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Comparison of Protein Content and Physicochemical Characteristics of Fresh Noodles Enriched with Tuna and Mackerel Fish Flours

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Abstract: Noodle products are classified as low-nutrient noodles because they have a high carbohydrate content but low protein, vitamins and minerals. Marine fish such as tuna and mackerel are food ingredients with high protein content, and they are abundant in Indonesia. The purpose of this study was to partially substitute wheat flour with tuna flour and mackerel flour and analyze the physical (rehydration power, cooking loss, elasticity power) and chemical (protein) characteristics of the resulting wet noodles. The data obtained were analyzed statistically using a simple group randomized design and repeated 3 times. The results showed that the physical and chemical characteristics of wet noodles with the addition of mackerel flour had a cooking loss value of 11.51-16.42%, elasticity value of 29.82-17.12 gf, rehydration power of 177.33-140.65%, and protein 11.25-15.24% db. The addition of tuna fishmeal to wet noodles has a cooking loss value of 15.11-20.03%, elasticity value of 30.12-19.22 gf, rehydration power of 183.15-160.72%, and protein 13.37-21.72% db. The addition of mackerel flour and tuna flour to wet noodle products increased protein content while affecting the product's physical properties. It is hoped that this research can provide comparative insights into the utilization of marine resources as fortification ingredients in noodle products.

Keywords: Fresh Noodles; Functional Food; Mackarel; Tuna.

Introduction

Noodles are one of the most popular food products, especially in Asia. Noodles are an alternative food to rice because they are practical, taste good, have a wide variety, and are relatively cheap. The public knows various types of noodles, namely wet, raw, dry, and instant noodles [1]. Noodles are made from wheat flour or wheat flour with or without the addition of other food ingredients and permitted food additives [2]. Indonesia is not a wheat-producing country, so substituting ingredients with non-wheat flour for making noodle products is important to reduce dependence on wheat imports. Noodles are generally used as a source of energy. The gluten content in wheat flour influences the chewy texture of noodles. Noodle products are classified as low-nutrient noodles because they have a high carbohydrate content but low protein, vitamins, and minerals. Protein deficiency in the body puts one at risk of kwashiorkor. Kwashiorkor is a severe protein energy deficiency (PEM) caused by inadequate protein intake with sufficient energy intake [3].

Marine fish is a good source of protein for health. Marine fish is a food with a high protein content, and its presence is abundant in Indonesia. Tuna has a protein content of 81.65% (db) with an omega 3 content of eicosapentanoic acid (EPA) of 1.17% and docosahexaenoic acid (DHA) of 8.82% [4] [5]. Mackerel has a protein content of 21.4% (db), calcium, phosphorus, magnesium, sodium, and strontium [6]. In 100 grams of mackerel fish, there are 6.3 grams of fat, 19.29 grams of protein, omega-3, calcium, iron, phosphorus, zinc, selenium and iodine [32]. Processing of marine products such as fish into intermediate products such as flour has begun to be widely practised as an ingredient in the fortification of food products.

Adding tuna flour with concentrations of 25, 50 and 75 grams significantly affects the protein content of moringa biscuits. The increase in protein content ranged from 20.29-27.14% [31]. In macaroni pasta products fortified with cork fish flour, there was an increase in protein content, which ranged from 12.89-20.97%. The addition of cork fishmeal also significantly affects development capacity, water absorption, and cooking loss [30]. In cracker products fortified using mackerel flour and mangosteen peel flour, there was an increase in protein content ranging from 10.35-14.90%. Regarding taste assessment, the use of 35% mackerel flour was categorized as preferred by panellists with a value of 4.6 [7] [33].

Tuna and mackerel fish can be used as raw materials to diversify food products and improve nutrition in wet noodles. One way that can be done is by fortification. Comparative exploration of the use of two types of fish flour has not been done, so this research is important.

The purpose of this study was to partially substitute wheat flour with tuna flour and mackerel flour and analyze the physical and chemical characteristics of the resulting wet noodles. The benefit of this research is to provide additional information and knowledge about the innovation of utilizing tuna and mackerel flour in making high-protein noodles.

Research Methods

The research design used in this study is a quantitative research design using a simple group randomized design (RAK) method. There were 8 treatments with 3 replications,

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resulting in 24 experimental units. Details of the treatment combination are presented in Table 1.

Table 1. Details of Research Treatments

Treatment	Details
K1T1	95 grams of flour with 5 grams of mackerel flour
K1T2	90 grams of flour with 10 grams of mackerel flour
K1T3	80 grams of flour with 20 grams of mackerel flour
K1T4	70 grams of flour with 30 grams of mackerel flour
K2N1	95 grams of flour with 5 grams of tuna flour
K2N2	90 grams of flour with 10 grams of tuna flour
K2N3	80 grams of flour with 20 grams of tuna flour
K2N4	70 grams of flour with 30 grams of tuna flour

Manufacture of Fishmeal

Manufacture of fishmeal is done by cleaning fresh fish. Separate the meat from the skin (fillet). Separate thorns and bones, then boil for 2 minutes at 100 °C to remove fat. Shred the raw materials into small pieces. Put in oven (Memmert) for drying process at 50 °C for 6-8 hours. The dried raw materials are blended using a dry mill and then sieved using an 80 mesh sieve for smoother and uniform results [8],[1]

Noodle Making

Wheat flour and fish flour (according to treatment) with 100 grams are made according to the predetermined ratio. Additional ingredients such as 2% table salt, 1% STTP, 10% chicken eggs and 65 ml of water were added slowly while continuing to be homogenized. After the dough is smooth, let it rest for 5-10 minutes for the gluten formation process. After that, flatten the dough using a roll pressing (sheeter) until the dough sheet is 2 ± 0.5 mm. The flattened dough is moulded using a noodle maker to be bent into strands of noodles. The noodle strands are then boiled using boiling water for 2-3 minutes, then cooled [9], [10]

Results and Discussion

Protein Content

Based on the ANOVA test results, the combination of wheat flour substitution treatments using various fish flours in wet noodle products significantly affects protein content ($P < 0.01$). Duncan test results showed the interaction between treatments was significantly different. The average protein content of wet noodles is presented in Table 2.

Table 2 shows that the highest protein content is in the K4N4 treatment (70 grams of flour with 30 grams of tuna flour) at 21.720%db and the lowest protein content in the K1T1 treatment (95 grams of flour with 5 grams of mackerel flour) at 11.256% db. The protein content of the noodles increased along with the addition of fishmeal percentage, both in the addition of mackerel fishmeal and tuna fishmeal. This shows that the substitution of fishmeal in the product causes the protein content of the noodles to increase. Because fish is a food that has a very high protein content and essential amino acids compared to other animal proteins [11], [8]. Protein is the highest content after water in the fish body [12].Asam amino essensial yang terkandung pada ikan yaitu asam amino metionin, lisin, asam glutamat, asam aspartat, serin, glisin, arginin, treonin, alanin, prolin, tirosin, valin, sistein, isoleusin, leusin, phenilalanin, dan histidin. These amino acids are limiting amino acids with higher amounts compared to higher amounts compared to plant-based protein sources. Generally, the type and amount of amino acid content in marine fish is higher and more complete than that of freshwater fish. This is due to the availability of natural food in the fish habitat. Natural food in seawater fish in the form of zooplankton and phytoplankton is rich in amino acid content ([12] Fish is divided into two groups based on the amount of protein content, namely high-protein fish (15-20%) and low-protein fish (<15%). Peptides isolated and purified from marine organisms are further known to have cancer cell-inhibiting effects. Research results [13] showed the purified protein inhibited the proliferation of human colon adenocarcinoma cells (HT 29) at a concentration of 20µg/ml. Comet and fluorescence microscopic analyses also confirmed a significant increase in DNA fragmentation and degradation of HT 29 cells when treated with the protein isolate.

Table 2. Average Protein Content of Fresh Noodles

Treatment	Protein Content (% db)
K1T1	11.25 ±0.02
K1T2	11.88 ±0.05
K1T3	13.75 ±0.02
K1T4	15.24 ±0.02
K2N1	13.37 ±0.01
K2N2	15.77 ±0.01
K2N3	19.11 ±0.01
K2N4	21.72 ±0.01

Description: Data are presented as mean ± standard deviation (SD) of 3 replications

Mackerel is categorized as a high-protein food. Fresh mackerel has a protein content of 17.85-20% db. The protein content in wet noodle products fortified with mackerel flour and carrot juice produces a protein content of 17.65-19.78% db [14]. In research [15], the results obtained in the treatment of mackerel flour fortification with as much as 25, 50, and 75 grams of product protein content were 15.56%db, 18.28%db, and 19.20% db, respectively. In wet noodle products with 10% catfish concentrate fortification, the protein content is 10.56% and at 15% catfish concentrate fortification, the protein content increases to 18.22% [34].

The components of protein compounds in fish are not the same in each species. The influencing factors are different environmental and habitat conditions. Higher pressure will affect the formation of protein [12].

Tuna is a type of fish with a high protein and low fat content [16]. Tuna contains protein between 22.6-26.2 grams/100 grams, besides being enriched with minerals such as calcium, phosphorus, iron, sodium, vitamin A (retinol), vitamin B (thiamin, riboflavin, and niacin) [17]. In research [8], the protein content of wet noodles with Decapterus sp fishmeal fortification and sago flour substitution has a protein content of 17.66% in the 12% fishmeal fortification treatment and 30% sago flour substitution. The results of this study are in line with research on dry noodle products with pumpkin substitution and tuna flour fortification, which has a protein range of 17.43-23.74% [18] with the addition of 10-20%. The use of tuna flour in dry noodle products can increase protein content up to 2 times compared to adding tuna flour by 20-50% resulting in protein content of 11.09-11.93% [19].

Cooking Loss

Based on the ANOVA test results, the wheat flour substitution treatment combination using various fish flours in wet noodle products has a very significant effect (P <0.01) on cooking loss. Duncan test results showed that the interaction between treatments was significantly different. The average cooking loss of wet noodles is presented in Table 3.

Table 3. Average of Cooking Loss

Treatment	Cooking Loss (%)
K1T1	11.51±0.01
K1T2	12.15±0.02
K1T3	15.34±0.01
K1T4	16.42±0.02
K2N1	15.11±0.01
K2N2	16.21±0.03
K2N3	18.32±0.01
K2N4	20.03±0.01

Description: Data are presented as mean ± standard deviation (SD) of 3 replications

Treatment K4N4 (70 grams of wheat flour with 30 grams of tuna flour) produced the highest cooking loss value of 20.033% and treatment K1T1 (90 grams of wheat flour with 5 grams of mackerel flour) produced the lowest cooking loss of 11.517%. Cooking loss is the amount of solid substitution that is lost with water as a result of the noodle cooking process [20]. The more substances other than wheat flour that are added, the higher the cooking loss value will be. This is because the amount of gluten is decreasing, so that the dough formed is unstable and not compact. As a result, during the cooking process, many particles are released [21]. This can also be seen in the K4T4 treatment (70 grams of wheat flour with 30 grams of mackerel flour), which also experienced an increase in cooking loss to 16.423%, although the percentage value is still smaller when compared to the K4N4 treatment (70 grams of wheat flour with 30 grams of tuna flour). The more fish flour added, the higher the cooking loss in the product, because the protein concentrate added, the solids lost during the cooking process will be higher [22]. During the cooking process, the starch granules will swell and then break down so that the cooking water becomes cloudy. This is because short-chain linear starch molecules come out of the granules and then enter the noodle cooking water, resulting in cooking loss. Cooking loss is also influenced by the weak binding power of dough components, so that these components will leach into cooking water [23].

The increased cooking loss value in tuna and mackerel flour noodles is due to the absence of gluten in fish flour. Reduced gluten content in noodles can cause gluten protein bonds to be disrupted and weakened, so that the ability to form a three-dimensional network that can inhibit the release of starch granule contents is reduced [24]. The addition of tuna flour up to 40% in dry noodle products increases cooking loss up to 14.44% [25]. The cooking loss value of wet noodle products made with composite flour consisting of wheat flour, mocaf, and tuna fish flour produces a cooking loss value of 5.29% in the use of 25% mocaf and 10% tuna fish flour while in the 50% treatment and 20% tuna fish flour has a cooking loss of 8.39% [1]. In dry noodle products with the addition of moringa leaf protein concentrate and carrageenan and substituted with mocaf flour, there was an increase in cooking loss in line with the increase in protein concentrate from 1.40 to 2.20% [22]. The value of solids loss due to cooking (KPAP) in noodles is an important parameter for wet noodle products. The lower the KPAP value of the noodles, the better the texture of the noodles is and the more homogeneous they are. The KPAP value of wet noodles is influenced by several factors such as material moisture content and starch retrogradation [1].

Elasticity

Based on the ANOVA test results, the treatment combination of wheat flour substitution using various fish flours in wet noodle products has a very significant effect (P < 0.01) on elasticity. Duncan test results showed that the interaction between treatments was significantly different. The average elasticity value of wet noodle products is presented in Table 4.

Table 4. Elasticity Value (gf)

Treatment	Elasticity (gf)
K1T1	29.82±0.01
K1T2	25.15±0.03
K1T3	21.43±0.05
K1T4	17.12±0.01
K2N1	30.12±0.05
K2N2	27.78±0.01
K2N3	23.39±0.01
K2N4	19.22±0.01

Description: Data are presented as mean ± standard deviation (SD) of 3 replications

The treatment with the highest elasticity level was obtained in the K1N1 treatment (90 grams of wheat flour with 5 grams of tuna flour) at 30.12 gf, and the lowest elasticity level was obtained in the K4T4 treatment (70 grams of wheat flour with 30 grams of mackerel) at 17.12 gf.

Elasticity of noodles is a physical property that is influenced by several factors such as the amount of flour concentration and amylose content in flour. Elasticity is the ability of a material to withstand a pulling force applied at a certain amount until it is cut off [26]. The addition of fishmeal, both tuna and mackerel flour, will reduce the elasticity value. The addition of tuna and mackerel flour causes less gluten content in the noodles. Gluten content functions in forming strong bonds between starch granules that cause resistance to pulling [27]. In wheat flour, there are gliadin and glutenin proteins that can form gluten when the flour is moistened with water in the kneading process. This occurs due to the interaction between prolamien, which has a slightly polar nature, with glutenin, which has more polar groups. The elasticity characteristic of gluten is ascribed to the glutenin fraction, while the clayey and clingy characteristics are obtained from the prolamien fraction. Gluten is a cohesive and viscoelastic mass that can stretch elastically. This ability is very instrumental in the process of making noodles with reduced gluten due to substitution with tuna and mackerel flour, the resulting noodles are easily disconnected and broken [8].

The elasticity value is also affected by expandability. Flour or starch that has high expandability will have a smaller elasticity value. The elasticity value of composite noodles (wheat flour and pumpkin) with 10% tuna flour fortification has an elasticity value of 44.17 gf, and the 25% tuna flour fortification treatment has an elasticity value of 18.17 gf [25]. The decrease in elasticity value indicates poor noodle quality, which is easy to break. The lower the elasticity value, the easier the noodles will break.

Rehydration

Based on the results of the ANOVA test, the combination of wheat flour substitution treatments using various fish flours in wet noodle products has a very significant effect (P <0.01) on rehydration power. Duncan test results indicate the interaction between treatments is significantly different. The average value of rehydration ability of wet noodle products is presented in Table 5.

Table 5. Rehydration

Treatment	Rehydration (%)
K1T1	177.33±0.03
K1T2	165.29±0.02
K1T3	149.59±0.03
K1T4	140.65±0.01
K2N1	183.15±0.05
K2N2	178.30±0.03
K2N3	169.18±0.01
K2N4	160.72±0.01

Description: Data are presented as mean ± standard deviation (SD) of 3 replications

Treatment K1N1 95 grams of wheat flour with 5 grams of tuna fishmeal. produced the highest rehydration value of 183.150% and the treatment that produced the lowest rehydration power value was treatment K4T4 (70 grams of wheat flour with 30 grams of mackerel flour) at 140.650%. The more the use of fishmeal, both in the treatment of adding tuna flour and mackerel flour, the results show a decrease in rehydration power. The results of this study are in line with research [1] on wet noodle products with composite flour raw materials (wheat flour, mocaf and tuna flour) the rehydration power produced in the use of 75% wheat flour, 25% mocaf and 0% tuna flour produced the highest rehydration value of 64.09% while in the treatment of adding tuna flour up to 20% the rehydration power produced was 49.54%. The higher the addition of fishmeal, the lower the rehydration power. This is related to the decreasing gluten content; the protein in fishmeal, both tuna and mackerel, will compete with carbohydrates to bind water molecules. The rehydration value shows the state of the noodles after the boiling process. The higher the rehydration power value, the more fluffy the noodles will be. Wet noodle products with seaweed addition treatment up to 35% had a rehydration power value of 55.80% which was the lowest rehydration power value. In the treatment of the addition of seaweed 0% rehydration power value of 60.36% is the highest of all treatments [28].

The results obtained are also in line with research on wet noodle products with the addition of seaweed pulp. The more seaweed is added to the wet noodle dough, the lower the water absorption value. The treatment of formulation M0 (100% wheat flour) has an average water absorption of 113.5% rehydration power decreased to 88.13% in formulation M7 [29].

Rehydration power is the ability of noodles to absorb water after gelatinization [30]. The water absorption value is calculated from the weight of the noodles after boiling minus the weight of the noodles before boiling [8]. The higher the water absorption value, the more fluffy the noodles will be.

Conclusion

The results showed that the physical and chemical characteristics of wet noodles with the addition of mackerel flour had a cooking loss value of 11.51-16.42%, elasticity value of 29.82-17.12 gf, rehydration power of 177.33-140.65%, and protein 11.25-15.24% db. The addition of tuna fishmeal to wet noodles has a cooking loss value of 15.11-20.03%, elasticity value of 30.12-19.22 gf, rehydration power of 183.15-160.72%, and protein 13.37-21.72% db. The addition of mackerel fish meal and tuna fish meal to wet noodle products successfully increased the protein content while affecting the physical properties of the product. Tuna flour and mackerel flour can be applied to the manufacture of functional food products to increase protein content.

Author's Contribution

Ida Ayu Putu Ary Widnyani: designed the research framework, experimental process, conducted the physicochemical and protein content analysis, and led the manuscript writing and revision. Putu Rima Sintyadewi: formulation of noodle samples and assisted in data interpretation.

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