Food Research 7 (Suppl. 3) : 86 - 96 (2023)
Journal homepage: https://www.myfoodresearch.com

FULL PAPER

Product characteristics, amino acid and fatty acid profiles of milkfish (*Chanos chanos*) with different cooking methods

Nopiyanti, V., *Fahmi, A.S., Swastawati, F., Kurniasih, R.A. and Riyadi, P.H.

Department of Fisheries Product Technology, Faculty of Fisheries and Marine Science, Universitas Diponegoro, Semarang, Central Java 50275, Indonesia

Article history:
Received: 11 November 2022
Received in revised form: 29 June 2023
Accepted:27 September 2023
Available Online: 31 October 2023

Keywords:
Milkfish,
Cooking method,
Sensory analysis,
Amino acid profile,
Fatty acid profile

DOI:
https://doi.org/10.26656/fr.2017.7(S3).12

Abstract

Different cooking methods would produce different product characteristics. The aim of this study was to identify product characteristics (sensory analysis, texture, color, yield, and proximate analysis), amino acid profile, and fatty acid profile of cooked milkfish. Milkfish were boiled (18 mins, 100°C), steamed (30 mins, 100°C), and pressure steamed (120 mins, 121°C with a pressure of 1 atm). Based on the sensory value, the most preferred milkfish by the panelists was pressure steamed milkfish. Pressure steamed milkfish had the highest a* and b* values and produced the hardest texture. The highest yield was obtained from steaming. The proximate composition showed that boiled milkfish had the highest moisture, ash, protein, and fat content. Different cooking methods had different effects on amino acids and fatty acids because cooking time plays a role in determining changes in the amount of amino acids and fatty acids. Glutamic acid, aspartic acid, lysine, and leucine were the dominant amino acids. The dominant fatty acid profiles were palmitic acid, oleic acid, docosahexaenoic acid (DHA), and linoleic acid. Pressure steaming was the process that took the longest time, so that the proximate and amino acid content in it was lower than boiled and steamed, which had a shorter cooking time. However, pressure steamed cooking resulted in the most preferred product by the panelists.

1. Introduction

Milkfish belongs to the *Chanidae* family which is mostly found in the Indo-Pacific as consumption fish. Milkfish (*Chanos chanos*) is one of the potential commodities of aquaculture that has important economic value. Milkfish production in Central Java, Indonesia from 2018 to 2019 has increased, from 956,944.76 tons to 985,006.27 tons (Statistics and Information Center for Data of the Ministry of Maritime Affairs and Fisheries Republic of Indonesia, 2022). This amount was higher than catfish (149,702.28 tons), carp (17,178.13 tons), and common carp (11,697.53 tons) (Statistics and Information Center for Data of the Ministry of Maritime Affairs and Fisheries Republic of Indonesia, 2022). Milkfish cultivation is often found in tropical countries, especially Indonesia, due to the availability of abundant food, fast growth, disease resistance, and tolerance to a wide range of environmental conditions (Vasava *et al.,* 2018).

Most of the milkfish in Semarang, Central Java, Indonesia was processed into products such as softed bone milkfish, smoked milkfish, grilled fish cake, meatballs, sausage, nuggets, fish crackers and other value added products. Tourists are usually use softed bone milkfish as typical gifts from Semarang city. The effect of cooking or processing on milkfish meat components could cause changes in product characteristics and chemical composition of milkfish meat. Several studies have shown that the cooking process that involves heat affects the water content, ash, fat, protein, fatty acids, and amino acids contained in fish (Oluwaniyi *et al*., 2010; Oluwaniyi *et al*., 2017; Yu *et al.,* 2017). Cooking or processing is one of the important methods where the purpose of processing is to get the desired quality and effect. The processing also plays a role in flavor formation, provides a lasting effect, and also improves nutritional components. According to Ma *et al.* (2015), thermal processes significantly affect the flavor and taste of food products. Different cooking methods such as steaming and boiling affect the appearance and texture of the meat, which had a different texture with different humidity (Jiao *et al.,* 2020).

Milkfish were classified as high protein and low-fat fish. Based on the research results of Malle *et al.* (2019),

*Corresponding author.
Email: *suhaeli.fahmi@live.undip.ac.id*

eISSN: 2550-2166 / © 2023 The Authors.
Published by Rynnye Lyan Resources

the protein content of milkfish originating from Pangkep, Indonesia was 24.18%, with fat content of 0.87%. According to Murthy *et al.* (2016), milkfish originating from Narasapur, India had protein content of 20.37% with fat content of 3.84%. Proteins are composed of amino acids. The quality of protein was determined by the type and amount of constituent amino acids. Specifically, amino acids were divided into two types, namely, essential amino acids and non-essential amino acids. The higher the levels of essential amino acids in a food, the better the quality of the protein in the food. Different cooking methods in fish affect the physical, chemical, and nutritional content. In addition, the cooking method affects Polyunsaturated Fatty Acids (PUFA) and product acceptance by consumers (Abraha *et al.,* 2018).

This study aimed to determine the product characteristics, amino acid profile, and fatty acid profile of milkfish using different cooking methods.

2. Materials and methods

2.1 Sample preparation

Fresh milkfish (*Chanos chanos*) was obtained from a fish seller at a local market in Sayung District, Demak, Central Java, Indonesia. Fish transportation uses styrofoam boxes, which contain ice cubes to maintain freshness.

2.2 Experimental procedure

Fresh fish were removed from the visceral in the laboratory with knives, then cleaned and washed. Cooking methods were used in this study including boiling, steaming, and pressure steaming. The sample was boiled in 5 L water using a temperature of 100°C for 18 mins. Milkfish was steamed in 2.5 L water using a temperature of 100°C for 30 mins. Next, the fish was put into an autoclave which had been filled with water and then cooked using a temperature of 121°C, a pressure of 1 atm with a cooking time of 120 mins.

2.3 Sensory analysis

Sensory analysis was carried out using a hedonic assessment sheet based on the Indonesian National Standard (2015) SNI 2346:2015. The hedonic scale ranges from 1 to 9. The samples were divided into three groups depending on three different cooking methods. Each group was taken in triplicate, and then the panelists were given a hedonic scoresheet, descriptive test file, water, and tissue. The panelists were six undergraduate students of Fisheries Products Technology, Universitas Diponegoro, Semarang City, Indonesia.

2.4 Yield

The yield was calculated by dividing the weight of the final product (ripe product) by the weight of the whole fish product (raw product) (Hafiluddin, 2014). The calculation of the yield percentage uses the following formula:

$$\text{Yield (\%)} = \frac{\text{Weight of cooked samples (g)}}{\text{Whole weight of fish (g)}} \times 100\%$$

2.5 Texture (hardness)

The texture (hardness) was analyzed by the Texture Analyzer tool. Whole fish samples were divided into two parts and then analyzed for texture (hardness). The probe was installed and then positioned close to the sample. After the probe was close to the sample, the computer operated to run the probe. This method was according to the procedure described by Untoro *et al.* (2012).

2.6 Color

Fish color was determined by measuring the values of L (lightness), a* (component (+) red to (-) green) and b* (component (+) yellow to (-) blue). Taking pictures using a Logitech camera connected to a PC and Logitech Camera software. Color testing was measured using the Software smartphone "Color Grab" (Loomatix). The picture was taken using a styrofoam box in the form of a cube with size (30×30×30 cm). The sample was placed in a box with a white background and sufficient lighting. The captured image was entered into the application. Then, the selected image was locked and picked as a color sample.

2.7 Proximate analysis

The moisture or water content of milkfish was analyzed using the Association of Official Analytical Chemists method at a temperature of 105°C to constant weight (AOAC, 2005). The ash content of milkfish was analyzed using the Association of Official Analytical Chemists method at a temperature of 550°C (AOAC, 2005). Milkfish protein content was analyzed using the Kjeldahl method (AOAC, 2005). Fat content in milkfish was analyzed using the soxhlet (National Standardization Agency of Indonesia, 2017).

2.8 Amino acid profile

Amino acid profile analysis using UPLC (Ultra Performance Liquid Chromatography) method. The sample of about 0.1-1.0 g was put into a 20 mL headspace vial. The sample was added with 5-10 mL of 6 N HCl solution and hydrolyzed in an oven at 110°C for 22 hrs. The hydrolyzed sample was transferred to a 50 mL volumetric flask, and aquabides were added to the mark and then homogenized. The solution was filtered using a 0.2 m syringe filter, and the filtrate was then collected. The derivatization solvent (methanol, sodium acetate, and triethylamine in a ratio of 3:3:4) of 30 microliters was added to the drying product. Further dilution was carried out by adding 20 ml of 60% acetonitrite or 1M sodium acetate buffer, then left for 20 mins. The filter results (40 microliters) were taken to be injected into the UPLC. (Column: C18, Mobile phase: Eluent accq. ultra tag; Distilled water, Column temperature: 49°C, and Detector: PDA) (Waters, 2012).

2.9 Fatty acid profile

Analysis of the fatty acid profile using the GC method refers to the AOAC (2005) with modification. The preparation of a standard solution of a mixture of 1 point concentration of FAME (Fatty Acid Methyl Ester) in hexane solvent. The sample was put into a 50 mL falcon tube. For the oil matrix, 0.5 M KOH was added. The sample was added with isopropanol and then vortexed. After being vortexed, the sample was added with hexane and then shaken with a mechanical shaker. The sample was then mixed with distilled water and vortexed again, after which it was centrifuged. Take the top layer (organic phase) into a 10 mL screw tube. Evaporate with N_2 gas. Methylation was processed by adding a solution of KOH in methanol into a 10 mL screw tube that already contains oil or fat extract and then vortexed. Heat the solution in a water bath, then cool the solution to room temperature and add a solution of BF_3 in methanol, and then vortex. After that, the solution is heated again in a water bath. After the cold solution was shaken and added with saturated NaCl solution and hexane, then shaken again. After forming two layers, transfer the top layer (organic phase) to a 2 mL tube containing anhydrous Na_2SO_4. The solution was let stand at room temperature for 1 hr and then put into a 2 mL vial. The solution was injected into the GC FID system.

3. Results and discussion

3.1 Sensory analysis

Panelist acceptance of the appearance, aroma, taste, and texture of milkfish with boiled, steamed and pressure steamed methods was shown in Table 1. This assessment is based on a hedonic scale of 1-9. The scores for the acceptance of the boiled sample were 6.50-7.17 which were evaluated as "like". The acceptance score of the boiled sample was 6.50–7.17, which was rated as "like." The acceptance score of the steamed fish sample was 6.77–7.33, which indicates that the sample has a "like" rating. The acceptance evaluation on the pressure steamed sample had an acceptance score of 8.00-8.33, this was evaluated as "very much like". The results of the sensory evaluation showed that the pressure steamed milkfish sample was preferred by the panelists. These results revealed that different cooking methods significantly affected the appearance, aroma, taste, and texture of milkfish. The difference was caused by the cooking method, cooking time, and temperature used (Fabre *et al.,* 2018). The composition of volatile flavor compounds in fishery products affects the taste and smell of fishery products. They come from aldehydes, alcohols, ketones, and hydrocarbons (Liu *et al*., 2009). Based on the research of Cui *et al.* (2020), cooked meat contains volatile compounds, namely aliphatic hydrocarbons, aldehydes, ketones, carboxylic acids, alcohols, and esters.

A descriptive analysis method involves detection (discrimination) and description of both qualitative and quantitative sensory aspects of a product and is carried out by 5-100 trained panelists. These qualitative aspects were combined to define a product that includes the appearance, aroma, taste, texture, or nature of a product that distinguishes it from other products (Meilgaard *et al.,* 2007). Table 2 shows the results of the descriptive test and the physical appearance of milkfish with different cooking methods.

Different cooking methods give different characteristics of milkfish which include appearance, aroma, taste, and texture. The temperature difference used and the length of cooking time affect the appearance of milkfish meat and its external appearance. The appearance of the fish after pressure steamed treatment is golden yellow or brownish flesh and skin. The yellowish color of the pressure steamed milkfish caused a Maillard reaction. This reaction was caused by reducing sugars (ketone groups or aldehydes) and amino components (amine groups). Maillard reaction rate increases with increasing temperature and decreasing water content. Based on Ayub and Ahmad (2019), the

Table 1. Sensory value of milkfish with different cooking methods.

Cooking Methods	Parameters			
	Appearance	Aroma	Taste	Texture
Boiling	7.00 ± 0.89^a	6.67 ± 1.21^a	6.50 ± 0.83^a	7.17 ± 0.75^a
Steaming	7.17 ± 0.75^a	6.67 ± 0.81^a	7.00 ± 0.63^b	7.33 ± 0.51^a
Pressured Steaming	8.33 ± 0.81^b	8.16 ± 0.75^b	8.00 ± 0.89^a	8.33 ± 0.51^b

Values are presented as mean±SD of three replicates. Values with different superscripts are statistically significantly different ($p<0.05$).

https://doi.org/10.26656/fr.2017.7(S3).12

Table 2. Sensory descriptions test of milkfish with different cooking methods.

Cooking Methods	Descriptions	
Boiling 	Appearance	White, whole, and the flesh was slightly pale and slightly brownish.
	Texture	Dense, slightly runny, slightly mushy, and the meat was cooked well.
	Aroma	Specific boiled fish and fragrant volatile aroma.
	Taste	Dominantly sweet and slightly savory.
Steaming 	Appearance	Whole, yellowish-white, bright, and flesh was brownish white.
	Texture	Dense, compact, and the meat was cooked well.
	Aroma	Specific to steamed fish, fragrant, and prominent volatile aroma.
	Taste	Sweet and savory.
Pressure Steaming 	Appearance	Golden yellow, whole, and bright.
	Texture	Dense, compact, the meat was cooked well, and the milkfish bones were tender.
	Aroma	Specific pressure steamed fish and prominent volatile aroma.
	Taste	Salty and strong savory.

color of the meat turns brown because of the Maillard reaction and caramelization. The reaction takes place during the cooking process using high temperatures.

The processed fish produces a distinctive odor. Fatty acids found in fishery products were a major source of the emergence of volatile compounds. This compound affects the aroma of a commodity. The main volatile components in fish and fishery products come from aldehydes, alcohols, ketones, and hydrocarbons (Liu *et al.,* 2009). According to Liu *et al.* (2021), the main fishy odor substances from fish originating from freshwater fish and seawater fish are different. The main compounds found in freshwater fish are geosmin and 2-methylisobomeol. In seawater fish, aldehydes, alcohols, and ketones were the most common compounds found. Odor components also come from the environment, such as water, feed and algae, enzymeolysis, and oxidative reactions of proteins and lipids.

The differences in the cooking methods used affect the taste of meat products, especially the volatile components contained in meat (Cui *et al.,* 2020). The dominant flavor of boiled milkfish was sweet and less savory, whereas steamed milkfish was more savory and slightly less sweet. Pressure steamed fish had a very savory and salty taste. The glutamic acid content was responsible for the savory taste of fish. Glutamic acid was a source of savory or umami taste that gives a perfect taste to food. Glycine and alanine were active flavor components that were known to give sweet characteristics to aquatic foods. The amino acids glycine, alanine, and arginine contribute to sweetness, although the contribution of alanine does not have a significant effect. The amino acid arginine also contributes to the bitter taste that gives it its characteristic sweet taste (Risso and Carelli, 2017).

3.2 Yield

The results of the measurement of the yield of milkfish showed the pressure steamed method was significantly different (p<0.05) from the boiled and steamed cooking methods. The treatment of the boiled cooking method and the steamed cooking method was not significantly different. The highest product yield was found in milkfish with the steam cooking method, which was 77.09%. The yield of steamed and boiled products has a difference of 0.09%, while the yield of pressure steamed milkfish is the lowest (57.33%). This followed the research conducted by Yoon *et al.* (2018) on skipjack tuna, where the yield of steamed tuna (24.4%) was higher than that of boiled tuna (22.4%). Table 3 shows the yield of milkfish using different cooking methods.

Table 3. Yield and texture (hardness) of milkfish with different cooking methods.

Cooking Methods	Yield (%)	Texture (hardness) (gf)
Boiling	77.00 ± 0.55^b	575.46 ± 4.27^a
Steaming	77.09 ± 1.58^b	631.59 ± 21.52^b
Pressure Steaming	57.33 ± 1.86^a	741.33 ± 13.75^c

Values are presented as mean±SD of three replicates. Values with different superscripts are statistically significantly different (p<0.05).

3.3 Texture (hardness)

The texture (hardness) of boiled, steamed, and pressure steamed milkfish was shown in Table 3. Based on the results of the analysis of the texture (hardness) of milkfish with different cooking methods, it could be concluded that the different cooking methods have a significant effect on the texture (hardness) of milkfish.

https://doi.org/10.26656/fr.2017.7(S3).12

The results of the measurement of the hardness level of milkfish showed the pressure steaming method treatment had the highest hardness value of 741.33 gf. This means that the force to break the product was higher, so the product was harder. The value of the hardness or texture of Atlantic salmon increased along with the high pressure during the cooking process (Yagiz *et al.*, 2009). The pressure steam process could cause higher protein denaturation than other cooking methods. The lowest level of hardness was found in milkfish with boiled cooking method treatment (575.46 gf), which means that the force for breaking the product was lower, so the product is not too hard. Suryaningrum and Syamdidi (2013) reported that the boiled carp "pindang" (7.63) has a lower texture (less dense) than steamed carp "pindang" (8.13). This is because the amount of protein in steamed fish meat is higher, so it can affect the compact and dense texture.

3.4 Color analysis

Table 4 shows that the different cooking methods have a significant effect on color analysis, both the L, a*, and b* values of each treatment. Testing the value of L on milkfish aims to determine the level of brightness. The L value ranges from 0-100, where the closer the value to 100 the milkfish will be brighter or whiter in color. The highest L value was obtained in milkfish with the boiled cooking method, which was 53.7, while the lowest L value was obtained in milkfish with the pressure steamed method, which was 45.2. This means that the color of pressure steamed milkfish tends to be dark because the L value was close to 0. Temperature and pressure could affect color change, where high pressure would reduce the brightness of the product (Schubring *et al.*, 2003). The pressure steamed process that uses high pressure would cause the L value to decrease. The decrease in the value of L was due to the Maillard reaction process in pressure steamed fish. Due to high temperatures and long processing time would form a brown pigment.

Table 4. Color analysis of milkfish with different cooking methods.

Cooking Methods	Color		
	L	a*	b*
Boiling	53.7±0.61^{c}	1.8±0.10^{a}	9.4±1.30^{a}
Steaming	50.4±1.00^{b}	3.7±0.15^{b}	11.6±0.97^{a}
Pressured Steaming	45.2±0.70^{a}	6.9±0.37^{c}	19.0±1.12^{b}

Values are presented as mean±SD of three replicates. Values with different superscripts are statistically significantly different ($p<0.05$).

The notation or a* value interprets the mixed red-green chromatic color. The +a* (positive) value was the interpretation of the red color from 0 to +80. The value –a* (negative) is the interpretation of the green color from 0 to -80. Based on the results obtained, it could be concluded the different cooking methods affect the a* value of milkfish. The highest a* value was obtained in milkfish with the pressure steaming method treatment, which was 6.9, while the lowest a* value was obtained in milkfish with the boiled cooking method treatment, which was 1.8. Because the result was positive and close to zero, the color of the pressure-steamed milkfish tends to be close to red. The concentration and chemical composition of myoglobin would affect the color of the meat (Sen *et al.*, 2014). The use of high temperatures for a long time in the pressure steaming process increases the intensity of the reddish color level in fish. Amino acids in protein contain iodine. The formation of a red color occurs when iodine reacts with glycogen in fish. The myoglobin content in pressure steamed fish would undergo oxidation due to the heating process. According to Singh *et al.* (2022), during the cooking process, myoglobin would undergo oxidation from ferrous (Fe^{2+}) to ferric (Fe^{3+}) and form metmyoglobin, which gives the meat a brownish color.

The value of b* is an interpretation of the mixed blue -yellow chromatic color. Value +b* (positive) from 0 to +70 for yellow. Value –b* (negative) from 0 to -70 for blue. Based on the results obtained, it can be concluded that the different cooking methods affect the b* value of milkfish. The highest b* value was obtained in milkfish with the pressure steaming method treatment, which was 19.0, while the lowest b* value was obtained in milkfish with the boiled cooking method treatment, which was 9.4. The result of an increasing b* value or positive value, causes the color of milkfish to become closer to yellow. According to the research results of Sen *et al.* (2014), the b* value in mutton cooked using an increase in endpoint temperature leads to yellowness and the b* value increases. The yellow pigment in processed fish appears due to the presence of carotenoid compounds present in fish. Carotenoid compounds give yellow, orange to bright red colors (Sefc *et al.,* 2014). Carotenoid compounds are antioxidants that easily react with oxygen and are unstable at high temperatures. The yellow color formed in processed fish is also caused by the Maillard reaction which is a reaction that occurs between amino acid groups and reduces sugars as a result of the heating process (Murata, 2021).

3.5 Proximate analysis

Changes in moisture content, ash content, protein content, and fat content were expressed on a dry basis and shown in Table 5. Based on the analysis of the water content of milkfish with different cooking methods, the average total water content was obtained in the range of

Table 5. Proximate analysis of fresh milkfish and milkfish with different cooking methods.

Samples	Moisture (%)	Ash (%, db)	Protein (%, db)	Fat (%, db)
Fresh	73.49±0.73	5.88±0.20	81.10±1.67	16.42±0.46
Boiled	66.29±0.18^{c}	3.80±0.08^{b}	83.98±0.71^{c}	12.06±0.10^{c}
Steamed	62.86±0.83^{b}	3.68±0.09^{ab}	79.57±1.05^{b}	11.39±0.26^{b}
Pressure Steamed	57.73±1.24^{a}	3.46±0.10^{a}	73.97±2.29^{a}	10.19±0.30^{a}

Values are presented as mean±SD of three replicates. Values with different superscripts are statistically significantly different ($p<0.05$).

57.33-66.29%. The results of the measurement of the water content of milkfish showed the treatment of boiled, steamed, and pressure steamed methods were significantly different ($p<0.05$). The water content of boiled milkfish was highest when compared to other fish, except fresh fish. Generally, the water content of foodstuffs after undergoing the cooking process will decrease. The results of the analysis showed the water content decreases after milkfish was boiled, steamed, and pressure steamed. Cooking is a process that could reduce the water content of food. The research of Pratama *et al.* (2019), showed that the water content of steamed milkfish decreased when compared to fresh fish. The water content of grouper fish fillet, Spanish mackerel, pompano, and red snapper was reduced after the cooking process (Gall *et al*., 1983).

Ash content is an inorganic residue obtained by ashing organic components in food. Based on the analysis of the ash content of milkfish with different cooking methods, the average total ash content on a dry basis was 3.46-3.80%. The results of the measurement of the ash content of milkfish showed the steamed cooking methods were not significantly different from the boiled and pressure steamed treatments, but the pressure steamed treatment was significantly different from the boiled treatment. The ash content of boiled milkfish was highest when compared to steamed and pressure steamed milkfish. Based on Zhang *et al.* (2013), the ash concentration decreased in boiled grass carp fillet samples because some minerals might have come out of the fillets due to the washing process.

Based on the analysis of the protein content of milkfish with different cooking methods, the average total protein content was obtained in the range of 73.97-83.98% on a dry basis. The results of measuring the protein content of milkfish showed the treatment of boiled, steamed, and pressure steamed methods were significantly different. The protein content of boiled fish was highest when compared to the protein content of steamed and pressure steamed fish. According to Asghari *et al*. (2013), the protein content increased in boiled rainbow trout fillets when compared with fresh fillets. Food processing affects the damage that occurs to proteins. The high temperature and length of processing time caused major protein damage in food ingredients. This means that the nutritional value of protein in fish will also decrease. Abraha *et al*. (2018), reported that time and temperature were factors that affected protein quality during the heating process. If time and temperature increased, protein denaturation would be large enough so that it would also cause a loss of minerals, vitamins, essential amino acids, and other nutrients.

Based on the analysis of the fat content of milkfish with different cooking methods, the average total fat content expressed on a dry basis is 10.19-12.31%. The results of measuring the fat content of milkfish showed the treatment of boiled, steamed, and pressure steamed methods were significantly different. The fat content of boiled milkfish was highest than steamed and pressure steamed milkfish. The process of processing food would cause damage to the fat contained in it. The degree of fat breakdown depends on the temperature used and the length of the processing time. The higher the temperature used, the greater the fat damage. Based on Devi and Sarojnalini (2012), the fat concentration decreased in steamed mola carplet (*Amblypharyngodon mola*) fish when compared with fresh fish. The boiling process results in a decrease in fat content. Fat has heat-resistant properties, so it makes the fat content decrease. Another component that arises as a result of fat melting and evaporating during the cooking process is flavor. According to Koubaa *et al*. (2012), an increase in fat content would lead to an increase in the energy value of fish fillets.

3.6 Amino acid profiles

Amino acid profiles of raw fish and their cooked products were expressed as (%/100 g) dry base. Compositions of the amino acid profiles of fresh, boiled, steamed, and pressure steamed milkfish were shown in Table 6. The amino acids that dominated the entire sample were glutamic acid (11.80%, 11.22%, 11.81% and 11.56%), followed by aspartic acid, lysine, and leucine. According to Murthy *et al.* (2016), the dominant essential amino acids in milkfish were leucine, lysine, phenylalanine, and histidine. In milkfish, glutamic acid was the most abundant non-essential amino acid. This is also confirmed by the research of Malle *et al.* (2019), milkfish contains the highest essential amino acid,

Table 6. Amino acid content (%, db) in fresh milkfish and milkfish with different cooking methods.

Types of Amino Acid	Fresh	Boiled	Steamed	Pressure Steamed
Essential Amino Acid				
Lysine	6.36	6.26	7.07	6.74
Leucine	6.11	6.66	6.13	6.00
Arginine	5.12	6.13	4.70	4.62
Histidine	4.85	4.67	4.10	3.16
Valin	4.32	4.71	4.35	4.23
Phenylalanine	4.18	5.24	3.45	3.41
Threonine	4.03	4.42	3.72	3.81
Isoleucine	3.78	4.11	3.84	3.75
Total EAA (%, db)	38.74	42.21	37.35	35.72
Non-Essential Amino Acid				
Glutamic Acid	11.80	11.22	11.81	11.56
Aspartic Acid	7.67	7.35	7.85	7.62
Alanine	4.67	4.51	4.46	4.46
Glycine	4.54	4.45	3.61	3.99
Serine	3.28	3.59	2.93	2.89
Tyrosine	2.95	3.99	2.73	2.61
Proline	2.83	2.82	2.58	2.82
Total NEAA (%, db)	37.74	37.93	35.97	35.95
Total Amino Acids (%, db)	74.48	80.14	73.32	71.67

namely leucine. *Sphyraena jello* fish contains the highest non-essential amino acids, namely glutamic acid and aspartic acid, and the highest levels of essential amino acids, namely lysine and leucine (Aberoumand and Baesi, 2021).

The highest total content of essential amino acids and non-essential amino acids was found in boiled milkfish samples (42.21%, 37.93%). Meanwhile, the total essential amino acids (EAA) and non-essential amino acids (NEAA) of fresh fish were not significantly different from steamed fish and pressure steamed fish. Both essential and non-essential amino acids increased in milkfish that were given boiled treatment, except lysine. After steaming, lysine, valine, and isoleucine were increased. Essential amino acids are amino acids that cannot be synthesized by the body, so they can be obtained from food. All essential amino acids were decreased after pressure steaming. This was by the research of Gómez-Limia *et al.* (2020), who reported that the sterilization treatment caused the histidine and phenylalanine content in canned eels to decrease. Arginine content decreased after 2 months of storage with sterilization treatment.

Non-essential amino acids are amino acids that can be synthesized by the body. The non-essential amino acids in steamed milkfish that had increased when compared to fresh fish were glutamic acid and aspartic acid. The pressure steamed treatments reduced the levels of all non-essential amino acids. Serine and tyrosine levels increased in boiled fish but not in steamed or pressure steamed fish. Three cooking temperatures (60°C, 100°C and 140°C) affect the thermal stability of three aromatic amino acids in meat: tryptophan, phenylalanine, and tyrosine. The amino acid proline contains active sulfur atoms which are oxidized to varying degrees (Xia *et al.*, 2021). In the study by Bressani *et al.* (1978), the amino acid content of tyrosine in *Cannavalia* spp. with the pressure steaming method decreased, in which the amount of tyrosine content of *Cannavalia* spp. after the cooking process is 0.197 g/gN and the tyrosine content in *Cannavalia* spp. without the cooking process is 0.219 g/gN.

Heating affected the amino acid content of the material. Differences in cooking methods and cooking times applied to fish affect the amino acid composition of fish, so it would cause a loss or decrease in amino acids. The heating process of the material would reduce the water content, and this would cause the amino acid content to significantly increase. Heating causes chemical changes in amino acid residues, and as a result of this, heating could change the structural, digestibility, and functional properties of proteins. This depends on the thermal treatment and the processing or processing conditions applied (Deng *et al.*, 2015).

3.7 Fatty acid profiles

The fatty acid profile of raw and cooked milkfish was expressed as %/100 g dry base. Based on Table 7, the fatty acid profile of milkfish with different cooking methods could be seen to have a lower content of omega 3 than omega 9, except in pressure steamed milkfish.

https://doi.org/10.26656/fr.2017.7(S3).12

Table 7. Fatty acid content (%, db) in fresh milkfish and milkfish with different cooking methods.

No	Types of Fatty Acid	Fresh	Boiled	Steamed	Pressure Steamed
	Omega 3	0.40	0.81	1.08	2.13
	Omega 6	0.46	0.33	0.42	0.69
	Omega 9	2.84	1.72	2.52	0.89
	Saturated Fatty Acids (SFA)	10.92	8.64	12.25	10.67
1	C14:0 (Myristic)	1.61	1.10	1.48	0.90
2	C15:0 (Pentadecanoic)	0.78	0.97	1.58	2.88
3	C16:0 (Palmitic)	7.10	5.20	7.37	4.11
4	C17:0 (Heptadecanoic)	0.21	0.25	0.36	0.77
5	C18:0 (Stearic)	1.21	1.08	1.37	1.13
	Monounsaturated Fatty Acids (MUFA)	5.45	3.66	5.45	3.26
1	C14:1 (Myristoleic)	0.12	0.06	0.09	–
2	C15:1 (Pentadecenoic)	0.78	–	–	–
3	C16:1 (Palmitoleic)	2.10	1.46	2.21	0.97
4	C17:1 (Cis-10-Heptadecanoic)	0.19	0.27	0.45	1.34
5	C18:1ω9c (Oleic)	2.84	1.72	2.52	0.89
6	C20:1 (Cis-11-Eicosenoic)	0.21	0.14	0.18	0.06
	Polyunsaturated Fatty Acids (PUFA)	0.92	1.20	1.56	2.89
1	C18:2ω6 (Linoleic)	0.22	0.13	0.15	0.26
2	C18:3ω3 (Linolenic)	0.07	0.06	0.07	0.16
3	C20:2 (Cis-11,14-Eicosedienoic)	0.06	0.05	0.07	0.07
4	C20:4ω6 (Arachidonic/AA)	0.24	0.20	0.27	0.43
5	C20:5ω3 (EPA)	0.13	0.32	0.47	0.86
6	C22:6ω3 (DHA)	0.21	0.44	0.55	1.06

Omega 3, omega 6 and omega 9 are unsaturated fatty acids. The omega 6 content of boiled milkfish (0.33%) steamed milkfish (0.42%), and pressure steamed milkfish (0.69%) was lower than the omega 3 boiled milkfish (0.81%), steamed milkfish (1.08%), and pressure steamed milkfish (2.13%). The content of Saturated Fatty Acid (SFA) was higher than Monounsaturated Fatty Acid (MUFA) and Polyunsaturated Fatty Acid (PUFA). This was different from the research of Murthy *et al.* (2016), who found that milkfish were rich in Unsaturated Fatty Acids compared to SFA.

SFA are fatty acids that contain single bonds in the hydrocarbon chain. The highest component of SFA was palmitic acid, and palmitic acid was found in fresh milkfish (7.10%), boiled milkfish (5.20%), steamed milkfish (7.37%), and pressure steamed (4.11%). Steamed milkfish had higher palmitic acid than milkfish with other cooking methods. Based on research by Malle *et al.* (2019), the highest SFA in fresh milkfish was palmitic acid. The same results were found in Memon *et al.* (2011), who reported the most abundant saturated fatty acids were palmitic acid and stearic acid. The abundance of palmitic acid in the SFA component was found in carp (73.46% in *Labeo rohita*, 71.76% in *Cirrhinus mrigala* and 69.54% in *Catla catla*) of the total SFA.

Unsaturated fatty acids are fatty acids that have double bonds in the hydrocarbon chain. Unsaturated fatty acids are divided into two types, namely MUFA and PUFA. MUFA has one double bond in its molecule. PUFA contains two or more double bonds. Because the body cannot synthesize PUFA, they are considered essential fatty acids. The MUFA component was dominated by oleic fatty acid. The content of oleic acid in fresh, boiled, steamed, and pressure steamed milkfish is sequentially 2.84%, 1.72%, 2.52% and 0.89%. Based on research by Paul *et al.* (2018), oleic acid was the primary component of MUFA. The total oleic acid in fresh *Catla* was 16% of total fatty acids. The highest component PUFA was docosahexanoic acid with a value of 0.21% in fresh milkfish, boiled milkfish at 0.44%, steamed milkfish at 0.55%, and pressure steamed milkfish at 1.06%. In the research of Weber *et al.* (2008), the content of boiled silver catfish docosahexanoic acid was around 4.89% of total fatty acids.

4. Conclusion

Differences in cooking methods had a significant effect on product characteristics, amino acid content, and fatty acid content of milkfish. In terms of proximate composition, L value (lightness), and amino acid composition, milkfish with boiled treatment obtained higher yields when compared to steamed and pressure steamed. The highest amino acids contained in fresh, boiled, steamed, and pressure steamed milkfish were glutamic acid, aspartic acid, lysine, and leucine. The highest fatty acid profiles identified were palmitic acid, oleic acid, docosahexanoic acid, and linoleic acid. Panelists preferred pressure steamed milkfish because of

https://doi.org/10.26656/fr.2017.7(S3).12

its salty and savory taste.

Conflict of interest

The authors declare no conflict of interest.

Acknowledgments

The research work was funded by Faculty of Fisheries and Marine Science Universitas Diponegoro Research Grant year 2022 (No. 219/UN7.5.10.2/PP/2022).

References

Aberoumand, A. and Baesi, F. (2021). The effects of surimi process on amino acids profile of *Sphyraena jello* fish. *Journal of Aquatic Food Product Technology*, 30(3), 315-322. https://doi.org/10.1080/10498850.2021.1882634

Abraha, B., Admassu, H., Mahmud, A., Tsighe, N., Shui, X.W. and Fang, Y. (2018). Effect of processing methods on nutritional and physico-chemical composition of fish: a review. *MOJ Food Process Technology*, 6(4), 376-382. https://doi.org/10.15406/mojfpt.2018.06.00191

Asghari, L., Zeynali, F. and Sahari, M.A. (2013). Effects of boiling, deep-frying, and microwave treatment on the proximate composition of rainbow trout fillets: Changes in fatty acids, total protein, and minerals. *Journal of Applied Ichthyology*, 29(4), 847-853. https://doi.org/10.1111/jai.12212

AOAC. (2005). Official methods of analysis. USA: AOAC International.

Ayub, H. and Ahmad, A. (2019). Physiochemical changes in sous-vide and conventionally cooked meat. *International Journal of Gastronomy and Food Science*, 17, 100145. https://doi.org/10.1016/j.ijgfs.2019.100145

Bressani, R., Brenes, R.G., García, A. and Elías, L.G. (1987). Chemical composition, amino acid content and protein quality of *Canavalia* spp. seeds. *Journal of the Science of Food and Agriculture*, 40(1), 17-23. https://doi.org/10.1002/jsfa.2740400104

Cui, Z., Yan, H., Manoli, T., Mo, H., Li, H. and Zhang, H. (2020). Changes in the volatile components of squid (*Illex argentinus*) for different cooking methods via headspace–gas chromatography–ion mobility spectrometry. *Food Science and Nutrition*, 8(10), 5748-5762. https://doi.org/10.1002/jsfa.2740400104

Deng, Y., Luo, Y., Wang, Y. and Zhao, Y. (2015). Effect of different drying methods on the myosin structure, amino acid composition, protein digestibility and volatile profile of squid fillets. *Food Chemistry*, 171, 168-176. https://doi.org/10.1002/jsfa.2740400104

Devi, W.S. and Sarojnalini, C. (2012). Impact of different cooking methods on proximate and mineral composition of *Amblypharyngodon mola* of Manipur. *International Journal of Advanced Biological Research,* 2(4), 641-645.

Fabre, R., Dalzotto, G., Perlo, F., Bonato, P., Teira, G. and Tisocco, O. (2018). Cooking method effect on Warner-Bratzler shear force of different beef muscles. *Meat Science*, 138, 10–14. https://doi.org/10.1016/j.meatsci.2017.12.005

Gall, K.L., Otwell, W.S., Koburgier, J.A. and Appledorf, H. (1983). Effects of four cooking methods on the proximate, mineral and fatty acid composition of fish fillets. *Journal of Food Science*, 48(4), 1068-1074. https://doi.org/10.1111/j.1365-2621.1983.tb09163.x

Gómez-Limia, L., Cutillas, R., Carballo, J., Franco, I. and Martínez, S. (2020). Free amino acids and biogenic amines in canned European eels: influence of processing step, filling medium and storage time. *Foods*, 9(10), 1-19. https://doi.org/10.1111/j.1365-2621.1983.tb09163.x

Hafiluddin, H., Perwitasari, Y. and Budiarto, S. (2014). Analysis of the nutritional content and odor of milkfish (*Chanos chanos*) mud from two different locations. *Marine Journal,* 7(1), 33-44. [In Bahasa Indonesia]

Jiao, Y., Liu, Y. and Quek, S.Y. (2020). Systematic evaluation of nutritional and safety characteristics of Hengshan goat leg meat affected by multiple thermal processing methods. *Journal of Food Science*, 85(4), 1344-1352. https://doi.org/10.1111/j.1365-2621.1983.tb09163.x

Koubaa, A., Mihoubi, N.B., Abdelmouleh, A. and Bouain, A. (2012). Comparison of the effects of four cooking methods on fatty acid profiles and nutritional composition of red mullet (*Mullus barbatus*) muscle. *Food Science and Biotechnology*, 21(5), 1243-1250. https://doi.org/10.1111/j.1365-2621.1983.tb09163.x

Liu, J.K., Zhao, S.M., Xiong, S.B. and Zhang, S.H. (2009). Influence of recooking on volatile and non-volatile compounds found in silver carp *Hypophthalmichthys molitrix. Fisheries Science*, 75 (4), 1067-1075. https://doi.org/10.1111/j.1365-2621.1983.tb09163.x

Liu, Y., Huang, Y., Wang, Z., Cai, S., Zhu, B. and Dong, X. (2021). Recent advances in fishy odour in aquatic fish products, from formation to control. *International Journal of Food Science and Technology*, 56(10), 4959-4969. https://

doi.org/10.1111/j.1365-2621.1983.tb09163.x

Ma, Z., Boye, J.I., Azarnia, S. and Simpson, B.K. (2016). Volatile flavor profile of Saskatchewan grown pulses as affected by different thermal processing treatments. *International Journal of Food Properties*, 19(10), 2251-2271. https://doi.org/10.1111/j.1365-2621.1983.tb09163.x

Malle, S., Tawali, A.B., Tahir, M.M. and Bilang, M. (2019). Nutrient composition of milkfish (*Chanos chanos,* Forskal) from Pangkep, South Sulawesi, Indonesia. *Malaysian Journal of Nutrition*, 25(1), 155-162. https://doi.org/10.1111/j.1365-2621.1983.tb09163.x

Memon, N.N., Talpur, F.N., Bhanger, M.I. and Balouch, A. (2011). Changes in fatty acid composition in muscle of three farmed carp fish species (*Labeo rohita, Cirrhinus mrigala, Catla catla*) raised under the same conditions. *Food Chemistry*, 126(2), 405-410. https://doi.org/10.1111/j.1365-2621.1983.tb09163.x

Ministry of Marine Affairs and Fisheries Republic of Indonesia. (2022). Statistics and Information Center for Data of the Ministry of Maritime Affairs and Fisheries. Retrieved on September 24, 2022 from KKP Website: https://statistik.kkp.go.id

Meilgaard, M., Civille, G.V. and Carr, T. (2007). Sensory Evaluation Techniques. 4th ed. Boca Raton, USA: CRC Press Taylor and Francis Group.

Murata, M. (2021). Browning and pigmentation in food through the Maillard reaction. *Glycoconjugate Journal*, 38(3), 283-292. https://doi.org/10.1111/j.1365-2621.1983.tb09163.x

Murthy, L.N., Padiyar, P.A., Rao, B.M., Asha, K.K., Jesmi, D., Girija, P.G., Prasad, M.M. and Ravishankar, C.N. (2016). Nutritional profile and heavy metal content of cultured milkfish (*Chanos chanos*). *Fishery Technology,* 53(1), 245-249.

National Standardization Agency of Indonesia. (2015). Sensory testing guidelines on fishery products-Requirements with guidance for use (SNI 2346:2015). Retrieved from https://access-sni.bsn.go.id/sni

National Standardization Agency of Indonesia. (2017). Chemical Test Method-Part 3: Determination of total fat content in fishery products-Requirements with guidance for use (SNI 2354-3:2017). Retrieved from https://access-sni.bsn.go.id/sni

Oluwaniyi, O.O., Dosumu, O.O. and Awolola, G.V. (2010). Effect of local processing methods (boiling, frying and roasting) on the amino acid composition of four marine fishes commonly consumed in Nigeria. *Food Chemistry*, 123(4), 1000-1006. https://doi.org/10.1111/j.1365-2621.1983.tb09163.x

Oluwaniyi, O.O., Dosumu, O.O. and Awolola, G.V. (2017). Effect of cooking method on the proximate, amino acid and fatty acid compositions of *Clarias gariepinus* and *Oreochromis niloticus. Journal of the Turkish Chemical Society Section A: Chemistry*, 4 (1), 115-132. https://doi.org/10.1111/j.1365-2621.1983.tb09163.x

Paul, B.N., Singh, P., Bhowmick, S., Mandal, R.N., Adhikari, S., Pandey, B.K., Das, A. and Chakrabarti, P.P. (2018). Proximate, mineral and fatty acid composition of *Catla catla* reared in fresh water and wastewater environment. *Indian Journal of Animal Nutrition*, 35(4), 463-468. https://doi.org/10.1111/j.1365-2621.1983.tb09163.x

Pratama, R.I., Puspitawati, N., Hamdani, H. and Rostini, I. (2019). Volatile flavor compounds composition of fresh and steam milkfish (*Chanos chanos*). *Global Scientific Journals*, 7(1), 1006-1013.

Risso, S.J. and Carelli, A.A. (2017). Effects of conservation method and time on fatty acid composition, taste, and microstructure of southern king crab (*Lithodes santolla* Molina, 1782) meat. *Journal of Aquatic Food Product Technology*, 26(6), 731-743. https://doi.org/10.1080/10498850.2017.1283380

Schubring, R., Meyer, C., Schlüter, O., Boguslawski, S. and Knorr, D. (2003). Impact of high pressure assisted thawing on the quality of fillets from various fish species. *Innovative Food Science and Emerging Technologies*, 4(3), 257-267. https://doi.org/10.1016/S1466-8564(03)00036-5

Sefc, K.M., Brown, A.C. and Clotfelter, E.D. (2014). Carotenoid-based coloration in cichlid fishes. *Comparative Biochemistry and Physiology Part A: Molecular and Integrative Physiology*, 173, 42-51. https://doi.org/10.1016/j.cbpa.2014.03.006

Sen, A.R., Naveena, B.M., Muthukumar, M. and Vaithiyanathan, S. (2014). Colour, myoglobin denaturation and storage stability of raw and cooked mutton chops at different end point cooking temperature. *Journal of Food Science and Technology*, 51(5), 970-975. https://doi.org/10.1016/S1466-8564(03)00036-5

Singh, A., Mittal, A. and Benjakul, S. (2022). Undesirable discoloration in edible fish muscle: Impact of indigenous pigments, chemical reactions, processing, and its prevention. *Comprehensive Reviews in Food Science and Food Safety*, 21(1), 580-603. https://doi.org/10.1016/S1466-8564(03)00036-5

Suryaningrum, T.D. and Syamdidi, S. (2013). Quality deterioration of boiled salted carp fish (*Cyprinus* *carprio*), processed using different cooking methods, during chilling storage. *Squalen Bulletin of Marine and Fisheries Postharvest and Biotechnology*, 8(2), 77-86. https://doi.org/10.1016/S1466-8564(03)00036-5

Untoro, N.S., Kusrahayu, K. and Setiani, B.E. (2012). Water content, elasticity, fat content and taste of beef meatballs with the addition of pressure steamed milkfish (*Channos Channos,* Forsk). *Animal Agriculture Journal,* 1(1), 567-583. (in Bahasa Indonesia)

Vasava, R., Shrivastava, V., Mahavadiya, D., Sapra, D. and Vadher, D. (2018). Nutritional and feeding requirement of milkfish (*Chanos chanos*). *International Journal Pure and Applied Bioscience*, 6(2), 1210-1215. https://doi.org/10.18782/2320-7051.6463

Waters. (2012). Acquity UPLC H-Class and H-Class Bio Amino Acid Analysis System Guide. Ireland: Waters Corporation.

Weber, J., Bochi, V.C., Ribeiro, C.P., Victório, A.D.M. and Emanuelli, T. (2008). Effect of different cooking methods on the oxidation, proximate and fatty acid composition of silver catfish (*Rhamdia quelen*) fillets. *Food Chemistry*, 106(1), 140-146. https://doi.org/10.1016/j.foodchem.2007.05.052

Xia, C., Wen, P., Yuan, Y., Yu, X., Chen, Y., Xu, H., Cui, G. and Wang, J. (2021). Effect of roasting temperature on lipid and protein oxidation and amino acid residue side chain modification of beef patties. *RSC Advances*, 11(35), 21629-21641. https://doi.org/10.1039/D1RA03151A

Yagiz, Y., Kristinsson, H.G., Balaban, M.O., Welt, B.A., Ralat, M. and Marshall, M.R. (2009). Effect of high pressure processing and cooking treatment on the quality of Atlantic salmon. *Food Chemistry*, 116(4), 828-835. https://doi.org/10.1016/j.foodchem.2009.03.029

Yoon, I.S., Lee, G.W., Kang, S.I., Park, S.Y., Lee, J.S., Kim, J.S. and Heu, M.S. (2018). Chemical composition and functional properties of roe concentrates from skipjack tuna (*Katsuwonus pelamis*) by cook-dried process. *Food Science and Nutrition*, 6(5), 1276-1286. https://doi.org/10.1002/fsn3.676

Yu, L.C., Zzaman, W., Akanda, M.J.H., Yang, T.A. and Easa, A.M. (2017). Influence of superheated steam cooking on proximate, fatty acid profile, and amino acid composition of catfish (*Clarias batrachus*) fillets. *Turkish Journal of Fisheries and Aquatic Sciences,* 17(5), 935-943. https://doi.org/10.4194/1303-2712-v17_5_09

Zhang, J., Wu, D., Liu, D., Fang, Z., Chen, J., Hu, Y. and Ye, X. (2013). Effect of cooking styles on the lipid oxidation and fatty acid composition of grass carp (*Ctenopharynyodon idellus*) fillet. *Journal of Food Biochemistry,* 37(2), 212-219. https://doi.org/10.1111/j.1745-4514.2011.00626.x

