). Global Demand of Instant Noodles. Worl Instant Noodles Association (WINA). https://instantnoodles.org/en/noodles/demand/table/.

Wrigley, C. W., Bekes, F., & Bushuk, W. (2006). Gluten: A balance of gliadin and glutenin. Chapter 1. *Cereals & Grains,* 3-31. https://doi.org/10.1094/9781891127519.002

Yulianti, Y. (2018). Addition of skipjack fish flour as a protein source in taro porridge instant making. *Jurnal Galung Tropika*, 7(3), 169-174. https://doi.org/10.31850/jgt.v7i3.394

Yusida, A., Rahmawati., Utami, T. N., & Fachrozan, R. (2014). Formulasi dan fortifikasi ikan cakalang (*Katsuwonus* sp.) pada bubur instan sebagai pangan fungsional tinggi protein dan karbohidrat dalam penanggulangan kasus gizi buruk di Indonesia. *Pekan Ilmiah Mahasiswa Nasional Program Kreativitas Mahasiswa - Penelitian*, 4(2), 1-5.

Zuhri, N. M., Swastawati, F., & Wijayanti, I. (2014). The enrichment of dry noodle quality addition african catfish (*Clarias gariepinus*) meat meal as a source of protein. *Jurnal Pengolahan dan Bioteknologi Hasil Perikanan*, 3(4), 119-126.