

APPLICATION OF FOAM-MAT DRYING TECHNOLOGY ON PRODUCTION OF INDO-PACIFIC TARPON (*Megalops cyprinoides*) FLAVOR ENHANCER

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ABSTRACT

Fish have the potential to be a natural source of flavor. Hence, they can be used as the main ingredient in flavor enhancers. This research examines the characteristics of flavor enhancers made from Indo-pacific tarpon produced using foam-mat drying technology. The formulations were the ratio between the weight of fish fleshes and additives namely 30:70 (A); 40:60 (B); 50:50 (C); 60:40 (D); and 70:30 (E). The test parameters included yield, pH, Maillard reaction product, sensory (preference) and proximate value. The best formulation was based on proximate value. The results showed that the different formulations significantly affected the yield, pH, and Maillard reaction product ($p < 0.05$). The lower the fish flesh used in the formulation, the higher the yield and Maillard reaction product, while the pH decreased. The effectiveness index test based on sensory value (preference) showed that the formulation D (60:40) was the best formulation that contained water of $8.49 \pm 0.30\%$; ash of $33.03 \pm 0.10\%$; protein of $29.67 \pm 0.26\%$; total fat of $2.00 \pm 0.15\%$ and carbohydrates of $26.74 \pm 0.10\%$.

Keywords: characteristic; flavor enhancer; foam-mat drying; *Megalops cyprinoides*; proximate value

INTRODUCTION

Fish is a natural flavor source because it contains glutamic acid. Glutamic acid will give a savory taste (umami) to food when it has become free of glutamic acid due to protein hydrolysis during fermentation, ripening, and heating processes (Thariq *et al.*, 2014). One type of fish that has the potential to source natural flavor is Indo-pacific tarpon. Indo-pacific tarpon (*Megalops cyprinoides*) is a by-catch fish. Therefore, it has a reasonably low economic value. The market price for this type of fish generally ranges from IDR 10,000-15,000/kg. Another cause of the low selling price of this fish is the mushy texture of the meat, which affects consumer acceptance. However, this type of fish has a good taste when processed into fish jelly products such as meatballs, sausages, and nuggets. Besides, it has a high protein nutritional composition of 21.43% (Cahyani *et al.*, 2020). One of the efforts to increase the added value of Indo-pacific tarpon is to process it into a flavor enhancer.

A flavor enhancer is a food additive that functions as a flavor generator. Flavor enhancers are usually available in liquid or powder form. Flavor enhancers in liquid form are considered less practical than flavor enhancers in powder form because of difficulties in distribution and storage. In addition, the water content is still very high, so additional preservatives are needed to extend the shelf life. The drying process is one of the preservation methods to get flavor enhancers in powder form. Drying is an effort to preserve the product from losing its physiological power even though it is stored for a more extended period to produce a better quality product (Purbasari, 2019).

The manufacture of flavor enhancers in powder form often uses the spray drying method. However, apart from being quite expensive, the flavor components in the dried material are prone to damage due to the use of high temperatures. The use of other methods, such as freeze-drying, can be used for materials that are sensitive to high temperatures, but this method is costly to do. One alternative drying method which is relatively simple, cheap, and can protect flavor components is the foam-mat drying method. The foam drying method is a method of drying liquid materials with the addition of foaming agents and fillers, which function to expand the surface of the material, increase the total solids and increase the volume, so that the rate of evaporation of water in the material is faster. In addition, these ingredients can also prevent damage to nutrients and flavor components due to heat during drying (Widyasanti *et al.*, 2018).

Several studies on the production of flavor enhancers have been reported. The use of protein hydrolyzate from *Rasbora jacobsoni* and additional ingredients with a ratio of 50:50 can produce the best flavor enhancer based on organoleptic tests (Witono *et al.*, 2019). The best temperature based on sensory and chemical characteristics in making flavor enhancers from the *Channa striata* head is 70°C (Sobri *et al.*, 2017). The addition of the filtrate from boiling *Dangila cuvieri* can increase the protein content and level of preference for flavor enhancers (Tamaya *et al.*, 2020). The use of Indo-pacific tarpon as a flavor enhancer has never been reported. Therefore, this study aimed to examine the characteristics of the flavor enhancer of Indo-pacific tarpon produced using foam-mat drying technology.

MATERIAL AND METHOD

Materials and Tools

The raw materials used were Indo-pacific Tarpon (*Megalops cyprinoides*) originating from Tarakan, North Kalimantan, and obtained from Gusher Market, Tarakan City. They had weights ranging from 234-364 g/head. Additional ingredients included salt, shallots, garlic, seedless tamarind, ginger powder, pepper powder, granulated sugar, cinnamon powder, and cloves powder obtained from local supermarkets. The

foaming and filling materials used were Tween 80 (Polysorbate) and Maltodextrin (MD) (Yishui Dadi Developing Co., Ltd).

The study used tools such as a blender (Turbo EHM-8099), mixer (Maspion MT-1150), oven (Sharp EO-28LPK), analytical balance (AND GF-6100), pH-meter (Lutron PH-208), vortex mixer (Labnet International Inc), spectrophotometer (PG Instrument T60 VIS), and rotary evaporator (IKA RV 05 Basic).

Formulation of Flavor Enhancer

The initial step in this formulation was to determine the proportion between the fish meat weight and the additives used. The proportion between fish meat weight and additives were A (30:70), B (40:60), C (50:50), D (60:40), and E (70:30). The next step was to determine the weight of the additives for each formulation. The additional ingredients used were salt (37.5%), onion (20%), garlic (20%), tamarind without seeds (10%), ground ginger (5%), ground pepper (2.5%), granulated sugar (2%), ground cinnamon (2%), and ground cloves (1%). The weights of additives for each formulation are presented in Table 1 (Witono *et al.*, 2017).

Table 1. The weight of additives for each formulation

Treatment	Additives (g)								
	Salt	Shallots	Garlic	Seedless tamarind	Ginger powder	Pepper powder	Granulated sugar	Cinnamon powder	Cloves powder
A	26.25	14.00	14.00	7.00	3.50	1.75	1.40	1.40	0.70
B	22.50	12.00	12.00	6.00	3.00	1.50	1.20	1.20	0.60
C	18.75	10.00	10.00	5.00	2.50	1.25	1.00	1.00	0.50
D	15.00	8.00	8.00	4.00	2.00	1.00	0.80	0.80	0.40
E	11.25	6.00	6.00	3.00	1.50	0.75	0.60	0.60	0.30

Note: The proportion between the weight of fish meat and additives: A (30:70); B (40:60); C (50:50); D (60:40); E (70:30).

Production of Flavor Enhancer

The fish meat was crushed, then boiled for 30 minutes at 100°C. The decoction was squeezed and filtered to obtain the filtrate. The filtrate was added with additives according to the formulation in each treatment and heated while stirring until homogeneous. After that, the mixture was cooled. The mixture was added with 4% Tween 80 (v/v) and homogenized for 3 minutes. In a further step, 10% maltodextrin (w/v) was added and homogenized again for 5 minutes. The mixture was poured into a stainless steel pan lined with aluminum foil, placed in the oven, and dried at 70°C for 8-10 hours. The dry sheets were weighed and crushed for 2 minutes to obtain a flavor enhancer in powder form. The powder was sieved, and the results

were weighed, then packaged in PP (Polypropylene) plastic (Sobri *et al.*, 2017; Widyasanti *et al.*, 2018; Purbasari, 2019).

Test parameters

Test parameters included yield, pH (NSAI, 2019), Maillard reaction products (Witono *et al.*, 2017), sensory test (Witono *et al.*, 2017), effectiveness index (Cahyani & Nadia, 2022), water content (NSAI, 2006a), ash content (NSAI, 2006b), fat content (NSAI, 2006c), protein content (NSAI, 2006d), and carbohydrate content (Oiso & Yamaguchi, 1985).

Data analysis

The parametric data were analyzed using the ANOVA test, whereas the non-parametric data were analyzed using the Kruskal-Wallis test and Duncan's Multiple Range test to see significantly different treatments ($p < 0.05$). Statistical analysis was performed using SPSS 23.0 program.

RESULT AND DISCUSSION

Yield

Yield is a test parameter to determine the efficiency of a production process. The results of the ANOVA test showed that there was a significant effect of different formulations ($p < 0.05$) on the yield value of the flavor enhancer. A Duncan's Multiple Range test showed significant differences in the yield value at all treatments. The yield values of the Indo-pacific tarpon flavor enhancer are presented in Figure 1.

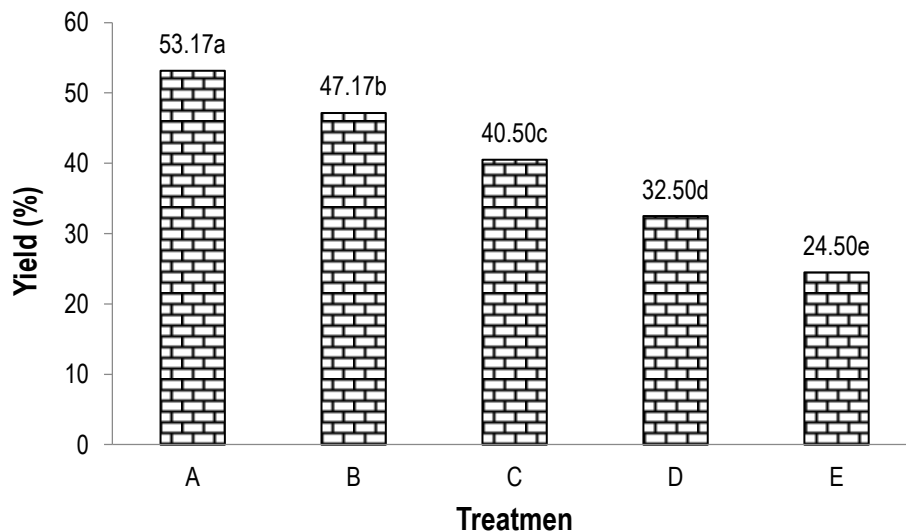


Figure 1. The yield value of Indo-pacific tarpon flavor enhancer: the proportion between the weight of fish meat and additives: A - 30:70; B - 40:60; C - 50:50; D - 60:40; E - 70:30. Different superscripts indicate significant differences ($p < 0.05$)

Based on data in Figure 1, the lowest yield value was treatment E (70:30), which was $24.50 \pm 0.50\%$, and the highest yield was treatment A (30:70), which was $53.17 \pm 0.76\%$. The highest yield was shown in the treatment with a larger proportion of additives. The proportion of fish meat did not affect the yield of the flavor enhancer as much because the water content in the fish meat filtrate evaporated during the drying process. It was in line with previous research, which stated that the highest yield (55.17%) was found in flavor enhancers at the proportion of fish meat to additives of 20:80 and the lowest yield (16.96%) at the proportion of fish meat to additives of 100:0. An increase in fish meat proportion was not followed by the increase in the yield of flavor enhancers. It was due to the proportion of the additives' weight increasing. In addition, the loss of moisture content and volatile components during the drying process caused the weight of the material to decrease (Witono *et al.*, 2017). The material yield decreased during the drying process because the water content evaporated due to heating and continued along with the increase in temperature and the length of the drying process (Erni *et al.*, 2018).

pH

pH is an indicator of acidity and alkalinity that can be used to control the quality of a food product. The results of the ANOVA test showed that there was a significant effect of different formulations ($p < 0.05$) on the pH value of the flavor enhancer. A Duncan's Multiple Range test showed significant differences in the pH value at all treatments. The pH values of the Indo-pacific tarpon flavor enhancer are presented in Figure 2.

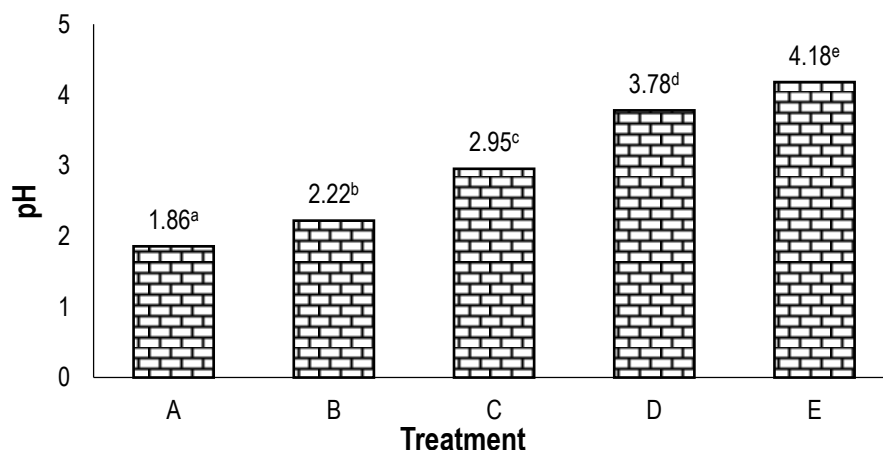


Figure 2. The pH value of Indo-pacific tarpon flavor enhancer: the proportion between the weight of fish meat and additives: A (30:70); B (40:60); C (50:50); D (60:40); E (70:30). Different superscripts indicate significant differences ($p < 0.05$)

Based on data in Figure 2, the lowest pH value was treatment E (70:30), which was 1.86 ± 0.02 , and the highest pH was treatment A (30:70), which was 4.18 ± 0.09 . The difference in the proportion of fish meat to additives caused the pH value to increase. It showed that the greater the proportion of additives in the formulation, the more acidic the flavor enhancer and the higher the shelf life. It was presumably due to the tamarind content in the additives. Tamarind can reduce the pH of foodstuffs because it has a high acidity level. An acidic pH can enhance flavor and inhibit bacterial growth (Wijayanti *et al.*, 2016). Acids can cause the exchange of acid ions (H^+) from the environment to bacterial cells, causing the creation of acidic conditions in the cell membrane. The main compounds in bacterial cells, such as DNA and ATP, cannot work under acidic conditions, resulting in metabolic disorders in bacteria (Pakaya *et al.*, 2014).

Maillard reaction products

The Maillard reaction product can be measured spectrophotometrically at a wavelength of 420 nm. The ANOVA test results showed a significant effect of different formulations ($p < 0.05$) on the Maillard reaction product of the flavor enhancer. A Duncan's Multiple Range test showed significant differences in the Maillard reaction product at treatments B and C and treatments C and D. The Maillard reaction products of the Indo-pacific tarpon flavor enhancer are presented in Figure 3.

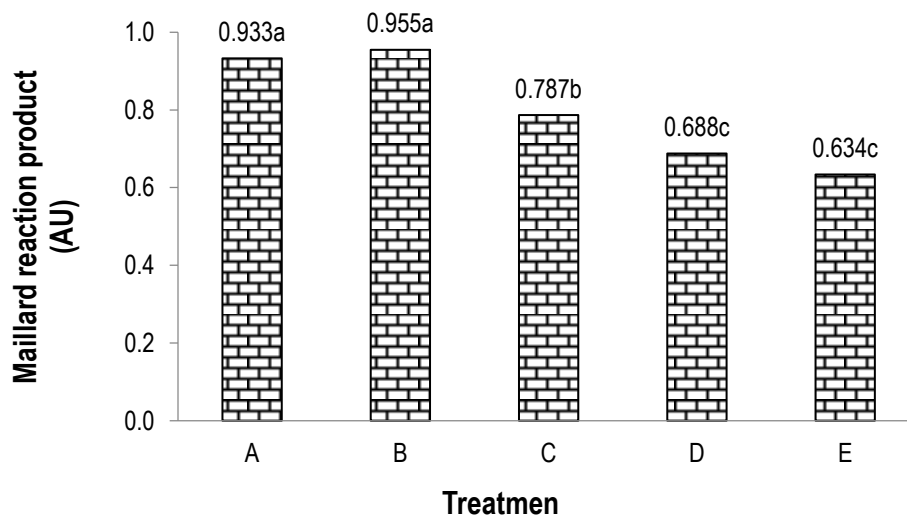


Figure 3. The Maillard reaction product of Indo-pacific tarpon flavor enhancer: the proportion between the weight of fish meat and additives: A (30:70); B (40:60); C (50:50); D (60:40); E (70:30). Different superscripts indicate significant differences ($p < 0.05$)

Based on Figure 3, the lowest value of the Maillard reaction product was treatment E (70:30), which was 0.634 ± 0.06 AU and the highest Maillard reaction product was treatment B (40:60), which was 0.955 ± 0.01 AU. It showed that the higher the proportion of fish meat in the formulation, the lower the value of the Maillard reaction product. Contrary to previous research which reported that a larger proportion of fish protein hydrolyzate would donate more primary amine groups, causing a larger production of Maillard reaction product. The increase of the Maillard reaction products in the lower proportion of fish meat might occur because the Maillard reaction product was already produced by the additives. The additives such as powdered ginger, cinnamon powder, ground pepper, and ground cloves that had gone through previous processing give the dominant brown pigment and increase absorbance values (Witono *et al.*, 2017). The Maillard reaction is an essential reaction during the processing process with indicators of the appearance of brown pigment in foodstuffs. In addition to causing color changes, the Maillard reaction can also affect the flavor and texture due to cross-linking of proteins and reactions between amino acids and carbonyl compounds that form reactive intermediates such as aminoketones (Agustini *et al.*, 2015; Hustiany, 2016)

Sensory

Sensory value can be obtained from the hedonic test (preference) subjectively using the five human senses to choose one product from several other products. This test is often used in the context of developing a product. Kruskal Wallis test showed no significant effect of different formulations ($p > 0.05$) on the value of color, aroma, and taste of flavor enhancers. The sensory values of the Indo-pacific tarpon flavor enhancer are presented in Figure 4.

Color is a sensory attribute that is easily recognized and is often used to increase consumer acceptance of a food product. The lowest color value was treatment A (30:70), which was 3.68 ± 0.85 , while the highest color value was treatment D (60:40), which was 4.12 ± 0.60 (Table 4). It showed that color preference tended to increase as the proportion of fish meat increased and the additives decreased. It was presumably due to flavor enhancers with a higher proportion of additives tended to have a darker brown color, making it less favorable. The formed brownish color can come from the Maillard reaction that occurs. In addition, a brownish color can also be formed due to the addition of additional ingredients such as powdered ginger, cinnamon powder, ground pepper, and cloves which tend to brown. This finding was in line with previous research which stated that the color of the petis powder was formed due to the Maillard reaction during heating. The longer the heating process, the reducing sugar content will increase, causing an increase in the browning reaction (Fauzy *et al.*, 2016). The brown color in the flavoring powder was

caused by the basic color of brownish fish meal and tomato flour which had undergone enzymatic and non-enzymatic browning reactions during the previous processing (Fitri, 2018).

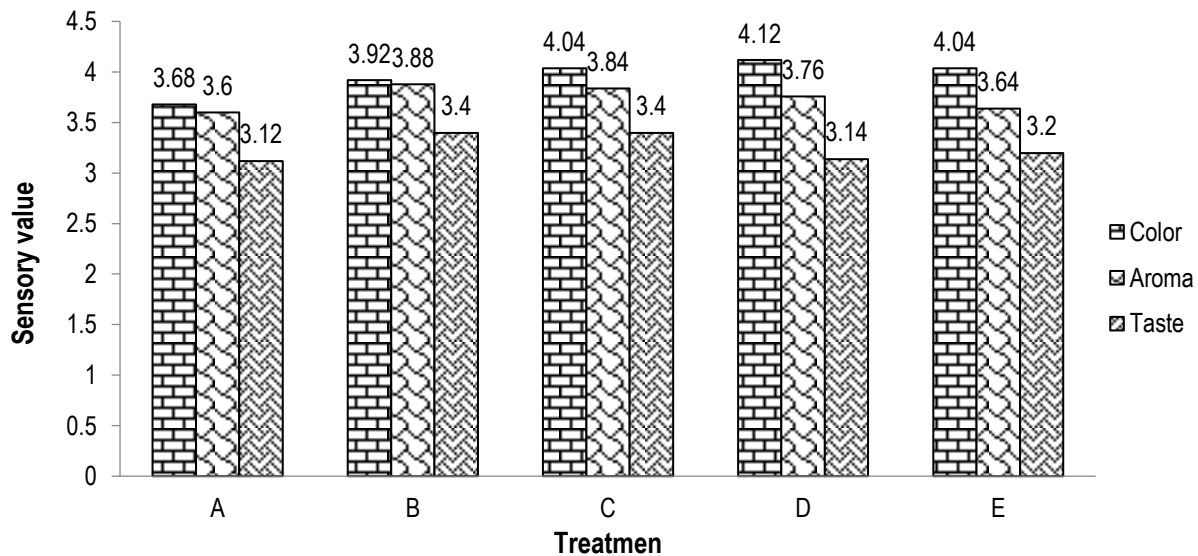


Figure 4. The sensory value of Indo-pacific tarpon flavor enhancer: the proportion between the weight of fish meat and additives: A (30:70); B (40:60); C (50:50); D (60:40); E (70:30).

Aroma is an important sensory attribute, especially in producing flavorings for the food industry. Aroma compounds can be found in various foodstuffs and are volatile so that they can quickly enter the human olfactory system. These compounds significantly affect consumer preferences for a food product (Tarwendah, 2017). The lowest aroma value was treatment A (30:70), which was 3.60 ± 0.85 , while the highest aroma value was treatment B (40:60), which was 3.88 ± 0.53 (Figure 4). It showed that the panelists dislike flavor enhancers with too much proportion of fish meat or additives. Too much fish meat proportion caused the flavor enhancer to have a powerful fish aroma. At the same time, the proportion of additives that are too much caused the flavor enhancer to have a powerful spice aroma. Panelists preferred the flavorings that did not have a strong aroma. Glutamic acid will cause an aroma that can manipulate the brain as if it had tasted delicious food (Djohar *et al.*, 2018). The aroma is easily recognized, and the test is highly dependent on the level of sensitivity and preference of the panelists. Aroma testing can be very subjective, but it is essential to be applied to the food industry to provide relatively fast results (Utami *et al.*, 2016).

The taste of flavor enhancer products can be determined by the hydrolysis process of protein, which produces an amino acid, peptide, and nucleotide compounds, as well as the Maillard reaction, which

produces 2-furfurylthiol, 1,2,3-trithiolan, 2-methyl-3-(methylthio) compounds, furans and other flavor-forming compounds (Palupi *et al.*, 2013). The lowest taste value was treatment A (30:70), which was 3.12 ± 0.83 , while the highest taste value was treatment D (60:40), which was 3.44 ± 1.08 (Figure 4). It showed that the flavor value trend of the flavor enhancer is in line with the aroma value. Strong aromas tend to give a strong taste as well. In addition, panelists also tend to dislike flavor enhancers that have a powerful aroma and taste. The higher concentration of nutmeg flesh oil could reduce the panelists' acceptance of the cake but be still at the level of liking. Taste is an important aspect that affects the level of consumer acceptance. Taste is a sensation obtained from a combination of taste, aroma, and all things that involve the tongue that produce a specific taste in food ingredients (Sipahelut *et al.*, 2017). A non-enzymatic browning reaction (Maillard reaction) is a reaction between reducing sugars and primary amino groups that form glucosamine. The amino group that has an essential role in forming flavor compounds is the amino group of lysine residues that are bound to peptides and proteins (Witono *et al.*, 2014).

Proximate value

The results of the effectiveness index test obtained the best formulation, namely the proportion of fish meat and additives 60:40 (D), then analyzed the proximate value, including water content, ash content, protein content, total fat content, and carbohydrate content. The proximate values of fish flavor enhancers for the best formulation of the Indo-pacific tarpon flavor enhancer are presented in Table 2.

Table 2. Proximate value of the best formulation of Indo-pacific tarpon flavor enhancer

Proximate	Value (%)
Water	8.49 ± 0.30
Ash	33.03 ± 0.10
Protein	29.67 ± 0.26
Total fat	2.00 ± 0.15
Carbohydrate	26.74 ± 0.10

Water is important to our food's appearance, texture, and taste. The water content goes along with the acceptability and durability of foodstuffs (Rahman & Naiu, 2021). Thus, it can inhibit the growth of spoilage bacteria. The water content of the flavor enhancer in the best treatment was relatively low, namely

8.49 ± 0.30% (Table 3). The average water content of instant beef broth with the comparison treatment between oxtail broth and broccoli juice ranged from 8.41 to 10.82%. The product's water content is directly proportional to the moisture content of the materials used. The higher water content of the material will cause the product water content to increase (Permata *et al.*, 2019). The addition of dextrin can also reduce the water content of the resulting powdered shrimp flavor product by up to 3.48%. Dextrin is known to have a simple molecular structure and low molecular weight so the water contained in the product will evaporate more efficiently during the drying process (Meiyani *et al.*, 2014).

Ash content is inorganic residues from the oxidation process of organic matter, which can be determined gravimetrically (Yuniastri & Putri, 2019). The ash content of the best treatment flavor enhancer was relatively high, namely 33.03±0.10% (Table 3). It was presumably because the flavor enhancer was made from ingredients containing high enough minerals, such as salt, marine fish, and spices. The ash content tends to increase along with the increase in the proportion of oxtail broth and broccoli juice, which are known to contain relatively high minerals (Permata *et al.*, 2019). Decreases in the water content of the material due to heating also caused an increase in ash content during food processing (Laboko, 2019).

Protein is a nutritional component with essential functions for the body and is needed in large quantities. Adequate protein intake indicates good nutritional status. The protein content of the best formulation flavor enhancer was relatively high, namely 29.67 ± 0.26% (Table 3). The protein content of Koya from various types of fish ranged from 27.13-to 29.83% (PTA *et al.*, 2012). The higher the drying temperature, the lower the water content and the higher the protein content. Dextrins are known to protect flavor components such as protein from high temperatures (Sobri *et al.*, 2017).

Fat is a substance that is quite important in the food and flavor industry because of its role in shaping taste. Fish fat can be degraded into saturated and unsaturated fatty acids, which produce volatile compounds, including hydrocarbon groups, aldehydes, alcohols, and ketones. Volatile compounds play a role in forming the flavor of a food ingredient (Pratama *et al.*, 2018). The total fat content of the flavor enhancer in the best treatment was relatively low, namely 2.00 ± 0.15% (Table 3). The fat content of instant chicken broth substituted with chicken liver flour was 2.87%. Thermal processing will cause the degradation of fat into carbonyl compounds that can cause a savory taste in the broth (Malichati & Adi, 2018).

Carbohydrates are essential macro substances that can affect the characteristics of foodstuffs, such as taste, color, and texture (Arnesih *et al.*, 2018). The carbohydrate content of the flavor enhancer in the best treatment was relatively high, namely 26.74±0.10% (Table 3). It was presumably due to the use of a

relatively low temperature (70°C) in the flavor enhancer processing so that it can reduce starch damage due to heating. It was in line with previous research, which reported that the powdered seasoning made from smoked roa fish has a carbohydrate content ranging from 22.05 to 34.65% (Botutihe & Rasyid, 2018). Higher temperatures in the drying process cause the starch content in food to be lower. The increasing levels of total acid also followed this due to the breakdown of starch molecules into simple sugars (Prasetyaningsih *et al.*, 2018).

CONCLUSION

This study has successfully produced flavor enhancers from Indo-pacific tarpon using foam-mat drying technology and determined its characteristics. These experiments confirmed that different treatments had a significant effect ($p < 0,05$) on yield, pH, and Maillard reaction product. The proportion of 60:40 was the best treatment based on the sensory test. Unfortunately, the study did not include the determination of glutamic acid that may contribute to producing flavor. Despite its limitations, the study offers an insight into applying foam-mat drying technology in producing flavor enhancers, especially from by-catch fish. A further study is needed to complete the information on flavor-forming compounds of Indo-pacific tarpon flavor enhancers.

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