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NUTRITIONAL AND AMINO ACID COMPOSITION OF RED TILAPIA FISH (*Oreochromis niloticus*)

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ABSTRACT

Tilapia has received much attention to be used as a source of food protein. In making tilapia fish as a source of food protein, there are many by-products (head, frame, and tail) produced during the processing of fish which are usually discarded. The nutritional properties of tilapia muscle and by products were quantitatively determined. It was found that the proximate compositions of tilapia muscle were 18.59 ± 0.35% of crude protein content, 80.66 ± 0.48% of dry matter content, 1.15 ± 0.07% of ash, 0.38 ± 0.06% of oil content and 27.02±0.30 mg/g of soluble protein content. While for tilapia by-product were 14.60 ± 0.30% of crude protein content, 66.57 ± 0.39% of dry matter content, 8.93 ± 0.46% of ash, 5.50 ± 0.30% of oil content and 25.83 ± 0.45 mg/g of soluble protein content. Identification of amino acids composition on tilapia muscle and by product have found that the total amino acid content were 93.08 ± 1.08 g/kg and 92.80 ± 1.48 g/kg respectively while the essential amino acid were 36.57 ± 0.51 g/kg and 31.38 ± 0.51 g/kg respectively. The most abundant amino acid in tilapia muscle was glutamic acid (15.94 ± 0.22 g/kg), while for tilapia by product was glycine (14.35 ± 0.22). Lysine was the most abundant essential amino acid in tilapia muscle and by product (7.03 g/kg and 5.55 g/kg respectively). These results indicate that tilapia fish has excellent source of protein, particularly an essential amino acids such as lysine. Along with a growing interest in food protein to be used as food ingredient, it appears tilapia fish has very good potential to serve as source of protein.

Keyword: *Tilapia, nutritional, amino acid*

INTRODUCTION

Tilapia (<u>*Oreochromis niloticus*</u>) is an important species in freshwater aquaculture [1]. It is the third most widely cultured fish, after carp and salmon [2]. Tilapia have many attributes to make them suitable for the main livestock because they have special features such as fast-growing, resistant to environmental changes and disease, bone is less and have dense and white flesh. This makes it a high market demand and good prices. Tilapia fish are beneficial to human beings as they make up a major part of the human diet and provide humans with as much of needed proteins as in meat [3]. The concentration of dietary essential amino acids is a major factor determining the nutritional value of food protein. Fish muscle contains an excellent amino acid composition particularly an essential amino acids such as lysine, which is an excellent source of nutritive and easily digestible proteins [4].

Industrial processing of fish yields more than 60% by-products and only 40% edible fish products [5]. Fish by-products such as head, bone, tail and scale produced from fish filleting process contain considerable amounts of proteins which known to posses higher nutritional values with well-balanced amino acid composition [4]. Fish muscles normally yield less than 50% of the total fish weight [5], other parts like viscera, backbone, skin, tail, head and scale are poorly utilized by the fish processing industry which accounted about 30-60% depending on the types of fish [5-8]. It was found that, total protein of these by-products are varies from 15-60% [7, 9-12]. Obviously, it would be a loss to the fishing processing industry if such by-products are disposed without any effort to make the by-products more valuable. In fact, by removing the by-products would cause a serious environmental problem.

Studies on the chemical composition of tilapia fish muscles have very well established. Nutrient values of tilapia fish such as the proximate, amino acid and mineral composition have been reported by several researchers [13-17]. Although reports on the nutritional value of tilapia fish muscle could be found in the literature, it is still be considered relatively less report on nutrient composition from freshwater fish by-product particularly tilapia by-product when compared to reports from other marine fish such as from mackerel, sardine, cod and salmon by-products. Determination of nutrient and amino acid compositions of tilapia by-product is a crucial part of the present study to look at the potential of such by-product to be converted into valuable product through enzymatic hydrolysis which may be widely applied to improve functional and nutritional properties of proteins. Therefore, the aim of this study was to determine the chemical and amino acid compositions of tilapia by-product as well as tilapia muscle.

MATERIALS AND METHODS

1. Sample preparation
   Fresh red tilapia (*Oreochromis niloticus*) bought from the local wet market in Selangor, Malaysia were transported immediately to the laboratory on ice. Upon arrival, the samples were washed, eviscerated and hand filleted. After removed the viscera, fillets and by-products (head, tail, frame and fin) were minced using waring blender and then packed in polyethylene bags and freeze-stored at -20°C until used.

2. Proximate analysis
   a) Moisture content.
      Moisture was determined using the air oven AOAC method [18]. About 5g of sample weighed into petri dish. Sample was heated in the oven overnight at temperature 105^0C.
   b) Crude protein content
      Crude protein was determined by using the Kjeldahl method. 1g of sample was weighed into digestion tube. 12 ml sulfuric acid was added with 2g of kjeltab and digests the mixture at 420^0C until the color of mixture change to green light. Then, crude protein was calculated by titration.
   c) Oil content.
      Fat content of fish muscle and by products will be determined by Soxhlet method of AOAC [18]. About 4g of sample weighed into the 100 ml erlenmeyer flask. Sample was added with 20 ml 4N HCl then soaked in water at 60^0C for 20 minutes. The mixture was added with diethyleter then transferred into monjonnier tube. Fat was extracted by shaking the monjonnier tube. Solution at upper layer of the tube was transferred into round bottom flask and evaporates using rotavapor. Flask was heated in the oven at 105^0C for 1 hour then transferred into the dessicator. Oil content was then calculated.
   d) Ash content.
      Ash was determined by heating the samples in the furnace at 550 ^{0}C for 8–12 h referring to AOAC method [18].

3. Determination of amino acid composition
   The amino acid composition of proteins was determined by amino acid analyser (AAA) after digestion of samples in 6N HCI at 110°C [19].

All chemical analyses were performed in duplicate and the results were expressed as percentage (%).

RESULTS AND DISCUSSIONS

1. Chemical composition

The proximate analyses of tilapia fish muscle and by-product are shown in Table 1. Fish muscle has high moisture content with value 80.66 ± 0.48%. The high moisture content of the fish sample would increase the deterioration level of fish when kept for a long time. This is because the micro-organisms would be highly active with high moisture content [20]. Several studies have showed that moisture content of tilapia fish muscles were varies with ranging from 70.15-81.2% [13, 15-17]. The value of the ash content was 1.15 ± 0.07% which is similar to the finding of Ng and Bahurmiz [13] who studied the tilapia fish muscle quality during frozen storage with ash content ranging from 1.06-1.22%. Relatively lower ash content in tilapia muscle were also reported by Usydus et al. [17] (0.5%) and Clement and Lovell [15] (2.3%). Lower lipid content was measured for tilapia fish muscle in this study with value 0.38 ± 0.06%. Tilapia fish generally showed lower lipid content with varies values ranging from 0.9-5.7% [13-15, 17]. The protein content of tilapia fish muscle was 18.59 ± 0.35%. This data is in agreement with the result obtained by Ng and Bahurmiz [13] with crude protein values ranging from 16.9-18.2% and other researchers reported that crude protein content in tilapia muscle were varies ranged between 16.4-23.1% [15-17, 21]. The protein content of tilapia muscle in this study showed slightly lower when compared with other species of fish such as mackerel (20.3%) [22], salmon (20.0-21.8%) [21,23] but considerably higher when comparing with catfish (12.9-17.3%) [15,17,24]. Crude protein content of fish muscle varies depending on the species, nutritional condition, type of fish, state of nutrition, and productive cycle of animal as well as the parts of the organism [21,25]. Puwastien et al. [26] also reported that the protein content ranged from 17-20% for raw freshwater fish. Generally, the crude protein value of tilapia muscle is relatively high indicating that the tilapia fish is a good source of protein. The soluble protein content of tilapia muscle was 27.02 ± 0.30 mg/g in which this value could be considered as low. This indicates that most of tilapia muscle is insoluble.

Table 1: Proximate Analysis of tilapia (Orechromis niloticus) fish muscle and by product

Component	Fish Muscle	Fish By-product
Moisture content (%)	80.66 ± 0.48^a	66.57 ± 0.39^b
Crude protein (%)	18.59 ± 0.35^a	14.60 ± 0.30^b
Lipids (%)	0.39 ± 0.06^b	5.50 ± 0.30^a
Ash (%)	1.15 ± 0.07^b	8.93 ± 0.46^a
Soluble protein (mg/g)	27.02 ± 0.30^a	25.83 ± 0.45^b

All data are expressed as the mean ± S. D (n=15)
Means within each row sharing same upper case were not significantly different (P > 0.05)

When comparing the proximate analysis values between tilapia fish muscle and by-product, the values obtained differ significantly on the moisture, proteins, ash, lipid content and soluble protein. The moisture content in tilapia by-product was significantly lower (66.57 ± 0.39%) than in tilapia muscle. This is due to the major constituent of tilapia muscle is water which contributed to the high moisture content. The lipid content of tilapia by-product was significantly higher than in tilapia muscle. This is might be due to high lipid content in several parts of tilapia by-product such as head and bones which in line with the results of cod by-products obtained by Arnesen & Gildberg [5]. Lee et al. [27] also reported that lipids could be adsorbed to the bone surface and this would partly explain the difference lipid level between tilapia muscle and by-product. Tilapia muscle and by-product also showed significant differences in the level of ash content. The mean ash content for tilapia by-product was 8.93 ± 0.46% which much higher compared to tilapia muscle. High ash content indicated that tilapia by-product has high inorganic minerals which is contributed mostly by the bones in every part of tilapia by-product including head, fin, tail and frame. Generally fish bone consists of 60-70% of inorganic substances and mainly composed of calcium phosphate and hydroxyapatite [28]. The mean protein content of tilapia by-product was 14.60 ± 0.30% which was significantly lower than that of tilapia muscle. Slizyte et al. [10] found that protein content in cod by-product varied from 12-16%. According to Jayasinghe and Hawboldt [12], average crude protein content of fish by-products (e.g salmon, cod and catfish) ranging from 11-19%. The crude protein of fish by-products were varies depending on the type of fish, product and processing techniques [12]. Overall the crude protein content in tilapia by-product was within the ranges observed by Jayasinghe and Hawboldt [12] which indicated that tilapia by-product consist of considerable amount of protein, which can be used as potential bioactive substances. From the result also showed that soluble protein content of tilapia by-product was significantly lower than in tilapia muscle. The results show that tilapia muscle has higher in moisture and crude protein content but lower in lipid content, while for the tilapia by-product has lower in moisture and crude protein content but higher in lipid content. This pattern is in agreement with the findings of other researches [15, 29].

2. Amino acids

Table 2 shows the amino acid (AA) composition for the tilapia muscle and by-product. Glutamic acid was the highest concentration (15.94 ± 0.27 g/kg) for tilapia muscle followed by glycine (7.95 ± 0.23 g/kg) and aspartic acid (7.79 ± 0.10 g/kg), while glycine was the highest concentration (14.35 ± 0.22 g/kg) for tilapia by-product followed by glutamic acid (13.08 ± 0.32 g/kg) and proline (9.13 ± 0.19 g/kg). The lowest amino acid concentration in tilapia muscle were tryptophan and cysteine with value 0.65 ± 0.07 g/kg and 0.86 ± 0.11 g/kg respectively. As for tilapia by-product, the lowest amino acid concentration was cysteine (0.67 ± 0.01 g/kg). Most animal proteins are found to be low in cysteine [3]. The total amino acid for tilapia muscle was significantly higher than in tilapia by-product with value 93.08 ± 1.08 g/kg and 92.84 ± 1.48 g/kg respectively. The total essential amino acid in tilapia muscle was 36.57 ± 0.51 g/kg which significantly higher than in tilapia by-product (31.38 ± 0.51 g/kg). Lysine and leucine were the highest essential amino acid for both samples. This suggests that tilapia fish will contribute significantly to the supply of essential amino acid in the diet.

Table 2: Amino acids composition in tilapia muscle and by-product (g/kg)

Amino acid	Tilapia muscle	Tilapia by-product
Aspartic acid	7.79 ± 0.10	6.66 ± 0.10
Glutamic acid	15.94 ± 0.27	13.08 ± 0.32
Serine	4.26 ± 0.08	3.89 ± 0.06
Glycine	7.95 ± 0.23	14.35 ± 0.22
Alanine	4.62 ± 0.08	4.69 ± 0.09
Cysteine	0.86 ± 0.11	0.67 ± 0.01
Tyrosine	3.75 ± 0.13	2.96 ± 0.10
Arginine	5.63 ± 0.15	6.01 ± 0.08
Proline	5.72 ± 0.16	9.13 ± 0.19
Valine*	4.30 ± 0.08	3.61 ± 0.06
Methionine*	1.78 ± 0.62	2.47 ± 0.05
Isoleucine*	4.18 ± 0.09	2.94 ± 0.06
Leucine*	6.19 ± 0.11	4.93 ± 0.13
Phenylalanine*	4.48 ± 0.07	3.46 ± 0.09
Histidine*	3.31 ± 0.07	2.36 ± 0.06
Tryptophan*	0.65 ± 0.07	2.22 ± 0.03
Lysine*	7.03 ± 0.27	5.55 ± 0.02
Threonine*	4.64 ± 0.07	3.86 ± 0.09
Total amino acids	93.08 ± 1.08^a	92.80 ± 1.48^a
Essential amino acids	36.57 ± 0.51^a	31.38 ± 0.51^b
Hydrophobic amino acids	39.87 ± 0.36^b	47.79 ± 0.76^a

All data are expressed as the mean ± S. D (n=3)
* Essential amino acid.
Means within each row sharing same upper case were not significantly different (P > 0.05)

Amino acids can be classified by their side chains which contain of aliphatic (Gly, Ala, Val, Leu, Ile, Pro), aromatic (Tyr, Phe, Trp), polar (Cys, Ser, Met, Thr), acidic (Asp, Glu) and basic (Arg, Lys, His). Aliphatic and aromatic are grouped in a hydrophobic group which tends to increase hydrophobicity of the protein molecule and less soluble in water. The next group comprises the basic side chains, which have an amino group that carries a charge and causes the side group to act as a weak base (positively charge). Another group includes acidic side chains which have a carboxyl group attached and act as weak acid (negatively charge) [30]. Many researchers have extensively studied peptides derived from fish proteins as functional foods particularly in the synthesis of ACE inhibitors [7, 9, 31]. There is a relationship between amino acid sequences on ACE inhibition activity, which peptide contains hydrophobic amino acid at the C-terminal contributes to the potential in ACE inhibitory activity [7]. When comparing the amino acid compositions between tilapia muscle and by-product, it was found that tilapia by-product contains higher hydrophobic amino acids (47.79 ± 0.76 g/kg) than in tilapia muscle (39.87 ± 0.36 g/kg). By using an appropriate proteolytic enzyme in enzymatic hydrolysis reaction, it is obviously possible to produce bioactive peptide from tilapia by-product with effective functional properties particularly to inhibit ACE activity.

CONCLUSIONS

It can be concluded that tilapia muscle and by-product have a good nutritional and amino acid composition. Relatively high amount of protein and essential amino acid indicated that both samples can be a good source of protein. In addition, the data on amino acid composition also provides additional evidence that tilapia muscle and by-product have potential application to be utilized as a functional food. Therefore, this study will contribute to the basic information for further research in functional food for the benefits of human beings.

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