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Utilization of waste from trimming process for the development of pangasius fish nugget

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Abstract

Currently, the processing of pangasius fish is limited in most industries in Indonesia. This fish can be processed into nuggets, but the texture is a common issue determined by the composition of the meat and fat. Therefore, optimal composition is needed to produce the desired texture. The fat used was derived from the trimmings, waste of the Pangasius fillet factory. This study, then, aims to determine the effect of substitution of fillet with trimmings on chemical and sensory characteristics of fish nugget. Furthermore, it obtains the best formulation using 6 ratios of fillet and trimmings at 100:0, 60:40, 50:50, 40:60, 30:70, and 20:80. Proximate analysis of moisture, ash, carbohydrate, protein, and fat content was conducted, while acceptance testing was used in sensory analysis. The results showed that the substitution of trimmings only resulted in significant difference in fat content. This is due to the direct proportionality between the percentage of trimmings, and the fat content of nuggets. Meanwhile, the sensory analysis only resulted in significant differences in crispness, hardness and overall. In conclusion, nugget with 20:80 treatment was the best formulation because it has the highest preference value and can utilize waste optimally.

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1. Introduction

Pangasius is one of the types of freshwater fish that is quite popular among Indonesian people. Generally, the processing only produces fillet products in frozen or fresh forms. It is also the main ingredient in traditional foods such as *tempoyak patin*, *pindang patin*, and pangasius fish soup. However, without further productivity, most industries' processing is still constrained in turning this fish into a high value product. Nugget is one of the processed fish products that can use Pangasius fish as an ingredient. According to the National Standardization Agency of Indonesia (1), nugget is a processed product made from a minimum of 30% mashed fish meat or surimi added with flour with other necessary ingredients. It is then coated with a binder and bread flour before cooking.

Nugget is one of the most developed frozen food products in Indonesia besides sausages, meatballs, dumplings, and croquettes. Additionally, the manufacturing of frozen fast food is known to be increasing annually. Based on data from PT Capricorn Indonesia Consult (2), nuggets production in 2014-2018 has an average of twice as high as sausage production. Furthermore, the production has an average increase of 6.8% per year, from 51,400 tons in 2014 to 66,900 tons in 2018.

On the other hand, many nuggets are processed from chicken meat. Fish-based types are not often found, even though the nutritional content is quite good. Klemeyer et al. (3) stated that Pangasius is one of the fish with an excellent source of unsaturated fats, including omega 3 fatty acids such as eicosapentaenoic and docosahexaenoic acid, which have positive

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functions for human health. Suryaningrum (4) stated that a Pangasius fillet industry generally produces a yield of 33%, while the remaining 67% is a waste. PT Selera Pangan Andalan (SPA), one of the industries that produce frozen Pangasius fillets in Indonesia, discovered that the processing of Pangasius fillets produces wastes, such as head, belly, guts, bones, skin, trimmings, and eggs in the range of 59.72 – 72 %. The waste should be converted into a high-value product.

This study aims to use trimmings from the Pangasius fillet industry (SPA) to make fish nuggets. Trimmings have more fat content than protein. Therefore, one of the obstacles is texture, which is influenced by the composition of meat and fat. Most fish-based nuggets on the market use fillets as their main ingredient, where the amount of protein content is more than the fat. Therefore, optimal meat and fat composition are needed to produce a good texture. The effect of substitution of fillet with trimmings on the chemical and sensory characteristics of Pangasius fish nuggets was tested, and an analysis was conducted to obtain the best formulation. Furthermore, sensory characteristics that affect consumer preference were also assessed.

2. Materials and Methods

2.1. Materials

The main ingredients used in making the nuggets were Pangasius fish fillet and trimmings (*Pangasius* sp.) from Palembang (Figure 1). The whole fish from the suppliers were sent directly to the factory, and the delivery was through a cold chain distribution. The fish will be directly processed upon arrival at the factory to remain fresh. Other ingredients include tapioca flour, wheat flour, orange bread crumbs, salt, sugar, pepper, ice water, eggs, garlic powder, onion powder, monosodium glutamate, and isolate soy protein (ISP). The types of equipment used are a digital scale, nugget mold, meat grinder, steamer, deep fryer, food tongs, measuring cups, and airtight plastic containers.

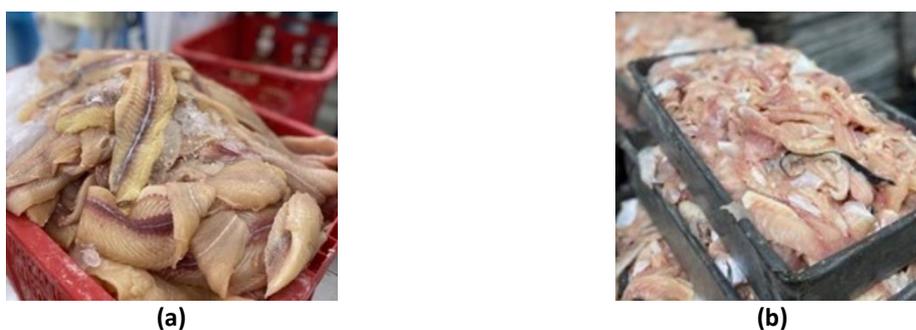


Figure 1. (a) Pangasius Fish Fillet; (b) Pangasius Trimmings.

2.2. Research Procedure

2.2.1. Research Design

This research was conducted experimentally using a completely randomized design with one treatment factor. It includes the substitution of fillet with trimmings in making Pangasius fish nuggets with six levels of treatment. The ratio of Pangasius fillet and trimmings are 100:0 (P1), 60:40 (P2), 50:50 (P3), 40:60 (P4), 30:70 (P5), and 20:80 (P6).

2.2.2. Fish Nuggets Making Procedure

The process of making fish nuggets starts with soaking the Pangasius fillet and trimmings with vinegar water to remove the fishy odor, and washing it with clean water. Then, ground the meat and mix it with the remaining ingredients (Table 1 and Table 2). Next, the dough should be molded to produce nuggets with a uniform shape and thickness (0.8 cm). The nuggets were then steamed for 20 minutes and cooled in the refrigerator for approximately 30-45 minutes. Furthermore, nuggets were coated with flour and orange bread crumbs until evenly distributed. Coating flour is made by mixing 42.5 ml of water, wheat flour, egg, and seasonings of salt, pepper, sugar, and monosodium glutamate. Nugget coated with coating flour and bread crumbs should be half-cooked using a deep fryer for 1 minute at 180°C, cooled, and packaged. The results in each treatment can be seen in Figure 2.

Table 1. Comparison of meat in fish nugget formulation.

| Treatment | Pangasius Fillet (g) | Trimmings (g) |
|------------|----------------------|---------------|
| P1 (100:0) | 150 | 0 |
| P2 (60:40) | 90 | 60 |
| P3 (50:50) | 75 | 75 |
| P4 (40:60) | 60 | 90 |
| P5 (30:70) | 45 | 105 |
| P6 (20:80) | 30 | 120 |

Table 2. Fish nugget formulation (exclude meat).

| Ingredients | Quantity (%) |
|--|--------------|
| Tapioca Flour | 11 |
| Wheat Flour | 11 |
| Seasoning (Garlic Powder, Onion Powder, Salt, Pepper, Sugar, Monosodium Glutamate) | 8 |
| Egg | 12 |
| Isolate Soy Protein | 0.5 |



Figure 2. Fried Nugget in Each Treatment.

2.2.3. Chemical Analysis

In two repetitions, chemical analysis was carried out on each formulation with a proximate analysis of moisture, ash, carbohydrate, protein, and fat content. The water content of each sample was measured by thermogravimetry according to the SNI-01-2354.2-2006 method, the ash content by dry method according to the SNI-01-2354.1-2006 method, the protein content by the Kjeldahl method (5), the fat content by Soxhlet extraction (5), and carbohydrate content using the by difference method.

2.2.4. Sensory Analysis

In this research, 100 untrained panelists carried out the acceptance test. The number of samples presented was six samples with different combinations for each panelist. First, each sample of the fish nugget was deep-fried at 180°C for 2 minutes and cooled. Then the samples were presented separately in equal volumes, each in an airtight plastic container labeled with a random three-digit code (Figure 3).



Figure 3. Fish Nugget Sample Serving to Panelist.

Panelists were asked to taste each sample sequentially, give a preference rating on a scale of 1-9 on each attribute, and fill in the comments column regarding the characteristics of the sample. A scale of 1 represents “dislike extremely,” while a scale of 9 represents “like extremely.” In this research, the selection of sensory attributes was carried out through a Focus Group Discussion (FGD) with four trained panelists. The FGD results found that the attributes of fish odor, overall taste and flavor, crispness texture, hardness texture, and juiciness texture were the most detected sensory attributes.

2.2.5. Data Analysis

The data obtained in the sensory and proximate tests were then analyzed using the ANOVA test with the XL STAT 2020.5.1 software (Addinsoft, New York, USA, 2021) and continued with the Tukey test (HSD) when there was a significant difference. Additionally, principal component analysis (PCA) was conducted to describe the relationship between several dependent variables and between treatments.

3. Results and Discussion

3.1. Chemical Characteristics of Pangasius Fish Nuggets

Chemical analysis was carried out on each formulation of Pangasius fish nugget with proximate analysis, including water, ash, protein, fat, and carbohydrate content, as summarized in Table 3.

Table 3. Results of proximate analysis of pangasius fish nuggets.

| Attributes | P-value | Treatments | | | | | |
|--------------|---------|-------------------------|--------------------------|---------------------------|--------------------------|--------------------------|-------------------------|
| | | P1 (100:0) | P2 (60:40) | P3 (50:50) | P4 (40:60) | P5 (30:70) | P6 (20:80) |
| Water | 0.650 | 53.27±0.00 ^a | 51.40±0.02 ^a | 50.00±0.03 ^a | 49.93±0.03 ^a | 48.19±0.06 ^a | 47.89±0.04 ^a |
| Ash | 0.825 | 2.34±0.00 ^a | 2.38±0.00 ^a | 2.39±0.00 ^a | 2.39±0.00 ^a | 2.40±0.00 ^a | 2.44±0.00 ^a |
| Protein | 0.247 | 9.51±0.00 ^a | 9.69±0.00 ^a | 9.32±0.00 ^a | 9.12±0.01 ^a | 8.64±0.00 ^a | 8.58±0.00 ^a |
| Fat | 0.001 | 9.91±0.00 ^d | 10.89±0.01 ^{cd} | 11.84±0.01 ^{bcd} | 12.38±0.01 ^{bc} | 13.57±0.00 ^{ab} | 15.04±0.00 ^a |
| Carbohydrate | 0.988 | 24.97±0.01 ^a | 25.65±0.02 ^a | 26.45±0.02 ^a | 26.19±0.03 ^a | 27.20±0.06 ^a | 26.05±0.04 ^a |

ns = numbers followed by different lowercase letters in the same row indicate significant differences.

3.1.1. Water Content

Water is an important chemical component as it can affect food products' appearance, texture, and taste. Table 3 showed that the water content in nuggets with the combination of pangasius fillet and trimmings ranged from 47.89% to 53.27%. It meant that all treatments produced water content under the chemical requirements of the National Standardization Agency with a maximum value of 60.0%. The highest and lowest water content was found in treatment P1 (100:0) and treatment P6 (20:80), which were 53.27% and 47.89%, respectively. Moreover, the results of the ANOVA test on the water content also indicated a significance value of the sample or p-value higher than 0.05, meaning that the substitution of pangasius fillet with trimmings in fish nuggets resulted in no significant difference amongst the six samples.

3.1.2. Ash Content

Ash content is an inorganic material produced from the combustion process of organic components in food (6). Based on Table 3, the sample significance value was shown at 0.825 in the ash attribute. This indicated no significant difference between the six samples, as the p-value was more significant than 0.05. The table also showed that the ash content produced in each treatment ranged from 2.34% to 2.44%. Therefore, the ash content results in all these treatments were judged to have complied with the chemical requirements of the National Standardization Agency, which did not exceed the value of 2.5%. In contrast to the research conducted by F. M. Jaya, and I. A. Yusanti (7), the ash content of Pangasius nuggets ranged from 1.84%-2.34%. This is due to differences in raw materials, where research of F. M. Jaya and I. A. Yusanti used a combination of Pangasius surimi and carrot puree to manufacture fish nuggets.

3.1.3. Protein Content

Unlike carbohydrates and lipids, protein food substances comprise N atoms. As shown in Table 3, the results of the ANOVA test on the protein content showed a significance value of the sample or p-value higher than 0.05. Therefore, the substitution of pangasius fillet with trimmings in fish nuggets resulted in no significant difference amongst the six samples. Table 3 also exhibited that the protein content of the fish nuggets with the combination of Pangasius fillet and trimmings ranged from 8.58% to 9.69%. These results were under the chemical requirements of the National Standardization Agency, where the minimum value of protein content is 5.0%. Pangasius meat is known to contain protein and essential amino acids in the form of lysine and arginine (8). The protein content produced was observed to decrease with the increasing percentage of trimmings used. This happened because Pangasius fillet is known to have a higher protein content than trimmings, which is 16.34%. The results are not much different from those of D. F. Ayu et al. (9), where the percentage of pangasius fillet used is directly proportional to the protein content produced. The study had an average content of 14.37% to 16.24%.

3.1.4. Fat Content

Fat is one nutrient that is not soluble in water and is considered necessary for the body. The fat content results in Table 3 showed that the p-value was obtained at 0.001, which was lower than 0.05. Substantial differences were found across the six samples since the pangasius fillet was substituted with trimmings. Usually, when a significant difference was

found on the ANOVA, the Tukey test can identify which significantly different samples, as seen in Table 3. Additionally, the results also showed that the P6 (20:80) and P1 (100:0) treatments had the highest and lowest fat content values of 15.04% and 9.91%. The addition of the percentage of trimmings is observed to cause the increase of fat content in fish nuggets. This happened because trimmings contain a higher fat content than *Pangasius* fillet. The trimming meat had a fat content of 14.48%, while *Pangasius* fillet only 1.53%. The fat content value produced in all treatments is still acceptable. It meets the quality standard for fish nuggets from the National Standardization Agency with a maximum value of 15.0%. In contrast to the research conducted by D. F. Ayu et al. (9), the average fat content in making fish nuggets with *Pangasius* meat and young jackfruit is 1.99% to 4.94%. However, according to E. Hastarini et al. (10), the fat in *Pangasius* meat contains more than 50% unsaturated fatty acids, and it is very good for human health.

3.1.5. Carbohydrate Content

Carbohydrates are the primary energy source for living things to carry out their activities. The calculation of the content for each treatment of fish nugget can be seen in Table 3. The sample significance value was valued at 0.988 in the carbohydrate attribute based on the table. The p-value was greater than 0.05, indicating no statistically significant difference between the six samples. Table 3 also showed that the content produced in each treatment ranged from 24.97% to 27.20%. Almost all the carbohydrates in these fish nuggets come from the dough and coating flours. Susanti et al. (11) also found similar results that the substitution of tilapia fish in nugget produced carbohydrates in 15.36% to 31.31%.

3.2. Sensory Characteristics of *Pangasius* Fish Nuggets

Based on the evaluation and rating of the fish nuggets, 20 panelists produced outlier data. The outlier selection was based on the panelists' interest in fish nuggets. The panelists were chosen from the consumer of fish products. Consumers can provide insight into consumer preferences, opinions and perceptions concerning products that are important in the product development process (12). The acceptance test results, which have final data from 80 panelists, were summarized in Table 4.

Table 4. Results of acceptance test of pangasius fish nuggets.

| Attributes | P-value | Treatments | | | | | |
|------------------|---------|------------------------|-------------------------|-------------------------|-------------------------|------------------------|------------------------|
| | | P1 (100:0) | P2 (60:40) | P3 (50:50) | P4 (40:60) | P5 (30:70) | P6 (20:80) |
| Fish Odor | 0.495 | 7.18±1.14 ^a | 7.36±1.11 ^a | 7.43±0.98 ^a | 7.31±1.01 ^a | 7.45±1.19 ^a | 7.28±1.48 ^a |
| Taste and Flavor | 0.165 | 7.08±1.33 ^a | 7.03±1.41 ^a | 7.19±1.34 ^a | 7.20±1.16 ^a | 7.41±1.25 ^a | 7.20±1.52 ^a |
| Crispness | 0.006 | 6.90±1.28 ^b | 7.24±1.12 ^{ab} | 7.13±1.05 ^{ab} | 7.40±1.31 ^a | 7.44±1.10 ^a | 7.34±1.23 ^a |
| Hardness | 0.066 | 6.94±1.26 ^a | 7.08±1.20 ^a | 6.98±1.07 ^a | 7.01±1.29 ^a | 7.34±1.26 ^a | 7.24±1.34 ^a |
| Juiciness | 0.018 | 6.74±1.42 ^b | 6.89±1.38 ^{ab} | 7.04±1.33 ^{ab} | 7.06±1.28 ^{ab} | 7.23±1.29 ^a | 7.24±1.40 ^a |
| Overall | 0.010 | 7.03±1.01 ^b | 7.13±1.06 ^{ab} | 7.14±1.03 ^{ab} | 7.28±1.09 ^{ab} | 7.45±1.24 ^a | 7.43±1.27 ^a |

ns = numbers followed by different lowercase letters in the same row indicate significant differences.

3.2.1. Fish Odor

According to I. P. Sari et al. (13), odor is an attribute that can be received by the olfactory cells to the brain in the form of electrical impulses. Based on the acceptance test results, it can be seen in Table 4 that the p-value is obtained at 0.495 in the fish odor attribute. There is no significant difference between the six samples because the p-value was higher than 0.05. Some panelists argued that these six fish nuggets had a specific odor. The others stated that the odor came from the spices used, such as garlic, onions, and others.

3.2.2. Taste and Flavor

Taste is an attribute assessed through the taste buds on the human tongue. The results in Table 4 showed that the variation of the percentage of Pangasius fillet and trimmings on fish nuggets had no significant difference in overall taste. This is because the same amount of spices in each treatment was added, resulting in a similar taste. Furthermore, taste attributes were also influenced by the frying process, where a Maillard reaction occurred caused by a chemical reaction between reducing sugars and free amino groups from a protein chain (14). This chemical reaction is responsible for the resulting product flavor and is strongly influenced by temperature and time factors. As a result, frying at the same temperature and time produces the same taste in each treatment of fish nuggets. Some panelists gave the impression of a more savory strong taste. According to H. A. Rasyid et al. (15) research, the higher fat content in food can offer a delightful taste and strengthen the flavor of other food ingredients.

3.2.3. Crispness

Texture was defined by HT Lawless and H. Heymann (16) as a sensory manifestation of a product's structure or inner makeup measured by kinesthetic senses in the muscles of the hand, fingers, tongue, jaw, or lips. The crisp attribute produces a sound when the food product is chewed. Based on the acceptance test results on the crispness texture, it can be seen in Table 4 that the p-value of 0.006 is obtained. It meant that there was a significant difference between the six samples. From the results of the Tukey test (HSD), sample P1 was significantly different from P4, P5, and P6. The higher fat content caused the crispier texture of the fish nugget in the Pangasius fish nugget due to the increase in the percentage of trimmings. The most preferred crispy texture by panelists was found in sample P5 (30:70), with an average preference value of 7.44. Panelists preferred this sample because it had crispier characteristics, therefore, it created a better sensation when chewed. Meanwhile, the least preferred crispy texture was found in sample P1 (100:0), with an average preference value of 6.90.

3.2.4. Hardness

Hardness is the force exerted by the molars to compress food (17). The texture is generally related to the perception ranging from soft to hard when chewing food. In contrast to the crispiness, the hard texture did not significantly differ between the six samples. This is because the significance value of the sample or p-value was higher than 0.05, which was 0.066. Generally, harder texture can be caused by an increased percentage of meat in Pangasius fish nugget products. According to G. Pramuditya and S. S. Yuwono (18), protein can bind to meat shreds and emulsify fat, resulting in a dense and chewy texture. However, in this research, no significant difference was found.

3.2.5. Juiciness

According to I. P. Sari et al. (13), juiciness is the elasticity associated with the product's resistance to breaking due to compressive forces. The results of the ANOVA test on this attribute showed a p-value that was lower than 0.05. Therefore, it can be seen that the variation in the percentage of Pangasius fillet and trimmings resulted in a significant difference between the six samples. The results of the Tukey test (HSD) as a follow-up test showed that the treatment of P1 (100:0) was only significantly different from P5 (30:70) and P6 (20:80). The research also showed that the average preference value on the juiciness attribute ranged from 6.74 to 7.24. This attribute's lowest and highest average preference value was found in treatment P1 (100:0) and P6 (20:80). The sample P6 was observed to be preferred by panelists because it had a level of elasticity that suited the tastes of the panelists. In contrast, other samples were considered too juicy for most panelists. According to H. Kim et al. (19), inadequate water holding capacity can induce excessive water loss during cooking, resulting in a weaker gel and less juicy nuggets. Therefore, P6 nugget gel formation is weaker than other treatments due to the low water content.

3.2.6. Overall

The overall assessment includes all attributes, such as odor, taste, and texture. The results of the ANOVA test showed a p-value that was lower than 0.05. Therefore, the variation of fish nugget in the percentage of Pangasius fillet and trimmings resulted in significant differences between the six samples. Table 4 also showed P5 (30:70) as the most preferred sample with an average preference value of 7.45, but it is not significantly different from P1. This average value had met the sensory quality standard of fish nuggets from the National Standardization Agency, with a value of at least 7. Furthermore, P5, as the most preferred sample, had the characteristics of a specific odor and taste of Pangasius fish, a strong spice taste, as well as a slightly soft, crispy, and not too juicy texture. The lower the percentage of Pangasius fillet and the higher the percentage of trimmings increased overall hedonic response.

3.3. Principal Component Analysis (PCA)

The results of the acceptance test by 80 panelists on each attribute, as well as the proximate test, were then analyzed using the PCA method. Principal component analysis (PCA) is a multivariate technique that simplifies and describes the interrelationships between several dependent variables. From the results of the PCA analysis, a biplot graph is generated, as seen in Figure 4.

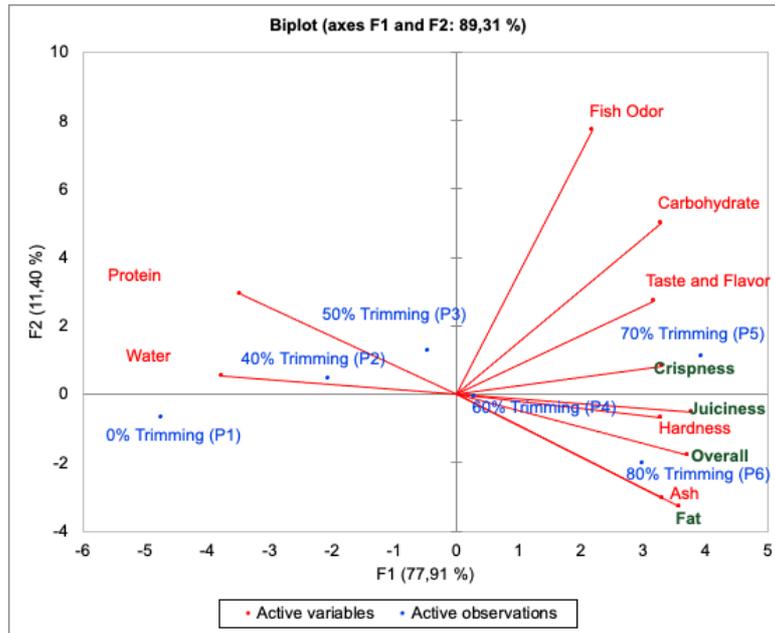


Figure 4. Biplot graph of chemical and sensory characteristics of pangasius fish nugget. Red color indicates attributes that have no significant differences. Green color indicates attributes that have significant differences.

The biplot graph showed that sample P5 (30:70) is more dominant in the characteristics of carbohydrate content with the attributes of fish odor, taste and flavor, crispness, and juiciness that the panelists prefer. In contrast, sample P6 (20:80) is more dominant in ash and fat content characteristics with the attributes of hardness and overall. The higher the fat content produced, the more favorable the sample. Furthermore, the fat content in this food product can provide a crunchier texture when fried, a savory taste, and determine other components such as water, protein, and minerals. This research found that the higher the fat content in the fish nuggets, the softer the texture most favored by most panelists. Therefore, the hardness attribute with fat content has a relative position in the biplot graph. This can be seen in the biplot that the position of the fat attribute was the opposite of the water and protein content. It means that they had an opposite relationship, where the fat content is inversely related to the water and protein. Likewise, the water had the opposite relationship with the crisp texture. Raw materials with low water content tend to affect the crispy texture of fish nuggets after frying (20).

However, it can also be seen from the biplot graph that the protein content has the opposite position with the sensory attributes of hardness and juiciness. The level of hardness and juiciness preferred was a fish nugget with a softer texture, not too hard or juicy. This preferred texture was found in samples with relatively low and high levels of protein and fat contents. On the other hand, high protein produced a denser and harder texture, as the content affects gel formation. According to the results, samples P5 (30:70) and P6 (20:80) were the dominant samples in almost all attributes and produced higher sensory values.

4. Conclusions

Based on the research results, it can be concluded that the sample of fish nuggets with a combination of Pangasius fillet and trimmings 20:80 was the best formulation. This is

because it had the highest overall preference value and utilized waste optimally. Furthermore, from the results of the chemical analysis, all treatments have met the chemical standards of the National Standardization Agency. The results of the chemical analysis also showed that the variation only resulted in significant differences in the fat content, where the percentage of trimmings is directly proportional to the fat content in fish nuggets. Meanwhile, the sensory analysis results only produced significant differences in the attributes of crispness, juiciness, and overall. This research also showed that the fat in *Pangasius* fish nuggets can increase the panelists' preference due to its ability to produce more savory and crispier texture.

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Author Contributions

L.J. designed and performed the experiments; L.J. also analyzed the data and wrote the paper; F., and A.P.W. are the supervising lecturers.

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Data Availability Statement

Available data are presented in the manuscript.

Conflicts of Interest

The authors declare no conflict of interest.

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