

Variation in the Proximate Composition, Amino Acids Content and Fatty Acids of Thai Pangus (*Pangasianodon hypophthalmus*) Fish Depending on Size

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Authors' contributions

This work was carried out in collaboration among all the authors. Authors MS and MH designed the study and wrote protocol, authors MS, MAI and PS conducted analysis and wrote the first draft, authors MH and SS corrected the draft and managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

The nutritional characteristics such as proximate composition, amino acids, and fatty acids properties of fish depend on the size of fish. Determination of the nutritional parameters of Thai pangus muscle depending on five different sizes, viz., 0.5 kg, 1.0 kg, 1.5 kg, 2.0 kg, and 2.5 kg showed that the moisture content was decreased whereas the protein content was increased with the increment of fish weight. The protein content was the highest 16.60% in 2.5 kg size fish and the lowest content 14.75% was in 0.5 kg size fish. The lipid content was found to increase significantly

($P \leq 0.05$) with the increment of fish weight. There were eight essential and nine non-essential amino acids available and the contents were found to increase with the increment of fish weight. The content of essential amino acids was the highest (14.43 g/100 g fish muscle) in 2.5 kg size fish while the lowest (7.79 g/100 g fish muscle) in 0.5 kg size fish. Total 13 fatty acids were detected in fish oil among which oleic acid content was the highest (44.55% to 47.10%) followed by palmitic acid (25.78% to 36.39%), however, the ω -3 polyunsaturated fatty acids content were very poor. The saturated fatty acids content were found to increase whereas the polyunsaturated fatty acids content were found to decrease with increasing the size of fish. So, the findings of this present study reveal that the muscles of Thai Pangus fish are considered as highly nutritive and healthy.

Keywords: Thai pangus; size; proximate compositions; amino acids; fatty acids.

1. INTRODUCTION

Thai pangus (*Pangasianodon hypophthalmus*) is native to Thailand and imported by Bangladesh government in 1990s [1]. Thai pangus is one of the most popular and common fish species cultured in Bangladesh. Currently, culture of this fish is rapidly increasing in Bangladesh because of high growth rate, simple culture method, high adaptability in stressed condition, and high market demand [2]. It is considered as a good source of protein and lipid for the poor, medium, and better-off consumers in not only rural but also urban areas [3]. Besides, Thai pangus fish is popular due to its taste, nutritional value, fat and fatty acids, high protein level, and poor carbohydrate content. Preparation before cooking is also very easy because of the lower amount of bone and absence of scale. For all these reasons, Thai pangus is preferable to children, teenagers, young, old, and all classes of people.

Fish muscle contains moisture, protein, and fat as key nutrients and carbohydrates, vitamins, and minerals as minor component [3]. Analysis of proximate composition such as moisture, protein, lipid, and ash content of any fish sample is important to determine the nutritive value of fish and for better utilization of fish during processing and preservation [4]. Knowledge on proximate composition is also important to different fishery products such as dried, salted, and smoked products and by-products based value added products such as fish protein concentrate, fish protein hydrolyzates, fish meal, or fish oil preparation [2]. Fish and fish products are unique sources of high class animal protein because of containing high amount of myofibrillar protein and less stroma protein content. Moreover, fish proteins are characterized by the presence of all essential amino acids in desirable quantity for human body [5] [3]. Amino acids such as methionine and lysine are available in high quantity in fish protein while the tryptophan

content is low compared to mammalian protein [6]. Fish provides essential nutrients sufficiently as required for the infants and adults supplementary diets [7]. The essential amino acids of Thai pangus fish are much higher which improves the quality of meat. Amino acids are the basic ingredients in fish flesh which play a role in building cell walls and the growth of the body, the role of amino acids is important in the growth of children. The benefits with the oily fish are due to high levels of omega-3 polyunsaturated fatty acids (PUFAs). The PUFAs are potential for maintaining proper human health and decreasing the risk of atherosclerosis, hypertension, neurological degeneration of aging, tumors cell growth, inflammation, improve insulin sensitivity, optimize visual signaling, and maintain bone mass. Fish oils are characterized by a rich source of long chain PUFAs including eicoapentanoic acid (EPA) and docosahexaenoic acid (DHA) which play a crucial role in the prevention of various health problems such as cardiac problem, hypertension, stroke, obesity, depression, cancer, premature aging etc [8-10].

The moisture, protein, lipid, and ash content of fish and fish muscle varies greatly in fish depending on the species, diet, age, sex, environment, and season [11-13]. Size of Thai pangus is an important factor which determines the nutritional properties, *i.e.*, proximate composition, amino acids contents, and fatty acids composition. Consumers of Thai pangus consume fish of variable sizes, however, there is debate which type of fish, either smaller size or larger one meets good nutritional properties. Additionally, it is not well-known whether the smaller size or larger size Thai pangus fish contains higher amount of ω -3 PUFAs and ω -6 PUFAs. There might have relationship between the ratio of ω -3 PUFAs and ω -6 PUFAs with the age and size of fish. An unbalanced ratio of ω -3 PUFAs and ω -6 PUFAs is associated with fatal physiological problems such as cardiovascular disease, asthma, cancer, arthritis, etc. because

there is a competition between the two groups of fatty acids in sharing metabolic enzymes [14]. There are few reports on the proximate composition and some other nutritional properties of Thai pangus fish, however there is no report on the fatty acids composition and contents depending on the size of fish. Though the type and contents of amino acids are influenced by the size and age of fish, so far there is no research report found on the variation in amino acid contents in Thai pangus fish depending on the size of fish. Therefore, the present study was conducted to assess the proximate compositions *viz.* protein, lipid, ash, and moisture contents and amino acids, and fatty acids composition of Thai pangus muscle of different sizes.

2. MATERIALS AND METHODS

2.1 Reagents and Instruments Used

Potassium sulfate, copper sulfate, sulfuric acid, sodium hydroxide, boric acid, HCl, indicators (bromocresol green and methyle red) was purchased from Sigma-Aldrich Co., St. Louis, Missouri, USA. Hot air oven (Model: PSO-451, MART, India), Muffle furnace (MF-205, Turkey), Soxhlet apparatus (Bher, Labor-Technik, Germany), Buchi Distillation unit (K-350), Kjeldhal digestion unit (Ra-158, Delhi), Rotary evaporator, Electric balance (Model: EK600i, Korea), and Amino acid analyzer (LA 8080, Hitachi, Japan) were used in this study. All the chemicals and reagents used in this study were of analytical grade.

2.2 Collection and Preparation of the Sample

Thai pangus of five different sizes: 0.5±0.15 kg (38.34±2.32 cm), 1.0±0.15 kg (45.64±3.21 cm), 1.54±0.24 kg (50.61±3.45 cm), 2.04±0.36 kg (53.54±4.27 cm), and 2.51±0.35 kg (55.67±4.54 cm) were purchased from a single fish farm of Jashore, Bangladesh. Total 25 fishes of five different sizes (n=5) were collected for getting accuracy of the values. The fishes were brought live in the laboratory. The fishes were washed thoroughly using tap water and killed by beheading and removing blood. Then the fishes were cut into smaller species and placed in different stainless steel tray. A portion of muscle was preserved in airtight polythene bags and stored at refrigerated temperature (-20 °C) for proximate composition analysis. The rest portion was dried in a hot air oven at 60 °C temperature

for overnight (12 h). Then the skins and bones were removed from this dry muscle and preserved in airtight polyethylene bag according to different sizes at refrigerator (-20 °C).

2.3 Determination of Proximate Composition of Thai Pangus fish

The proximate composition such as moisture, protein, lipid, and ash content of Thai pangus fish muscle were determined by the methods of AOAC [15].

2.3.1 Determination of moisture content

About 4 g. of chopped Thai Pangus muscle was taken into a pre-weighed porcelain crucible. The crucible was placed into the hot air-oven and maintained at 105°C for 12 h. Drying was continued at 105°C until the weight of the porcelain basins containing the dried samples was increased. After complete drying the porcelain basins containing the samples were finally weighed and the moisture content of the samples was determined by the following equation:

$$\text{Moisture content (\%)} = \frac{\text{Moisture evaporated} \times 100}{\text{Sample weight}}$$

Where,

$$\text{Moisture evaporated} = [(\text{Crucible} + \text{wet sample weight}) - (\text{Crucible} + \text{dry sample weigh})]$$

2.3.2 Determination of ash content

About 10 gm. of sample was weighed and placed in a pre-weighed crucible. The samples in the crucible were dried at 100°C for 2 h by hot air oven and transferred to a muffle furnace. The temperature of the muffle furnace was maintained at 600°C for 6 h and the sample turned slight grey. The crucible was cooled in a desiccator and the crucible with ashed sample was re-weighed.

$$\text{Ash content (\%)} = \frac{(W_2 - W_1) \times 100}{\text{Sample weight}}$$

Where, W2 = Weight of the crucible with ash; W1 = Weight of the empty crucible

2.3.3 Determination of protein content

About 1g of dried sample was measured and transferred to separate long neck Kjeldahl flasks. Protein content was determined by basic Kjeldhal procedure, the principle of which

involves digestion of the sample with concentrated sulfuric acid and digestion mixtures that causes oxidation and breakage of protein and conversion of organic nitrogen to ammonia that remains in the acid mixture as ammonium bisulfate. The total organic nitrogen was converted to ammonium sulfate. The digest was distilled with alkali and distilled water into a boric acid solution. The borate anions formed were titrated with boric acid titration (Add 60 ml of boric acid (4%), with adjusted pH 4.65 titrate with HCl) standardized acid which was converted to nitrogen in the sample. The result of the analysis represented the crude protein of the test feed. A factor was used to convert percent of nitrogen to percent crude protein. Most protein contains 16 percent nitrogen, so the conversion factor is 6.25 (100/16 = 6.25).

$$\text{Percentage of nitrogen} = \frac{(S-B) \times N \times 1.4007 \times 100}{W}$$

Where,

S = Titration reading for sample; B = Titration reading for blank; N = Strength of N/H₂SO₄; W = Sample weight

2.3.4 Determination of lipid content

About 10 g of dry sample was weighed in a thimble paper and 60 mL of *n*-hexane was taken for Soxhlet extraction at 65°C. The solvent was evaporated by using a rotary evaporator at 45°C. The separated lipid was then taken into pre-weighed conical flask and the conical flask was kept in an oven at 50°C for up to 4 hours for constant weight gain and then the flask with lipid was weighed.

$$\text{Percentage of fat content} = \frac{(A-B) \times 100}{\text{Sample weight}}$$

Where,

A = Weight of conical flask with lipid; B = Weight of conical flask

2.4 Determination of Amino Acid Composition

The amino acid composition and contents of Thai pangus muscle was determined by the method described by Islam et al. [16] with slight modifications. A high-speed amino acid analyzer (Model: LA 8080, Hitachi, Japan) equipped with a high-performance cation exchange column (Hitachi, Japan) was used for amino acid analysis maintaining column temperature at 57 °C. Briefly, 1 g sample was mixed with 25 mL of

6N HCl in a glass tube and heated at 110 °C for 24 h, keeping in a sand bath. The heated sample was dried by evaporating HCl and 6 mL distilled water was added for diluting the homogenates. Then the solution was filtered by using a 0.45 µm syringe filter. A standard external amino acid solution (2.5 µmol/ mL) was used for each amino acid identification and the values were presented as g/100 g fish muscle.

2.5 Determination of Fatty Acid Composition

The fatty acid composition of Thai pangus muscle oils (previously extracted by Soxhlet apparatus for lipid content estimation) was analyzed by using a 6890 model gas chromatograph (Agilent Technologies, Wilmington, USA). The instrument was equipped with a fused silica capillary column (length: 100m, internal diameter: 0.25 mm, and 0.2 µm film (Supelco, Bellefonte, USA). The fatty acids of triacylglycerol were converted to fatty acid methyl esters following the procedure of the American Oil Chemists Society [17]. The oven temperature was increased to 130 °C in 3 min, later increased to 240 °C at a rate of 4 °C/min, and then soaked for 10 min. The temperature of injector and detector were maintained at 250 °C. The fatty acids methyl esters of Thai pangus fish muscle oil was identified comparing with the standards of fatty acids methyl esters (Supelco^R 37 Components of FAME Mix, Bellefonte, PA, USA) and quantification was done by obtained peak area (%).

2.6 Statistical Analysis

Values are presented as means±standard deviations of triplicates. One-way analysis of variance (ANOVA) was used to analyze the data (SPSS 20, SPSS Inc., Chicago, IL). Duncan's Multiple Range Tests (DMRT) was used to determine the difference between the means and $P < 0.05$ was considered as significant.

3. RESULTS AND DISCUSSION

3.1 Proximate Composition of Thai Pangus Muscle

The proximate composition of the Thai pangus fish muscle of 5 different sizes is shown in Fig. 1. There was found significance differences in proximate composition of Thai pangus fish

muscle among the samples of different size groups.

3.1.1 Moisture content of Thai pangus muscle

From the Fig. 1, the moisture content (%) of Thai pangus fish muscle was found to vary depending on the size of fish. The moisture content in Thai pangus muscle decreased depending on increasing the weight of fish from 77.87% to 70.13% of wet fish muscle. The highest content of moisture was found in 0.5 kg size fish and the lowest moisture content was found in 2.5 kg size fish. The moisture was the main constituent of Thai pangus fish muscle. The obtained results of moisture content coincide with the findings of Begum et al. [3] who reported the moisture content in domesticated *Pangasianodon hypophthalmus* 78.29%. Nowsad et al. [6] reported that moisture content in fish varies widely between 70-80%. Orban et al. [18] determined high moisture level (80-85%) in Thai pangus fillets. The finding of the present study in moisture content was consistent to the result of Rao et al. [19] who reported the moisture content of *Pangasius* fillets was 78.20%. On the other hand, the Guimarães et al. [20] found the moisture content of Thai pangus 83.83–85.59%. Islam et al. [16] reported the moisture content of raw freshwater mud eel muscle 74.45%, which was similar in with the present study. So it can be said that the moisture content of present study is similar compared with other reports. The moisture content of fish varies greatly depending on the species, sex, age, season, and environment [21]. There is a reverse relationship

between the moisture and lipid content in fish and their sum is approximately 80% [22].

3.1.2 Protein contents of Thai pangus muscle

Protein was the second abundant composition in Thai pangus fish muscle. The protein content in Thai pangus muscle was found to increase depending on increasing the weight of fish and the protein content varied between 14.75% and 16.60%. In the present study, the highest protein content among different size Thai pangus muscle was found 16.60% in 2.5 kg size fish followed by 16.24%, 16.03%, 15.58%, and 14.75% in 2.0 kg, 1.5 kg, 1.0 kg, and 0.5 kg size fish, respectively. Shikha et al. [2] showed the average protein content of Thai pangus was $13.17 \pm 0.91\%$. The present study showed similarity in protein content with Guimarães et al. [20] who reported 12.51–14.52% protein in Thai pangus fish. The protein content in the present study was found higher than the previous report of Begum et al. [23] who investigated on *Pangasianodon hypophthalmus* cultured in Bangladesh. Generally, the protein content of cultured fish depends on feeding and movement of fish [24]. However, there was no previous research found on the changes in protein content depending on size of Thai pangus fish. The protein content of different size Thai pangus fish was high which can be used efficiently used as an animal protein source. Moreover, the protein content of Thai pangus was more than 15% except 0.5 kg size fish, which is categorized as the high protein fish [25]. Protein is one of the most important nutrients in fish and determines the nutritional status of particular organisms [26].

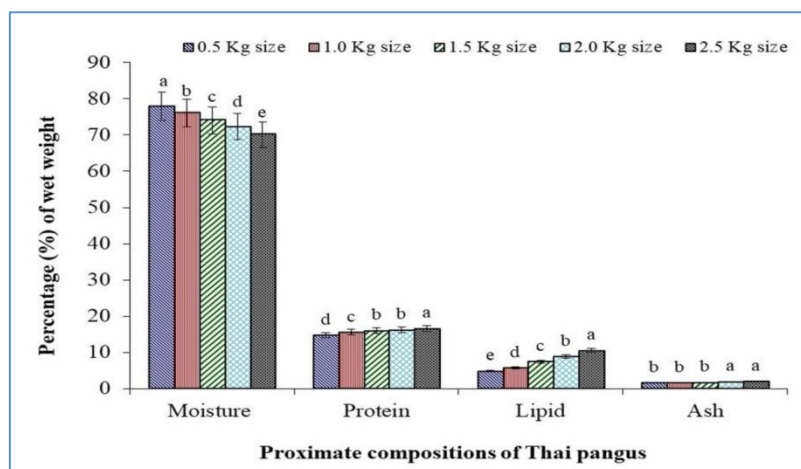


Fig. 1. Proximate composition of Thai pangus fish muscle of different size fish. Values are the results of Mean±standard deviation (n=3). Different small letters on each column bar indicate significant differences ($P < 0.05$)

3.1.3 Lipid contents of thai pangus muscle

The lipid content of Thai pangus muscle was found to be increased significantly with the increment of fish size. The lowest lipid content was found 4.84% in 0.5 kg size fish whereas the lipid content was increased to 5.72%, 7.46%, 8.82%, and 10.50% in 1.0 kg, 1.50 kg, 2.0 kg, and 2.50 kg size fish, respectively. The content of moisture and lipid is inverse in fish muscle. With the increment of size and weight of fish, there was deposition of lipids in fish tissue which increased lipid content in large size fish. In previous study, Begum et al. [3] reported that the fat content of Thai pangus was $16.55 \pm 1.52\%$. Guimarães et al. [20] divided fishes into two groups regarding total lipid content as follows: lean (<2%), low-fat (2–4%), medium-fat (4–8%) and high-fat (>8%). According to the classification, Thai pangus is classified as medium to high fatty fish. The lipid content of *Pangasianodon hypophthalmus* differed from 5.33% to 9.70% [27]. Monalisa et al. [28] reported that the fat content was $11.11 \pm 1.75\%$ in hybrid pangus, which shows consistency with the present study. Orban et al. [18] determined the amount of lipid content 1.1–3.0% that is much less amount compared to the present study. There is an inverse relationship between the lipid and protein content in fish and their contents are dependent on exercise or movement of fish and also feeding [24]. Differences in the fat or other nutrients content of the fishes might be due to the ability of fish to consume and exchange the nutrients available in aquatic environment [29]. Fish use a lot of fat as reserved energy during starvation and various health functional fatty acids are found in fish body [30].

3.1.4 Ash contents of Thai pangus muscle

The ash content of Thai pangus muscle slightly varied depending on the size of fish from 1.57% to 1.96%. The lowest ash content was found 1.57% in 0.5 kg size fish whereas the content was increased to 1.68%, 1.71%, 1.88%, and 1.96% in 1.0 kg, 1.50 kg, 2.0 Kg, and 2.50 kg size fish, respectively. It is observed in a same size Thai pangus fish muscle that the higher moisture content resulted in lower ash content. This result is quite similar with the report of Guimarães et al. [20] who found 1.09–1.65% ash content in Thai pangus muscle. The ash content was reported 1.75% in *Pangasianodon hypophthalmus* cultured in Bangladesh [27] Zaman, Naser, Abdullah, & Khan [31] reported the ash content in Thai pangus 0.60 %, which

was slight lower compared to present investigation. So it can be said that this present study is quite similar with the findings of other researcher.

3.2 Amino Acid Composition

Amino acids are the building blocks of protein which are classified to the essential amino acids (EAAs) and non-essential amino acids (NEAAs). The human body cannot synthesize EAAs. It means EAAs must be ingested from outside with food. Fish is one of the important foods providing high amount of EAAs. In this study, seventeen amino acids were detected in Thai pangus muscle and the amino acids chromatograms are shown in Fig. 2. The content of different EAAs and NEAAs in different size Thai pangus fish muscle is shown in Tables 1 & 2. The maximum contents of essential amino acids was found 14.43 g/100 g fish muscle in 2.5 kg size fish whereas the lowest content of essential amino acids was found 7.79 g/100 g fish muscle in 0.5 kg size fish. There are eight essential amino acids found in this study such as valine, leucine, isoleucine, methionine, threonine, arginine, phenylalanine, and lysine. Among the essential amino acids, lysine content was the highest (2.57%-3.24%) and the lowest content was found histidine (0.27%-0.5%). Phenylalanine, threonine, and arginine content also found in lower amount in Thai pangus muscle. The contents of leucine (1.41%) and valine (1.24%) were medium among the essential amino acids. The most important incidence noticed in this study showed that the amount of EAAs was increased with the increment of fish weight.

The non-essential and amino acids content was found to increase depending on the size of Thai pangus muscle from 12.14 g/100 g fish muscle (0.5 kg size fish) to 19.12 g/100 g fish muscle (2.5 kg size fish) Fig. 3. The highest amount of individual non-essential amino acid was glutamic acid (2.66-5.27%) and the lowest one was cysteine (0.06%-0.12%). Begum et al. [23] analyzed the amino acid profile of striped catfish and reported that glutamic acid was found the most dominant amino acid followed by lysine and aspartic acid and the content was 6.30%, 4.78%, and 4.77%, respectively. L-glutamic acid exist in glutamate form and plays key role in amino acid metabolism, regulate nitrogen balance, and also well-established excitatory neurotransmitter in the central nervous system [32].

The non-essential amino acids detected in the Thai pangus muscle were aspartic acid, serine,

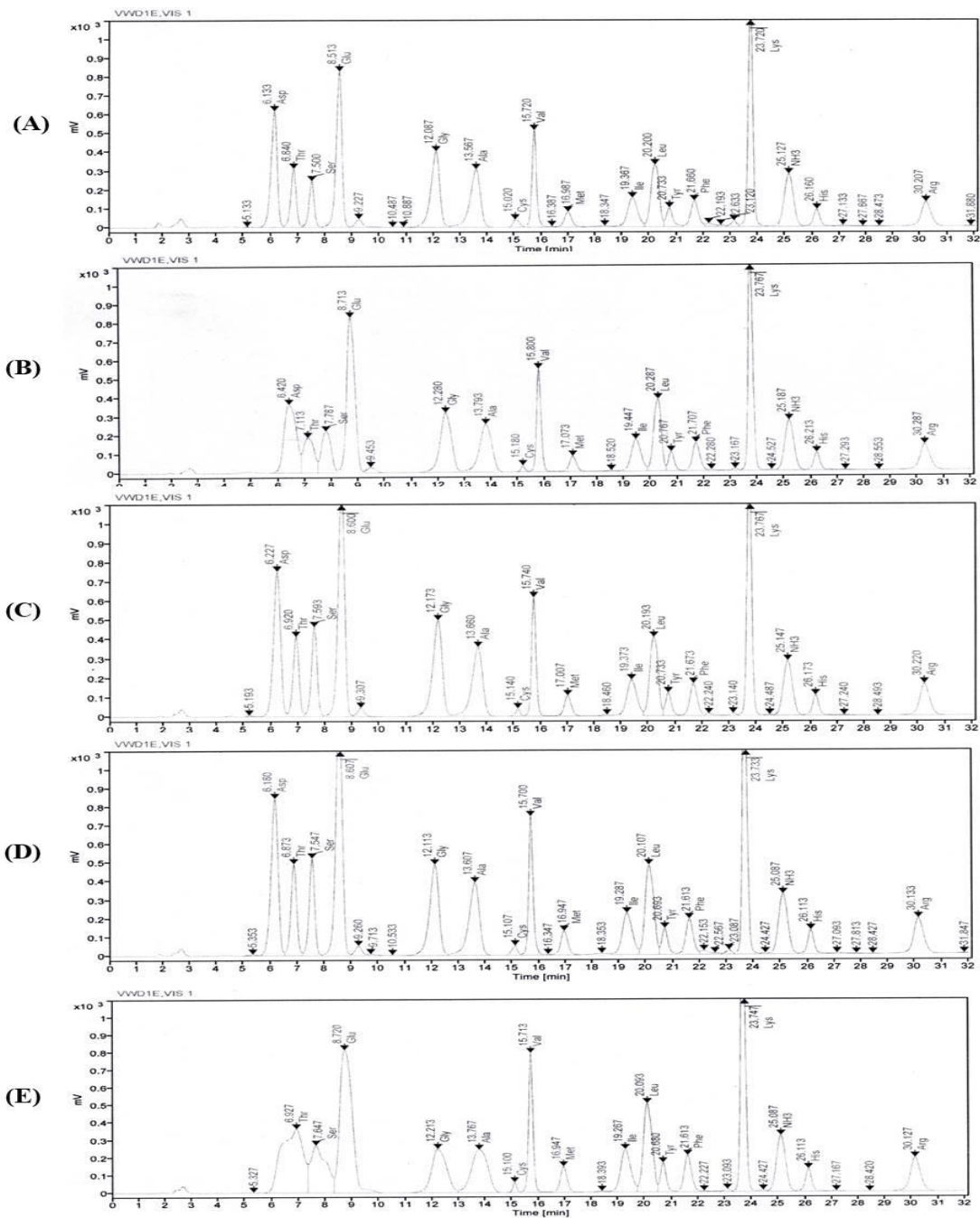


Fig. 2. Amino acid chromatogram of Thai pangus muscle. A: 0.5 kg size fish, B: 1.0 kg size fish, C: 1.5 kg size fish, D: 2.0 kg size fish, E: 2.5 kg size fish

glumatic acid, glycine, alanine, cysteine, isoleucine, tyrosine, and proline. Actually the amount of glutamic acid, aspartic acid, and proline were higher than other nine NEAAs. The content of serine and isoleucine was medium whereas the content of cysteine and tyrosine was very low. The total NEAAs content was the lowest in 0.5 kg weight Thai pangus fish muscle whereas the highest amount was found in 2.5 kg

size fish. In the previous study, Monalisa et al. [28] found that notable amount of glycine was found in native pangus. Statistical analysis showed that the amino acid content in native and hybrid pangus differed significantly at 5% level of significance except serine and arginine. Nurilmala et al. [33] found the highest quantity of glutamic acid that was similar with the present result and lower quantity was serine. Pratama,

Rostini, & Rochima [34] found that the highest amount of amino acids were detected in fresh and steamed Patin catfish was glutamic acid (3.28%; 5.50%, respectively) and lowest amount was tyrosine and cysteine. The previous results were similar to the results of present study. The results of Ghassem et al. [35] showed that the content of glutamic acid and aspartic acid was close with the present result. In a previous study, Monalisa et al. [26] found that hybrid pangus contained all of the essential amino acids including valine, leucine, isoleucine, lysine, threonine, methionine, and histidine in higher amount compared to native pangus. There was significant difference ($P < 0.05$) between native and hybrid pangus in containing those amino acids except leucine and methionine. Valine, leucine, and methionine were shown the lowest amount in that study. Danuwat et al. [36] found the highest amount of amino acid in fish aged 7.5 month and the total amino acid contents were 6.79%. The previous reports were similar with the present study in increasing total amount of amino acids with increasing the age of fish. Nurilmala et al. [31] reported that the highest content of individual amino acid was lysine among all the EAAs of all examined fillets. Pratama, Rostini, & Rochima [34] found that the highest amount of amino acids was lysine and methionine, and the lowest amount was histidine which was similar with the present study. Bhavan

et al. [37] detected eighteen amino acids among which eleven were essential and seven were non-essential in the muscle of prawn. According to that study valine, leucine, phenylalanine, and arginine were found to be statistically significant amount. All these reports coincide well with the results of present findings of amino acid contents in the muscle of Thai pangus fish muscle.

Lysine is an essential amino acid plays a significant role in healthy and nutritious diet formulation. Fish muscle contain high amount of amino acids such as glycine, arginine, glutamic acid, proline, and alanine. Lysine is essential for human body because it is needed as a elementary composition of blood antibody, maintain common cell growth, and strengthen fluid circulation in human body. Histidine is a vital amino acid associated with various metabolic functions such as histamines production, which is associated with allergic and inflammatory reactions. It also plays significant roles in osmoregulatory process and energy production or is used in other metabolic process during harsh conditions/ certain emergencies. The amino acids composition in fish in determined by several intrinsic (species, sex, size) and extrinsic (food, season, water parameters) factors [23]. There was no previous report found on the changes of EAAs and NEAAs contents in Thai pangus fish depending on the size of fish.

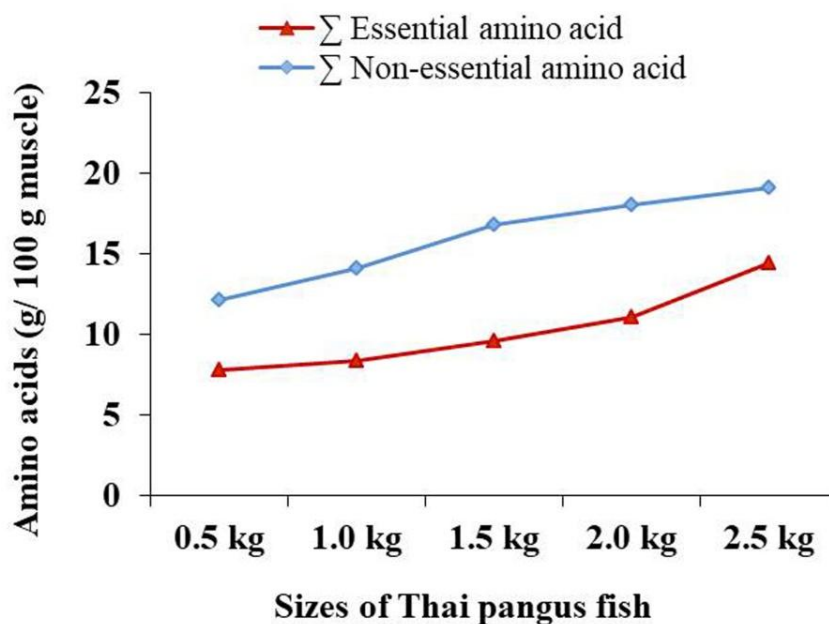


Fig. 3. Changes in total essential and non-essential amino acids contents of Thai pangus muscle depending on size of fish

Table 1. Essential amino acid compositions (g/100 g fish muscle) of Thai pangus

| Essential amino acids | 0.5 kg size | 1.0 kg size | 1.5 kg size | 2.0 kg size | 2.5 kg size |
|-------------------------------|---------------------------|---------------------------|---------------------------|---------------------------|---------------------------|
| Thr | 0.89 ± 0.097 ^a | 0.95 ± 0.056 ^a | 1.21 ± 0.037 ^b | 1.44 ± 0.081 ^c | 3.98 ± 0.047 ^d |
| Val | 1.24 ± .07 ^a | 1.36 ± 0.025 ^b | 1.46 ± .025 ^c | 1.79 ± .037 ^d | 1.99 ± .057 ^e |
| Met | 0.28 ± 0.05 ^a | 0.31 ± 0.026 ^a | 0.36 ± 0.043 ^b | 0.46 ± 0.06 ^b | 0.51 ± 0.04 ^b |
| Lys | 2.57 ± 0.09 ^a | 2.61 ± 0.066 ^b | 2.92 ± 0.088 ^c | 3.07 ± 0.06 ^d | 3.24 ± 0.04 ^d |
| Leu | 1.41 ± 0.043 ^a | 1.6 ± 0.0 ^b | 1.89 ± 0.085 ^c | 2.17 ± 0.049 ^d | 2.34 ± 0.041 ^e |
| Phe | 0.59 ± 0.015 ^a | 0.67 ± 0.023 ^b | 0.71 ± 0.07 ^c | 0.8 ± 0.026 ^{cd} | 0.91 ± 0.07 ^d |
| His | 0.27 ± 0.03 ^a | 0.29 ± 0.041 ^a | 0.34 ± 0.02 ^b | 0.5 ± 0.05 ^b | 0.5 ± 0.06 ^b |
| Arg | 0.54 ± 0.055 ^a | 0.62 ± 0.025 ^b | 0.71 ± 0.043 ^c | 0.82 ± 0.056 ^d | 0.96 ± 0.04 ^d |
| Σ Essential amino acid | 7.79 | 8.41 | 9.6 | 11.05 | 14.43 |

Values are presented as means ± standard deviation of triplicates. Different small letters on each row indicates significant ($P \leq 0.05$) differences. Thr: threonine, Val: valine; Met: methionine; Lys: lysine; Leu: leucine; Phe: phenylalanine; His: histidine; Arg: arginine

Table 2. Non-essential amino acid compositions (g/100 g fish muscle) of Thai pangus

| Non-essential amino acid | 0.5 kg size | 1.0 kg size | 1.5 kg size | 2.0 kg size | 2.5 kg size |
|-----------------------------------|---------------------------|----------------------------|----------------------------|----------------------------|---------------------------|
| Asp | 1.94 ± 0.086 ^a | 2.46 ± 0.09 ^a | 2.81 ± 0.05 ^b | 3.08 ± 0.087 ^c | 3.15 ± 0.085 ^d |
| Ser | 0.65 ± 0.095 ^a | 1.11 ± 0.051 ^b | 1.38 ± 0.07 ^b | 1.4 ± 0.035 ^c | 2.03 ± 0.04 ^d |
| Glu | 2.66 ± 0.11 ^a | 3.47 ± 0.13 ^b | 4.12 ± 0.10 ^c | 4.46 ± 0.10 ^d | 5.27 ± 0.083 ^e |
| Gly | 1.86 ± 0.09 ^a | 2.04 ± 0.07 ^a | 2.59 ± 0.036 ^b | 2.57 ± 0.083 ^b | 2.05 ± 0.041 ^c |
| Ala | 1.67 ± 0.075 ^a | 1.82 ± 0.066 ^a | 2.07 ± 0.035 ^b | 2.25 ± 0.05 ^c | 2.26 ± 0.055 ^d |
| Cys | 0.12 ± 0.01 ^a | 0.06 ± 0.01 ^a | 0.07 ± 0.0 ^a | 0.12 ± 0.0 ^b | 0.1 ± 0.01 ^b |
| Ile | 0.84 ± 0.15 ^a | 0.88 ± 0.03 ^{ab} | .99 ± 0.096 ^b | 1.13 ± 0.02 ^c | 1.23 ± 0.026 ^c |
| Tyr | 0.35 ± 0.03 ^a | 0.38 ± 0.032 ^{ab} | 0.37 ± 0.085 ^{bc} | 0.46 ± 0.045 ^{bc} | 0.53 ± 0.068 ^c |
| Pro | 2.05 ± 0.09 ^a | 1.92 ± 0.047 ^a | 2.43 ± 0.013 ^a | 2.58 ± 0.06 ^b | 2.5 ± 0.051 ^b |
| Σ Non-essential amino acid | 12.14 | 14.14 | 16.83 | 18.05 | 19.12 |

Values are presented as means ± standard deviation of triplicates. Different small letters on each row indicates significant ($P \leq 0.05$) differences. Asp: aspartic acid; Ser: serine; Glu: glutamic acid; Gly: glycine; Ala: alanine; Cys: cysteine; Ile: isoleucine; Tyr: tyrosine; Pro: proline

3.3 Fatty Acid Composition of Thai Pangus Muscle Oil

Thai pangus is a medium to high fatty fish depending on size and the lipid content makes it delicious and tasty [38]. The contents of saturated, monounsaturated, and polyunsaturated fatty acid compositions determined in Thai pangus fish muscle oil are presented in Table 3. In the present study, total thirteen fatty acids were identified in Thai pangus muscle oil. The most abundant fatty acids were oleic acid (45.67-47.10 %), followed by palmitic acid (25.78-36.39%), linoleic acid (7.27-13.49%), stearic acid (4.22-6.20%), and myristic acid (3.87-5.07%). On the other hand, the lower amount of fatty acids in Thai pangus muscle oil were cis-5,8,11,14,17-eicosapentanoic acid (0.05-0.09 %) and myristoleic acid (0.08-0.45 %) followed by behenic acid, arachidonic acid, lignoceric acid, arachidic acid, docosahexanoic acid and linolenic acid. Among the saturated fatty acids, palmitic acid content was the highest and the behenic acid and lignoceric acid content was the lowest. The saturated fatty acid contents in Thai pangus fish muscle oil varied between 37.60 % and 45.12% depending on the size of fish. The totality of saturated fatty acids in Thai pangus fish oil was found 45.12%, 43.28%, 42.08%, 38.85%, and 37.6% in 2.5 kg, 2.0 kg, 1.5 kg, 1.0 kg, and 0.5 kg size fish, respectively. The contents of saturated and mono unsaturated fatty acids in Thai pangus fish muscle increased with increasing size of fish. Interestingly, the content of PUFAs was lower in small size fish, where the content was 14.65% in 0.5 kg size fish and 8.10% in 2.5 kg size fish. The contents of

monounsaturated fatty acids were higher in smaller size fish Table 3. Only two monounsaturated fatty acid such as oleic acid and myristoleic acid were found in Thai pangus fish muscle oil. Among the PUFAs, the linoleic acid content was the highest (7.27-13.49%). The amount of ω -3 PUFAs were very poor in Thai pangus fish muscle and the content varied slightly depending on the size of fish from 0.71 to 1.01% Table 3. The contents of two important long chain ω -3 PUFAs, EPA and DHA were 0.06%-0.09% and 0.14-0.20%, respectively.

The EPA content in *Pangasidon hypophthalmus* was reported 0.44% [39]. EPA is considered as one of the most important fatty acids in fish oil [40]. However, the content of EPA was found in very poor quantities Thai pangus fish muscle oil. Shabani, Christianus, Tan, Che Man, & Ehteshami, [41]. Investigated the fatty acids composition of patinacatfish (*Pangasianodon hypophthalmus*) and reported the DHA content 0.84-1.49%. In the present study, the total PUFAs content were available at very low percentages (8.10–14.65% of total fatty acids) in Thai pangus fish muscle. Orban et al. [16] reported that high percentages of saturated fatty acids (41.1–47.8% of total fatty acid) and low percentages of PUFAs (12.5–18.8% of total fatty acids), which were mainly represented by linoleic acid (44–59% of total PUFAs). There was an inverse relationship found between the SFAs and PUFAs contents in Thai pangus muscle oil. The amount of PUFAs content was found to increase with increasing the size of Thai pangus fish Fig. 4. They also mentioned that Tra catfish contained lower amount of DHA, than

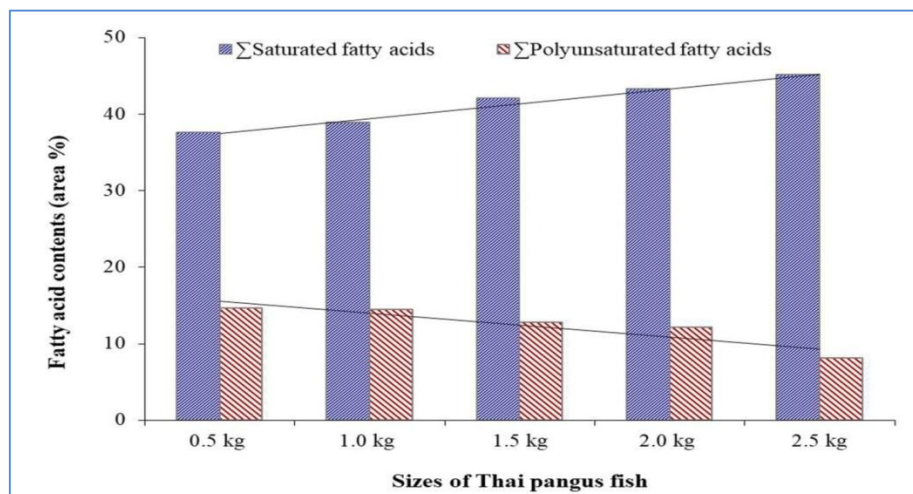


Fig. 4. Variations in saturated and polyunsaturated fatty acid contents in Thai pangus fish depending on size of fish

Table 3. The fatty acids composition (area %) of different size Thai pangus fish muscle oil

| Saturated fatty acids | 0.5 kg size | 1.0 kg size | 1.5 kg size | 2.0 kg size | 2.5 kg size |
|---------------------------------------------------|---------------------------|---------------------------|---------------------------|---------------------------|---------------------------|
| Myristic Acid (C14:0) | 5.07 ± 0.02 ^d | 4.74 ± 0.03 ^c | 4.63 ± 0.02 ^b | 3.63 ± 0.056 ^b | 3.87 ± 0.043 ^a |
| Palmitic Acid (C16:0) | 25.78 ± 0.02 ^e | 28.37 ± 0.02 ^d | 31.71 ± 0.03 ^c | 34.57 ± 0.03 ^b | 36.39 ± 0.06 ^a |
| Stearic Acid (C18:0) | 6.2 ± 0.05 ^d | 5.32 ± 0.42 ^c | 5.02 ± 0.08 ^b | 4.59 ± 0.03 ^b | 4.22 ± 0.025 ^a |
| Arachidic Acid (C20:0) | 0.2 ± 0.6 ^b | 0.22 ± 0.06 ^b | 0.33 ± 0.04 ^a | 0.34 ± 0.02 ^a | 0.42 ± 0.06 ^a |
| Behenic Acid (C22:0) | 0.21 ± 0.05 ^a | 0.15 ± 0.06 ^a | 0.33 ± 0.4 ^a | 0.1 ± 0.04 ^a | 0.11 ± 0.05 ^a |
| Lignoceric Acid (C24:0) | 0.14 ± 0.3 ^a | 0.05 ± 0.02 ^{bc} | 0.06 ± 0.02 ^{bc} | 0.05 ± 0.03 ^{ab} | 0.11 ± 0.04 ^a |
| ∑Saturated fatty acids | 37.6 | 38.85 | 42.08 | 43.28 | 45.12 |
| Myristoleic Acid (C14:1) | 0.45 ± .05 ^b | 0.11 ± 0.02 ^b | 0.16 ± 0.07 ^b | 0.08 ± 0.05 ^b | 0.08 ± 0.04 ^a |
| Oleic Acid (C18:1n9C) | 47.1 ± .14 ^e | 46.9 ± 0.04 ^d | 45.29 ± 0.08 ^c | 44.55 ± 0.05 ^b | 45.67 ± 0.7 ^a |
| ∑Monounsaturated fatty acids | 47.62 | 47.01 | 45.45 | 44.63 | 45.75 |
| Linoleic Acid (C18:2n6c) | 13.49 ± .05 ^c | 13.45 ± 0.06 ^c | 11.81 ± 0.1 ^{bc} | 11.15 ± 0.06 ^b | 7.27 ± 5.18 ^a |
| Linolenic Acid (C18:3n3) | 0.82 ± .06 ^c | 0.7 ± 0.04 ^{ab} | 0.6 ± 0.05 ^a | 0.56 ± 0.08 ^a | 0.51 ± 0.03 ^a |
| Arachidonic Acid (C20:4) | 0.05 ± .02 ^a | 0.04 ± 0.02 ^a | 0.07 ± 0.37 ^a | 0.11 ± 0.05 ^a | 0.12 ± 0.04 ^a |
| cis-5,8,11,14,17-Eicosapentanoic Acid (C20:5n3) | 0.09 ± .05 ^a | 0.09 ± 0.01 ^a | 0.08 ± 0.05 ^a | 0.05 ± 0.01 ^a | 0.06 ± 0.02 ^a |
| Cis-4,7,10,13,16,19-Docosahexanoic Acid (C22:6n3) | 0.2 ± 0.02 ^a | 0.2 ± 0.04 ^a | 0.2 ± 0.08 ^a | 0.2 ± 0.02 ^a | 0.14 ± 0.05 ^a |
| ∑Polyunsaturated fatty acids | 14.65 | 14.48 | 12.76 | 12.07 | 8.1 |
| ∑ω-3 polyunsaturated fatty acids | 1.01 | 0.99 | 0.88 | 0.81 | 0.71 |

Note: Values are presented as means ± standard deviation of triplicates. Different small letters on each row indicate significant ($P \leq 0.05$) differences

salmon and sea bass which contained 20.2% and 18.7%, respectively. In nutritional point of view, Tracatfish is a prospective source of ω -3 PUFAs and low fat food. Islam et al. [16] found 20 different fatty acids in freshwater mud eel muscle among which palmitic acid was in the highest quantity and the content varied between 26.51% to 29.70% in raw and cooked samples. Nurilmala et al. [33] found that palmitic and stearic acid content was found to be dominant among saturated fatty acids group for all examined fillet sample and monounsaturated fatty acids group was dominated by oleic acid in all fish fillets. Ghassem et al. [35] reported that the most abundant fatty acid in these fishes was C18: 1 (oleic acid) ranging from 28.4 to 39.3%. The results of fatty acids content in present study showed consistency with the previous reports. Other major fatty acids were C16: 0 (palmitic acid) and C18: 2 (linoleic acid). The composition of fatty acids showed that total monounsaturated fatty acids (approximately 34-45%) were the highest, followed by saturated and polyunsaturated fatty acids. All four fresh water fishes contained arachidonic acids but in a very small amount ranging from 0.55 to 1.24% of total fatty acids. Therefore, results of this present study and other studies indicated that Thai pangus has included sufficient contents of important fatty acids which are necessary to prevent many diseases.

4. CONCLUSION

The nutritional composition of Thai pangus varied significantly depending of the size of fish. Though the chemical composition of Thai pangus differed depending on size, the species is considered as a highly nutritious fish. Thai pangus contained high amount of protein compared to other fresh water fish species. There substantial amount of essential amino acids found in this fish which are very much needed for human health. Additionally, there were various fatty acids available in the Thai pangus fish muscle which is important for maintaining normal physiological process. However, Thai pangus fish muscle oil contained very poor amount of ω -3 PUFAs. The fat contents in Thai pangus increased significantly with increasing weight of fish. The report of the present study will be helpful to the consumers for selecting their desirable size fish considering nutritional aspects. Investigations on the causes of variation in proximate composition and nutritional properties and the minerals, vitamins,

and heavy metals deposition in different size Thai pangus fish could be conducted in future.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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