Amino acid and fatty acid profiles of Mozambique tilapia (*Oreochromis mossambicus*) in different aquaculture systems from Indonesian waters

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Abstract. The high production of tilapia in Indonesia shows that tilapia has a potential in fulfilling the nutritional needs of the community. This study aimed to find the effect of aquaculture systems using floating net cages in Papua and fixed cages systems in Central Java on the amino acid and fatty acid profiles, and chemical composition of Mozambique tilapia (*Oreochromis mossambicus*). Fish samples used were tilapia with an average individual weight of 300±0.01 grams. Fish were collected from three locations: Lake Rawa Pening and Wadaslintang Reservoir in Central Java, and Lake Sentani in Papua. Fish had been cultured for 3 months and the study used about 30 fish samples from each location. For determining the amino acid and fatty acid profiles, and the chemical composition, tilapia was cultured, collected, sampled and analyzed from Lake Sentani (A), Lake Rawa Pening (B) and Wadaslintang Reservoir (C). The water quality parameters were also determined. The results revealed that the fish quality in the floating net cage system from Lake Sentani have a better fatty acid profile, amino acid profile, and nutrient value than fish produced at Lake Rawa Pening and Wadaslintang Reservoir.
Key Words: aquaculture system, cages, nutritional value, tilapia.

Introduction. Tilapia (*Oreochromis mossambicus*) has some advantages for aquaculture compared with other fish, like the unique taste of fillet, easy rearing and the competitive selling price. In addition, tilapia fillet also contains biochemical compounds nutritious for the human body. Several studies have shown that fish biochemical composition is influenced by aquaculture conditions, such as salinity (Malik et al 2018), feed (Hallier et al 2007) and water temperature, that are furthermore influenced by habitat type and season (Vasconi et al 2015; Sushchik et al 2017). Increasing temperature and the decreasing water salinity in aquatic ecology can change the levels of fatty acids by increasing the levels of unsaturated fatty acids, like eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) in fish (Razak et al 2001).

The modifications in the chemical composition and nutritional profile of fillet, including the profile of amino acids and fatty acids can affect the taste and texture of fish fillet. The taste and texture of tilapia fillet will differ based on the location of farming. For instance, the fillet of tilapia cultivated in Papua Province has a more savory flavor and chewy texture than the tilapia cultivated in Central Java Province, even though the species are the same (Muhaemi 2015). Nevertheless, the production of tilapia in Central Java Province is higher (501 tons) than the production of tilapia in Papua Province (62 tons) and West Papua Province (10 tons) in 2014.

Data on the biochemical composition of tilapia is needed and utilized by food scientist and nutritionists in food processing and product development. Evaluation of chemical composition, such as protein, lipids, minerals, vitamins and moisture content are often needed to ensure that they meet the requirements of food regulations, postharvest handling, food processing and shelf life of fish. In addition, data on changes in biological conditions and the environment of fish is very useful for aquaculture scientists to create and maintain cultivation conditions that are conducive to producing high quality fish (Moses et al 2018).

Mozambique tilapia (*Oreochromis mossambicus*) is a popular fish in Indonesia, being widely cultivated in ponds, rivers and lakes. The present study aims to investigate the effects of different aquaculture systems on the chemical composition on nutritional value of tilapia.

Material and Method

Collection of fish. In this study, Mozambique tilapia were cultured and collected from three different farming areas in Indonesia: Lake Sentani (Jayapura, Papua Province), Lake Rawa Pening (Ambarawa, Central Java Province) and Wadaslintang Reservoir (Banjarnegara, Central Java Province). The Mozambique tilapia had an average weight of 300±0.15 g/fish. A number of 30 Mozambique tilapia were collected from each site. The collection sites are presented in Figure 1.

Figure 1. Farming sites: 1 - Lake Sentani, Papua; 2 - Lake Rawa Pening, Central Java; 3 - Wadaslintang Reservoir, Central Java.

The aquaculture system used at Lake Rawa Pening and Wadaslintang Reservoir consists in fixed net cages, while floating net cages were used at Lake Sentani. The same feed was administered in the three farming sites, three times a day in the morning (08.00), at noon (12.00) and in the evening (16.00) with the fix feeding rate method. The study was conducted from June to August 2018. The exact time and location of the study is presented in Table 1.

Collected fish were immediately put in a cool box with the addition of ice to keep the cold temperature during transportation to the Processing Technology Laboratory, Fishery Product Technology Department, Diponegoro University. Fish obtained from Lake Sentani were taken to the laboratory by airplane within 8 hours of travel. Meanwhile, the time needed to transport fish from Lake Rawa Pening to the laboratory was one hour, while the time needed to transport fish from Wadaslintang Reservoir was 5 hours. Therefore, to equalize the treatments, the fish were left in cool boxes at $-4^{o}C$ for a total of 8 hours.

Table 1

Description of the location of the study sites

Aquaculture Locations	*Surface Area (km^2)*	*Climate*	*Fish Collection Area (km^2)*
Lake Sentani	8.71	Dry Season: June 2018	1.92
Lake Rawa Pening	7.58	Dry Season: July 2018	1.65
Wadaslintang Reservoir	6.53	Dry Season: August 2018	1.52

Characterization of water quality. When the fish samples were collected, water parameters were also determined. Water temperature, dissolved oxygen (DO) and pH values were determined using a Water Quality Checker (Horiba U-52).

Fish fillet samples preparation. The fish were washed and then the meat was taken as fillet. Furthermore, the fish fillet was washed and drained. Fish fillet was mashed and homogenized, then put in sterile plastic and stored frozen at –4°C to be analyzed.

Amino acid profile analysis. The amino acid profile of the sample was determined using High Performance Liquid Chromatography (HPLC) (Shimadzu LC-6A) (AOAC 2005; Herawati et al 2018). The essential amino acid analysis was performed using a high-performance liquid chromatography (HPLC) type 1100 with a Eurospher 100-5 C18, 250 mm × 4.6 mm column that has a P/N: 1115Y535 pre-column. The effluents were 0.01 M acetate buffer at pH 5.9 and 0.01 M MeOH acetate buffer at pH 5.9; THF > 80:15:5 Λ fluorescence: ext: 340 mm Em: 450 nm. Approximately 2.5 g of sample was added to a sealed glass. Then, 15 mL of 6 N HCl was added. The mixture was vortexed and subjected to hydrolysis in an autoclave at 110°C for 12 h, before being cooled down to room temperature and neutralized with 6 N NaOH. After adding 2.5 mL of 40% lead acetate and 1 mL 15% oxalate acid, the mixture was filtered through a 0.45 µm Millex filter. A 25 µL aliquot of the filtered mixture plus 475 µL of OPAA solution was vortexed and incubated for 3 minutes. Finally, a 30 µL aliquot of the final mixture was loaded on the HPLC column.

Fatty acid profile analysis. The fatty acid compositions of the samples were determined using a gas chromatograph (Shimadzu) (AOAC 2005; Herawati et al 2018). The fatty acid profiles of the fillet samples of Tilapia were determined by analyzing the total fatty acid content using gas chromatography (GC; QP-2010) and mass spectrometry with a WCot fused Silica Counting CP-SIL-88 column (50 m length, 0.22 mm diameter, and at 120–200°C column temperature). The method employed was *in situ* trans esterification. 100 mg of fillet were homogenized in 4 mL of water. The resulting 100 µL homogenate was then transferred to a reaction tube. Methylene chloride (100 µL) was added with 1 mL 0.5 N NaOH to methanol. Once the nitrogen was added and the tube was sealed, it was heated to 90°C for 10 minutes. The reaction tube was then cooled and 1 mL of 14% BF3 was added in methanol. After adding nitrogen, heating ensued at the same temperature for the next 10 minutes. Then, the reaction tube was cooled to ambient temperature, and 1 mL of water and 200–500 µL hexane were added. The mixture was vortexed for 1 min to extract the fatty acid methyl esters. After centrifugation, the upper layer of the sample was ready for GC analysis.

Proximate analysis. The proximate chemical composition of the samples was determined using standard procedure (AOAC 2005; Herawati et al 2018). Crude protein content was calculated by multiplying the total nitrogen factor. Carbohydrate content was estimated by difference. Furthermore, crude fat was determined using the Soxhlet method. The ash content was also determined.

Statistical analysis. The experimental design used in this study was a completely randomized design (CRD). All data are presented as the mean of triplication ± the standard deviation. The statistical analysis of the data was performed by using SPSS version 20.0 (SPSS Inc., Chicago, USA). The statistics were calculated by one-way analysis of variance (ANOVA), and then evaluated by Tukey's test.

Results and Discussion

Amino acid profile. The different farming area will affect the nutritional content of fish. The results showed that the amino acid profile of fillet from Lake Sentani is higher compared with the other two locations. The amino acid profile of the fish fromn Lake Sentani presented significant differences ($P<0.05$) compared with the ones from the other two farming sites. Moses et al (2018) concluded that the habitat influences the nutritional quality and quantity of tilapia. The essential amino acid and protein composition of the fish were better in the dams than in the rivers. The amino acid profile of the fish sample revealed that glutamic acid and aspartic acid are the most concentrated amino acids present in the fish. The lysine content of the fish is also high. The amino acid profile of tilapia fillet in the three different aquaculture locations is presented in Table 2.

Table 2

Amino acid profile of tilapia fillet with different aquaculture locations

Amino acid content (%)	*Aquaculture locations*		
	Lake Sentani	Lake Rawa Pening	Wadaslintang Reservoir
	Essential amino acids		
Arginine	3.90±0.16[a]	5.25±0.18[b]	6.73±0.17[b]
Histidine	2.17±0.23[a]	4.27±0.13[b]	4.53±0.17[b]
Lysine	5.51±0.16[b]	7.91±0.12[a]	4.13±0.13[a]
Phenylalanine	9.07±0.17[b]	1.10±0.17[a]	0.05±0.21[a]
Isoleucine	4.16±0.11[a]	4.49±0.28[a]	6.98±0.09[b]
Leucine	6.39±0.21[a]	8.76±0.22[b]	7.24±0.16[b]
Threonine	5.61±0.18[a]	4.82±0.19[a]	3.15±0.15[b]
Methionine	3.09±0.21[a]	4.07±0.18[a]	4.10±0.11[a]
Valine	3.15±0.13[a]	4.32±0.23[a]	4.34±0.16[a]
Total EAA	43.05±0.17[a]	44.99±0.19[a]	41.25±0.15[b]
	Non-essential amino acids		
Proline	5.24±0.21[a]	5.08±0.11[a]	4.26±0.23[a]
Glutamic acid	7.21±0.15[b]	6.17±0.21[a]	5.30±0.25[a]
Aspartic acid	6.78±0.20[b]	4.91±0.17[b]	3.35±0.25[a]
Cysteine	2.39±0.19[a]	1.08±0.24[a]	1.06±0.14[a]
Tyrosine	3.06±0.16[a]	5.06±0.19[b]	5.15±0.14[b]
Serine	4.11±0.24[a]	3.03±0.12[a]	3.45±0.29[a]
Alanine	6.11±0.12[b]	5.10±0.14[b]	3.12±0.09[a]
Glycine	4.08±0.21[a]	3.16±0.22[a]	3.78±0.14[a]
Total of NEAA	38.98±0.18[b]	33.59±0.17[a]	29.47±0.19[a]
Total of EAA	24.18±0.17[b]	19.34±0.18[a]	15.55±0.18[a]

Note: the same superscript letters show no significant differences ($P>0.05$); EAA – essential amino acids; NEAA – non-essential fatty acids.

Fatty acids profile. Based on the results presented in Table 3, the fatty acid profile of tilapia from Lake Sentani is better than in the case of the other 2 locations. According to

Chauke et al (2008), tilapia is one of the richest fish in the concentration of many fatty acids, especially those essential for human nutrition, in South Africa.

Memon et al (2010) compared the proximate composition and fatty acid profile among Indus river fish species and the study revealed that the fish are good sources of n-3 fatty acids, particularly EPA and DHA, and should be recommended for dietary inclusion to reduce risks of cardiovascular diseases. The fatty acid profile of tilapia fillet in three different aquaculture locations is presented in Table 3.

Table 3

Fatty acid profile of tilapia fillet with different aquaculture locations

FAME (%)	*Aquaculture locations*		
	Lake Sentani	Lake Rawa Pening	Wadaslintang Reservoir
Methyl Butyrate	18.14±0.14[b]	5.89±0.16[a]	3.38±0.28[a]
Methyl Hexanoate	nd	nd	nd
Methyl Octanoate	nd	nd	nd
Methyl Decanoate	nd	nd	nd
Methyl Undecanoate	nd	nd	nd
Methyl Laurate	nd	nd	0,17±0.38
Methyl Tridecanoate	nd	nd	nd
Methyl Tetradecanoate	7.24±0.22[b]	3.33±0.21[a]	2.51±0.21[a]
Myristoleic Acid Methyl Ester	nd	nd	0.14±0.05
Methyl Pentadecanoate	nd	0.45±0.22[a]	0.15±0.08[a]
Cis-10-Pentadecenoic Acid Methyl Ester	nd	nd	nd
Methyl Palmitate	13.15±0.14[a]	13.25±0.23[a]	22.14±0.24[b]
Methyl Palmitoleate	5.99±0.16[b]	12.46±0.31[a]	4.58±0.20[b]
Methyl Heptadecanoate	nd	2.43±0.23	0.32±0.12
Cis-10-Heptadecenoic Acid Methyl Ester	nd	1.22±0.18	0.23±0.09
Methyl Octadecanoate	14.63±0.21[b]	3.98±0.12[a]	5.01±0.12[a]
Trans-9-Elaidic Acid Methyl Ester	14.23±0.23[b]	5.05±0.25[a]	0.51±0.12[a]
Cis-9-Oleic Methyl Ester	1.75±0.18[a]	2.69±0.11[b]	35.7±0.21[b]
Linolelaidic Acid Methyl Ester	nd	nd	0.42±0.20
Methyl Linoleate	7.64±0.23[b]	4.33±0.22[a]	13.98±0.20[b]
Methyl Arachidate	nd	nd	0.79±0.21
Methyl Cis-11-eicocenoate	nd	6.75±0.20	1.93±0.16
Methyl Heneicosanoate	nd	5.77±0.14	0.34±0.15
Cis-11-14-eicosadienoic Acid Methyl Ester	nd	nd	0.61±0.19
Methyl Erucate	nd	11.12±0.15	0.83±0.16
Methyl Tricosanoate	3.13±0.08	nd	1.44±0.22
Cis-11-14-17-eicosatrienoic Acid Methyl Ester	nd	nd	nd
Methyl Lignocerate	nd	nd	0,13±0.26
Methyl cis-5-8-11-14-17-Eicosapentaenoate	nd	nd	0,15±0.12
Methyl Cis-5-8-11-14-eicosatetraenoic	nd	2.93±0.14	0.15±0.12
Cis-13-16-Docosadienoic Acid Methyl Ester	nd	3.46±0.19	0.15±0.11
Methyl cis-5-8-11-14-17-Eicosapentaenoate	nd	nd	0.15±0.09
Methyl Nervonate	2.23±0.16[a]	3.05±0.14[a]	1.35±0.14[a]
Cis-4-7-10-13-16-19-docosahexaenoate	14.87±0.19[b]	10.19±0.26[a]	3.03±0.15[b]

Note: FAME – fatty acid methyl ester; nd - not detected. The values with the same superscript letters presented no differences (P>0.05).

***Proximate analysis**.* The proximate analysis of tilapia fillet from the three different aquaculture locations is presented in Table 4.

Table 4

Proximate analysis of tilapia fillet on a dry matter basis with different aquaculture locations

Parameters	*Lake Sentani*	*Lake Rawa Pening*	*Wadaslintang Reservoir*
Moisture (%)	51.37±0.62[a]	61.83±0.65[b]	63.17±0.68[b]
Protein (%)	29.13±0.71[b]	21.70±0.42[a]	21.85±0.05[a]
Lipid (%)	1.97±0.13[a]	2.18±0.15[a]	1.16±0.13[a]
Ash (%)	0.55±0.03[a]	0.35±0.04[a]	0.48±0.05[a]

Note: the same superscript letters show no differences (P>0.05).

Characterization of the water quality. The water temperature during the study was maintained at 24-30°C and the pH value at 7.2-7.7. The DO level was 3.3 mg/L in Lake Sentani, 3.0 mg/L in Lake Rawa Pening, and 3.1 mg/L in Wadaslintang reservoir. The water temperature in Lake Sentani and Lake Rawa Pening was in the optimum range, but the water temperature in Wadaslintang Reservoir was low. This is in line with previous studies, which show that the proper temperature for Mozambique tilapia culture is 25-30°C, with a DO level of 3.0-4.0 mg/L, and a pH of 6.5-9 (Damle & Chari 2011; Herawati et al 2015). A good water quality helps the growth of phytoplankton and algae as future feed for Mozambique tilapia. The water quality of tilapia aquaculture in three different locations is presented in Table 5.

Table 5

Water quality from the three locations of tilapia aquaculture

Parameters	*Lake Sentani*	*Lake Rawa Pening*	*Wadaslintang Reservoir*	*Decent range for water quality*
Temperature (°C)	28	27	24	25-30**
Dissolved Oxygen (mg/L)	0.36	0.38	0.35	3.0-4.0**
pH	7.2	7.4	7.7	6.5-9*

Note: * - Herawati et al (2015); ** - Damle & Chari (2011).

Aquaculture systems. Sambu & Amir (2017) stated that floating net cages are a medium for fish or aquatic biota, consisting in a frame or structure made from rectangular-shaped bamboo, wood, pipe, or iron, with nets and buoys to remain floating in the water. The main factors in the success of aquaculture using the floating net cage system are the location and optimal environmental factors. Optimal environmental factors consist in appropriate temperature and salinity, the presence of water flow and the availability of nutrients and light. Therefore, the physical factors of water become one of the determinants of the success of tilapia cultivation using floating net cages systems. Environmental parameters to determine an adequate location for cultivation are temperature, water depth, brightness and turbidity, among others.

The disadvantage of the floating net cages cultivation systems is that upwelling processes could occur. The reversal of water mass is usually followed by the lifting of sediment in the water, so that the ammonia content increases and the DO concentration decreases. Afrin et al (2015) reported that the cause of upwelling is the excessive feeding (ad libitum), until the fish are completely full. This causes a waste of feed and the accumulation in the bottom of the water. Upwelling will occur when the temperature from the surface of the water is different from the temperature in the water.

In contrast to the cultivation system from Lake Sentani, the cultivation systems at Lake Rawa Pening and Wadaslintang Reservoir use fixed cages. Samudra (2013) stated that the fish cultivated using fixed-net cages at Rawa Pening include carp, tilapia, pomfret and others.

The advantages of fixed net cages based on a previous study conducted by Wowor et al (2016) lies in the design that is easy and efficient in its manufacture, needs low manufacturing funds and it is easy to operate. However, fixed cages also have weaknesses, being easily influenced by the weather. Strong winds can break the bamboo and damage the nets, and the fish can escape.

Conclusions. The results obtained show that there are two major factors which affect the fatty acid profile, amino acid profile, and chemical composition of Mozambique tilapia (*Oreochromis mossambicus*) in three different lakes (Lake Sentani, Lake Rawa Pening, Wadaslintang Reservoir). They are the aquaculture systems (floating net cages or fixed cages) and the water quality. Good values for the water quality parameters (temperature, DO, pH value, nitrate and phosphate concentrations) will support the presence of phytoplankton. Furthermore, optimum values of the water quality parameters will help the absorption of the nutrients from the feed. The amino acid and fatty acid profiles of tilapia cultivated in Lake Sentani presented better values than in Lake Rawa Pening and Wadaslintang Reservoir. This is because of the different structures of the aquaculture systems (floating net cages and fixed cages). It is easier for fish to feed in floating net cages than in fixed cages. This can prove that the application of tilapia aquaculture systems with floating net cages can be better than using fixed cages.

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