



SIZE AND ORGAN-SPECIFIC VARIATIONS IN PROXIMATE COMPOSITION OF FRIGATE TUNA (*Auxis thazard*)

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Abstract

Different species of tuna are well-known seafood items for their economic importance and nutritional profiles. Tuna is a cheap marine fish of Bangladesh but is not popular with consumers compared to other coastal and marine fishes. In this study, the proximate composition of tuna (*Auxis thazard*) was compared based on their size and body portions because size and body portions might have a significant impact on the nutritional value of the fish. Three different sizes, i.e., ≤ 500 g, ≤ 750 g, and ≥ 1 kg, and three different body portions, i.e., head, middle, and tail, were subjected to study for proximate analysis. Standard methods (Kjeldal and AOAC) were followed for the determination of biochemical parameters. Among different sizes of fish, the highest average percentage of protein (23.07 ± 0.82), lipid (2.80 ± 0.41), and ash (1.62 ± 0.12) were calculated in the ≥ 1 kg size group, and among different body portions, the highest average percentage of protein (23.03 ± 0.91), ash (1.62 ± 0.09), and lipid (2.85 ± 0.39) were calculated in the muscle from the middle portion of the fish. The highest average percentage of moisture (73.91 ± 0.95) was found in the tail portion of the small-sized group. This study revealed that the comparatively larger fish and the middle portion of the body are nutritionally rich compared to the other sizes and body parts. Therefore, it is of utmost importance to raise awareness among consumers to ensure adequate nutrition at a cheap price.

Keywords: *Auxis thazard*, Proximate composition, Protein, Lipid, Moisture

Introduction

The majority of people who inhabit developing countries get their animal protein from fish. According to Ahmed (1993), fish is an important component of the Bangladeshi economy and a major source of protein, which helps to maintain a healthy diet. In addition to protein, fish is a good source of carbohydrates, fats, vitamins, and minerals (Falls, 2012). For many people, fish is a crucial part of their diet since it frequently offers essential elements that diets high in cereal-based foods do not (Clucas & Sutcliffe, 1981). One of the most significant arguments in favor of consumers choosing fish is its nutritional value (Gall, 1983). Seafood, particularly finfish, is a significant source of vital elements such as proteins, vitamins, lipids, and minerals that support healthy human life (Rao et al., 2016). All of the essential amino acids are present in fish protein, which is also highly and readily digested. (Jhaveri et al., 1984).

As a result of its abundance in protein, fat, and essential amino acids, tuna meat is often regarded as being very nutrient-dense (Chinnamma, 1975). The high levels of Omega-3 polyunsaturated fatty acids found in tuna fish contribute to its acceptance as a high-quality food item. These fatty acids have a number of health benefits, including lowering the risk of heart disease, lowering cholesterol levels, regulating blood pressure, preventing arteriosclerosis and several other advantages (Rani et al. 2016). Additionally, phosphorus, which is essential for the neurological system, and iodine, which promotes healthy growth, are elements found in tuna. Furthermore, it includes vitamins like niacin and vitamin B12, which are essential for cell development and proper metabolism of fatty acids and cholesterol (Karunaratna & Attygalle, 2010).

The Scombridae family of pelagic fish includes mackerels and tunas. There are currently 54 species in this family that are known to exist (Collette & Nauen, 1983; Pauly et al., 1989), of which 10 are found in Bangladesh's EEZ (Khan et al., 1997; BFRI/MFTS, 2003). As bycatch, tuna fish are mostly caught using drift gill nets, hooks, and lines at the Cox's Bazaar base in the South-East and North-West parts of the Bay of Bengal, as well as in mid-water

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trawls as bycatch and incidentally other fish trawls (Roy et al., 2014). However, one of the assessments conducted by the Bangladesh-Thai joint venture noted a good stock of large pelagic species, such as tuna and fish that look like tuna, as well as sharks, in Bangladeshi seawater (Rahman, 1993).

Six economically significant species of tuna are reported to be present in the Bay of Bengal by Khan et al. (1997); these species' habitats span the shallower and deeper areas of Bangladesh's Exclusive Economic Zone (EEZ). These species include *Auxis rochei* (bullet tuna), *Auxis thazard* (frigate tuna), *Thunnus obesus* (bigeye tuna), *Thunnus tonggol* (longtail tuna), and *Katsuwonus pelamis* (Skipjack tuna). Roy et al. (2014) also added *Thunnus albacares* (Yellowfin tuna) as one more species found in the Bay of Bengal. Tuna sizes range from 24–60 cm for *E. affinis*, 22–54 cm for *A. thazard*, 24–68 cm for *K. pelamis*, 28–90 cm for *T. albacares*, 36–54 cm for *S. orientalis*, and 22–34 cm for *A. rochei* (Somvanshi, 1998). The average size of *Auxis thazard* ranges from 25 to 40 cm, depending on fishing gear, seasonal variation, sex, and region of harvesting (Collete and Nauen, 1983). *Auxis thazard* has a maximum length of 65 cm (Cayre et al., 1993). Apart from a few scattered studies on population dynamics (Mustafa et al., 1996; Rashid, 2000) and reporting on the species' presence (Khan et al., 1997), not much research has been done on the production and physical and biological state of tuna in Bangladesh, despite the fact that it is one of the most significant marine species in the world.

Estimation of the proportion of the moisture, lipid, protein, and ash contents of fish is part of the proximate body composition procedure. The literature that is currently accessible on tuna fish indicates that its nutritional elements are quite well-balanced. The protein content of the bulk of tuna fish vary from 15 to 30% (Bykov, 1983). Since they are only found in trace amounts, non-protein molecules and carbohydrates are typically excluded from standard analyses (Cui & Wootton, 1988). Research on the biochemical composition of tuna is fairly lacking, particularly in tropical regions. The body's proportionate amounts of energy, proteins, and lipids can be determined by looking at the water content. Fish with lower water content have higher levels of fat and protein as well as higher energy densities (Dempson et al., 2004). The current investigation was carried out to track changes of biochemical composition in the *Auxis thazard*. Based on bodily parts and size, the approximate chemical composition (ash, fat, protein, and moisture) was assessed. Consumers selecting fish based on nutritional composition may find the study's conclusions useful as a guide.

Materials and Method

Sample collection and preparation

Three different sizes of tuna fish, i.e., ≤ 500 g, ≤ 750 g, and ≥ 1 kg, were collected from a wholesale fish market located at Rupsha in Khulna District. 5 individuals from each size group and a total of 15 fish were collected. 20–25 g of samples were taken from the head portion, middle portion, and tail portion of each sample fish for the experimental work. Bones and skins were removed from the samples, and meat from head, middle and tail portions were used for the experiment. Samples were ground with a mortar and pestle. Grinded samples were packed in small polythene bags and marked as head, middle, and tail portions. For additional analysis, prepared samples were kept in storage at -18°C .

Proximate composition analysis

Determination of protein

Micro Kjeldhal method was followed to determine the protein concentration, and it is considered the typical technique. Total nitrogen was estimated by following the Kjeldahl method (Pearson, 1976). The result was given as a percent (%) of dry weight. Digestion mixture, sulfuric acid, distilled water, sodium hydroxide, boric acid, and hydrochloric acid were the reagents used to determine the crude protein. The ammonia was extracted from an alkaline medium, absorbed in standardized mineral acid, and the concentration was determined by back titration with 0.1 N HCL solution. This method consists of three basic steps: digestion, distillation, and titration. Using the following formula, the percentage of gross proteinous nitrogen was determined:

$$\text{Nitrogen (\%)} = \frac{X \times 0.014 \times \text{Normality of HCl}}{\text{Weight of sample}}$$

Where, X = Titer value of the sample

$$\text{Crude protein (\%)} = \% \text{ of Nitrogen} \times 6.25$$

Determination of lipid

Using a 1:1, v/v ratio of chloroform to methanol, the Bligh and Dyer method was used to calculate total lipid. For the determination of lipid, a previously pulverized sample was taken in a beaker, and then methanol and chloroform solution (100 ml) were added. About 5 g sample was homogenized using an electric homogenizer. Next to that, the sample solution was filtered using Whatman filter paper. Following filtration, distilled water (50 ml) was mixed into the sample solution and kept in a separation funnel for eight hours, which created two distinct layers of the solution. The bottom layer of the separation funnel was discarded, and then the funnel was kept on the hotplate for drying. After evaporating all the chloroform, a simple amount of sticky liquid was left in the bottom of the beaker. After that, the beaker was taken off of the hotplate and given time to cool (AOAC, 2000). The following calculation was used to get the percentage of lipid:

$$\text{Lipid (\%)} = \frac{\text{Weight of the beaker with lipid} - \text{Initial weight of the beaker}}{\text{Sample weight}} \times 100$$

Determination of moisture

The samples were dried at $105 \text{ }^{\circ}\text{C} \pm 2 \text{ }^{\circ}\text{C}$ until a consistent weight was achieved, and the moisture content was ascertained using the hot air oven method (AOAC, 2000). A crucible was cleaned, dried and constant weight of the crucibles was taken, and then 5 g sample was put on the crucible and placed in the hot air oven to achieve the constant weight of the sample. Moisture percentage of the sample was calculated with the following formula:

$$\text{Moisture (\%)} = \frac{\text{Original sample weight} - \text{Dried sample weight}}{\text{Original sample weight}} \times 100$$

Determination of ash

The amount of ash was measured following a 20-hour burn at 550°C . Firstly, the weight of the crucibles was obtained, and then 5 g of samples were placed on the crucibles. Subsequently, every crucible containing a sample was put into the muffle furnace. For 20 hours, the samples were muted at $550 \text{ }^{\circ}\text{C}$. The crucibles were then left in the desiccator for a short while to cool to room temperature. The ash and crucible were then weighed. The following formula was used to calculate the percentage of ash:

$$\text{Moisture (\%)} = \frac{\text{Weight of crucible with original sample} - \text{Weight of crucible with ash}}{\text{Weight of original sample (wet basis)}} \times 100$$

Data analysis

Data obtained from experimental work was analyzed by Microsoft Office Excel. A one-way ANOVA was performed to check for significant differences (at the 5% level of significance) in proximate composition among different sizes and body portions of tuna fish. Fish size or different body parts were considered independent variables, while nutritional values were considered dependent variables for one-way ANOVA testing.

Results

Proximate composition of the size group ≥ 1 kg

Proximate analysis of the head portion of this size group showed that the proportions of protein, moisture, ash, and lipid ranged from 20.98 to 23.65, 71.45 to 74.86, 1.48 to 1.78, and 2.54 to 3.28, respectively. The middle portion showed the percentage of protein, moisture, ash, and lipid ranged from 22.68 to 24.80, 70.21 to 72.58, 1.54 to 1.82, and 2.96 to 3.45, respectively. The tail portion, on the other hand, exhibited that the percentages of protein, moisture, ash, and lipid ranged from 22.16 to 23.54, 72.44 to 74.41, 1.42 to 1.68, and 1.88 to 2.64, respectively. The average highest percentage of protein (23.69 ± 0.61), ash (1.70 ± 0.09), and fat (3.15 ± 0.17) was found in the middle portion, while the average highest percentage of moisture (73.05 ± 0.65) was found in the tail portion (Table 1). Lipid and protein percentages were found to be significantly higher ($p < 0.05$) in the middle portion compared to the head and tail portions. The lipid percentage was also significantly higher in the head portion than to the tail portion, but

the protein percentage did not vary significantly between the head and tail portions. However, other parameters did not show a significant difference ($p>0.05$) among the body portions of tuna fish.

Table 1. Proximate composition of different body portions of the size group ≥ 1 kg

Body portions	Biochemical parameters			
	Protein	Moisture	Ash	Lipid
Head portion	22.46 \pm 0.81 ^a	73.02 \pm 0.97 ^{ba}	1.61 \pm 0.10 ^a	2.91 \pm 0.21 ^a
Middle portion	23.69 \pm 0.61 ^b	71.46 \pm 0.69 ^a	1.70 \pm 0.09 ^a	3.15 \pm 0.17 ^b
Tail portion	23.06 \pm 0.38 ^a	73.05 \pm 0.65 ^a	1.56 \pm 0.11 ^a	2.33 \pm 0.24 ^c

*Different superscript letters in the same column represent significant difference among the treatments (one-way ANOVA, $p<0.05$)

Proximate composition of the size group ≤ 750 g

For the size group of ≤ 750 g, the percentage of protein, moisture, ash, and lipid of the head portion ranged from 20.88 to 23.15, 72.67 to 74.82, 1.44 to 1.68, and 2.46 to 2.98, respectively. Proximate analysis of the middle portion showed the percentages of protein, moisture, ash, and lipid ranged from 21.68 to 23.88, 71.31 to 74.28, 1.52 to 1.68, and 2.52 to 3.18, respectively. Proximate analysis, on the other hand, for the tail portion of this size group ranged from 21.85 to 23.54, 73.34 to 75.01, 1.35 to 1.62, and 1.68 to 2.65 for protein, moisture, ash, and lipid, respectively. The average highest percentage of protein (22.97 \pm 0.82), ash (1.61 \pm 1.01), and lipid (2.94 \pm 0.22) was calculated from samples of the middle portion, while the highest percentage of moisture (74.01 \pm 0.75) was calculated from samples of the tail portion. Data analysis showed that protein, lipid, and ash percentages were significantly higher ($p<0.05$) in the middle portion, and moisture content was significantly higher in the tail portion ($p<0.05$). On the other hand, protein, moisture, and ash did not show significant ($p= 0.323$, $p= 0.493$, $p= 0.725$, respectively) differences between head and tail portions.

Table 2. Proximate composition of different body portions of the size group ≤ 750 g

Body portions	Biochemical parameters			
	Protein	Moisture	Ash	Lipid
Head portion	22.03 \pm 0.78 ^a	73.73 \pm 0.82 ^a	1.55 \pm 0.09 ^a	2.70 \pm 0.18 ^a
Middle portion	22.97 \pm 0.82 ^b	72.49 \pm 1.01 ^b	1.61 \pm 0.07 ^b	2.94 \pm 0.22 ^b
Tail portion	22.40 \pm 0.49 ^a	74.01 \pm 0.75 ^a	1.50 \pm 0.08 ^a	2.09 \pm 0.25 ^c

Proximate composition of the size group ≤ 500

Proximate analysis of the head portion of this size group showed that the percentage of protein, moisture, ash, and lipid varied between 20.18 and 22.75, 73.3 and 76.29, 1.48 and 1.64, and 1.92 and 2.68, respectively. Analysis of the middle portion of the similar organs varied between 20.68 and 23.28, 72.3 and 75.79, 1.48 and 1.65, and 1.98 and 3.11, respectively. Proximate analysis of the tail portion showed that the percentages of protein, moisture, ash, and lipid ranged from 21.48 to 22.74, 73.61 to 75.25, 1.35 to 1.58, and 1.72 to 2.16, respectively. The average highest protein (22.43 \pm 0.80), ash (1.57 \pm 0.06), and lipid (2.45 \pm 0.36) were found in the middle portion, and the average highest moisture (74.68 \pm 0.62) was observed in the tail portion of the fish samples. The data analysis showed that protein percentage was significantly higher ($p<0.05$) in the middle portion compared to the head and tail portions, while this difference was non-significant ($p= 0.334$) between the head and tail portions. Analysis revealed that the lipid percentage was significantly higher ($p<0.05$) in the head and middle portions, but the difference was non-significant ($p= 0.156$) between the head and middle portions. Moisture content was found to be significantly higher ($p<0.05$) in the tail portion. However, differences of ash content was non-significant ($p>0.05$) among the body portions.

Table 2. Proximate composition of different body portions of the size group ≤ 500 g

Body portions	Biochemical parameters			
	Protein	Moisture	Ash	Lipid
Head portion	21.58±0.76 ^a	74.63±1.03 ^a	1.54±0.06 ^a	2.26±0.26 ^a
Middle portion	22.43±0.80 ^b	73.55±1.13 ^b	1.57±0.06 ^a	2.45±0.36 ^a
Tail portion	21.93±0.45 ^a	74.68±0.62 ^a	1.50±0.08 ^a	1.90±0.16 ^b

Comparison of proximate value among body portions

Data were analyzed to observe the comparative differences among body portions, irrespective of the size of the sampled fish. It had been found that the proportion of protein, moisture, ash, and lipid in the head portion varied from 20.18 to 23.65, 71.45 to 76.29, 1.42 to 1.78, and 1.92 to 3.28 percent, respectively. Analysis of the middle portion showed that the percentages of protein, moisture, ash, and lipid ranged from 20.68 to 24.80, 70.21 to 75.79, 1.48 to 1.82, and 1.98 to 3.45, respectively. On the other hand, proximate analysis of the tail portion revealed that the percentages of protein, moisture, ash, and lipid ranged from 21.48 to 23.54, 72.25 to 75.25, 1.35 to 1.72, and 1.65 to 2.65, respectively. The highest average percentage of protein (23.03±0.91), ash (1.62±0.09), and lipid (2.85±0.39) were calculated from the middle portion, while the highest average percentage of moisture (73.91±0.95) was calculated from the tail portion of the sampled fishes. Data analysis showed a significantly lower ($p < 0.05$) percentage of lipid and protein in the tail portion compared to the middle and head portions, while the middle portion had a significantly higher ($p < 0.05$) percentage of lipid and protein compared to the head portion. However, difference of the proportions of moisture and ash were non-significant ($p > 0.05$) among the body portions.

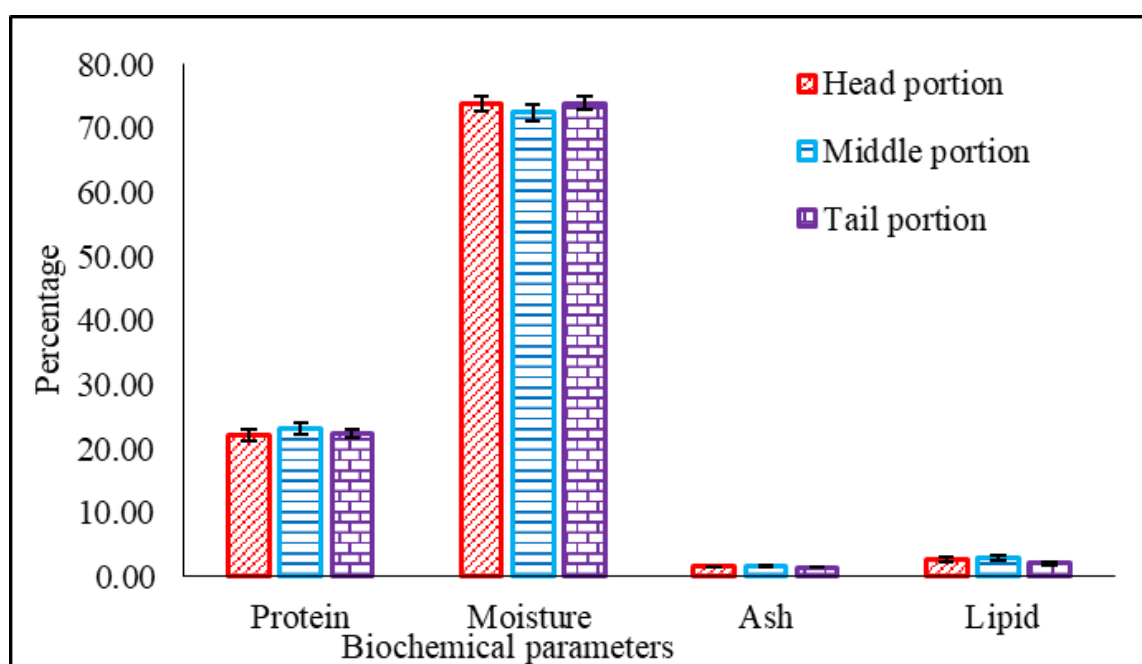


Figure 1. Proximate comparison among different body portions of Tuna

Comparison of proximate value among different size groups

Irrespective of body portions, data were analyzed to reveal the biochemical compositions based on the size groups. In the ≥ 1 kg size group, the percentages of protein, moisture, ash, and lipid ranged from 20.98 to 24.80, 70.21 to 74.86, 1.42 to 1.82, and 1.88 to 3.45, respectively. Proximate analysis of the ≤ 750 g size group showed that the percentages of protein, moisture, ash, and lipid ranged from 20.88 to 23.88, 71.31 to 75.01, 1.35 to 1.68, and 1.68 to 3.18, respectively. For the case of the ≤ 500 g size group, the percentage of protein, moisture, ash, and lipid fell between 20.18 and 23.28, 72.3 and 76.29, 1.35 and 1.65, and 1.65 and 3.11, respectively. The highest average

percentage of protein (23.07 ± 0.82), lipid (2.80 ± 0.41), and ash (1.62 ± 0.12) were calculated in the ≥ 1 kg size group, while the highest average percentage of moisture (74.29 ± 1.07) was found in the ≤ 500 g size group. From the data analysis, it was found that the percentage of all the biochemical parameters significantly differed ($p > 0.05$) among the size groups, except the rate of ash in the ≤ 750 g and ≤ 500 g size groups were found not to differ significantly ($p = 0.5913$).

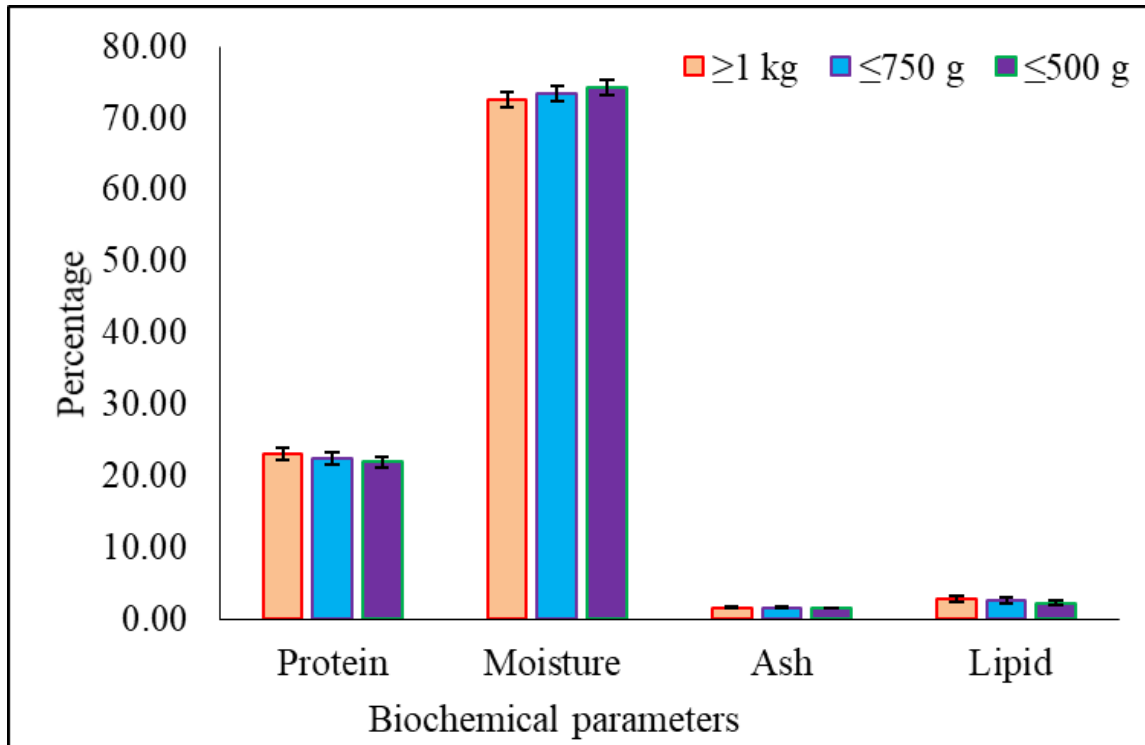


Figure 2. Proximate comparison among different size groups of Tuna

Discussion

Tuna is a source of high-grade protein and omega-3 fatty acids, and the protein content of tuna fish ranges from about 20 to 25% (Karunaratna & Attygalle, 2010; Bahurmiz, 2019). Rani et al. (2016) studied the seasonal variation of the biochemical proportion of tuna fish (*Auxis thazard*) from a fishing harbor on the east coast of India, and they mentioned the average percentage of protein (21.18 ± 0.57), moisture (77.04 ± 0.62), lipid (1.04 ± 0.09), and ash (0.88 ± 0.12). They also mentioned the proximate composition of *Euthynnus affinis*, and the percentages of protein, moisture, ash, and lipid contents were 22.73 ± 0.58 , 75.38 ± 0.46 , 1.03 ± 0.06 , and 0.93 ± 0.11 , respectively. Nurjanah et al. (2015) investigated the changes in the nutritional profile of shipjack tuna due to the frying process and mentioned that fresh shipjack tuna consisted of 71.76% moisture, 25.29% protein, 0.60% fat, 1.49% ash, and 0.87% carbohydrate. Sonavane et al. (2017) worked on Indian Mackerel (*Rastrelliger kanagurta*) and stated that the percentages of moisture, ash, lipid and protein content were 72.24%, 1.42%, 8.19%, and 19.14% respectively. The findings of the current study mostly corresponded with the protein, moisture, and ash percentages as found in the studies stated above. While the lipid content found in the present study was higher than the findings of Rani et al. (2016), but it was found to be significantly lower than the findings of Sonavane et al. (2017).

Numerous studies have been performed on commercially important coastal and marine species to observe their proximate composition and nutritional value. The protein content of *Lates calcarifer* collected from different Coastal of Indian Bay of Bengal were $17.7 \pm 1.02\%$ to $23.5 \pm 1.16\%$, lipid content varied from $3.25 \pm 0.44\%$ to 5.7 ± 0.3 , ash content varied from 3.25 ± 0.16 to $5 \pm 0.24\%$ and moisture content varied from $70 \pm 2.8\%$ to $72.49 \pm 0.27\%$ (Pervin et al., 2012; Kamruzzaman et al., 2015; Siva et al., 2016). Pratap et al. (2020) worked on the proximate composition of *Lates calcarifer* from Sarada and Varasha estuarine confluence point, Andhra Pradesh. According to him, adult

females had an average moisture content of $70.44 \pm 0.45\%$ percent, while adult males had the same of $70.42 \pm 0.72\%$ percent. Adult males had an average protein content of $19.03 \pm 1.12\%$, and adult females had an average protein value of $19.21 \pm 1.02\%$. Adult males had an average lipid percentage of $5.12 \pm 0.24\%$, whereas adult females had an average lipid content of $5.35 \pm 0.32\%$. For adult males, the average carbohydrate content was $0.74 \pm 0.05\%$, and for adult females, it was $0.75 \pm 0.07\%$. Adult males had an average ash percentage of $4.31 \pm 0.13\%$, whereas adult females had an average ash level of $4.36 \pm 0.12\%$. According to Kumaran et al. (2012), mullet (*Mugil cephalus*) caught off the southeast coast of India had an average percentage of moisture content, lipid content, protein content, and crude ash content of 75.27, 2.42, 17.56, and 1.15, respectively.

In the present study, the proximate composition has been studied based on the size (≤ 500 g, ≤ 750 g, and ≥ 1 kg) and body portion (head, middle, and tail) of the tuna *Auxis thazard*. Based on the size, the average percentage of protein, moisture, ash, and lipid was found to vary from 21.98 ± 0.77 to 23.07 ± 0.82 , 72.51 ± 1.10 to 74.29 ± 1.07 , 1.54 ± 0.07 to 1.62 ± 0.12 , and 2.20 ± 0.35 to 2.80 ± 0.41 , respectively. Based on the body portions, the average percentage of protein, moisture, ash, and lipid was found to vary from 22.02 ± 0.87 to 23.03 ± 0.91 , 72.50 ± 1.28 to 73.91 ± 0.95 , 1.52 ± 0.09 to 1.62 ± 0.09 , and 2.10 ± 0.29 to 2.85 ± 0.39 , respectively. The overall findings of the present study revealed that protein content in tuna was significantly higher, but lipid content was found to be a bit lower than that of other commercially important coastal and marine fish. Ash content was also found to be a little bit higher when compared with other species. Such a variation in proximate composition may occur due to several reasons.

Even among the same species of fish, the biochemical characteristics of fish flesh can change based on habitat, age, sex, and fishing season. (Srivastava, 1985; Krishna, 2023) and within different regions of the body (Jacquot, 1961). Bagthasingh et al. (2016) stated that lipid content in sardine *Sardinella gibbosa* is greatly influenced by season and varied from just 1.25 percent in May to a maximum of 6.33% in December. In the present study, seasonal variation had not been studied, but size and body portion were studied, and a significant difference in biochemical parameters was found among different sizes and body portions. It became apparent that the larger fish and middle section of the body had much higher levels of both fat and protein. Moisture content was found to be higher in smaller fish and in the tail portion of the body. According to FAO (1999), moisture and fat levels have an inverse relationship and make up about 80% of the total mass of fish fillets. The remaining 20% is comprised of other ingredients. The inverse association has also been noted in fish species from marine sources such as *Mullus barbatus* (Lloret et al., 2007), *Pseudo sciaenaaneas*, and *Johnius carutta* (Rao & Rao, 2002). In the current investigation, moisture and fat content had an antagonistic relationship.

Proteins have been believed to be the building blocks of all living things. Protein digestion produces amino acids, which are then utilized for generating new protoplasm and cells (Krishna, 2022). According to Krishna (2002), it is the most significant macromolecule in organisms. All of the necessary, easily digestible amino acids are present in fish protein, and the majority of the protein that the fish digests and absorbs is absorbed into its muscles (Dabhade et al., 2009). In this study, the average protein percentage in tuna (*A. thazard*) was calculated to be higher than most of the highly-priced marine fish species. In two different studies, the maximum proportion of protein was found 22.94% (Kamruzzaman et al., 2015) and 23.5% (Pervin et al., 2012) in *L. calcarifer*. Another study reported the highest protein content (22.56%) in Hilsha *T. ilisha* (Begum & Minar, 2012). In the present study, the highest 24.8% protein was calculated in tuna *A. thazard*. Hence, tuna *A. thazard* could be a cheap but prominent source of protein, particularly for low-income people.

Fish primarily store their energy as fats (Love, 1970; Adams, 1999; Tocher, 2003). According to Simpkins et al. (2003), lipid content is a significant predictor of reproductive capacity in certain fish stocks and a credible indicator of future survival in particular species. In the present study, even the smaller-sized tuna *A. thazard* showed a higher percentage of lipoprotein, id than the lipid percentage reported in *E. affinis* and *A. thazard* from the East Coast of India (Rani et al., 2016) and was comparable with the fat content in yellow fin tuna (*Thunnus albacares*) and big eye tuna (*Thunnus obesus*) (Peng et al., 2013). The higher lipid content in the middle portion might be attributed to the larger skin area, as most of the fat remains attached to the hypodermis of the skin, and for the same reason, larger fish had a higher fat content. Therefore, *A. thazard* found on the coast of Bangladesh could be a good source of fat in the diet.

Ash is a measurement of the mineral content of any food, including fish, according to Omotosho et al. (2011). It is well known that, even within the same region, fish migration patterns, feeding habits, growing fish size or length (Hassan, 1996), season, environment, ecosystem, and environment all affect the concentration of minerals and trace elements that make up fish total ash content (Andres et al., 2000; Canli & Atli, 2003; Abadallah, 2007).

Due to moisture absorption and loss of protein, the ash content fluctuates over the course of storage (Hassan et al., 2013). As a result of having more bone than flesh, smaller fish species have higher ash contents (Daramola et al., 2007). In the present study, higher ash content was found in the ≥ 1 kg size group of *A. thazard* than smaller groups, and in the middle portion of fish compared to head and tail portions.

Conclusion

Tuna is an excellent source of high-quality protein and omega-3 polyunsaturated fatty acids, which is why it is popular with consumers in many countries around the world. In Bangladesh, tuna is less popular and sells out at a low price in the markets of coastal districts. But the proximate composition of tuna in this research revealed that the tuna *A. thazard*, irrespective of size and body portions, contains a substantially higher amount of protein and fat than many commercially important coastal and marine fish species. Therefore, it is important to raise public awareness about the nutritional value of tuna, and this will help people consume sufficient protein in their diet at a relatively low cost. The findings of this study will also deliver a message to the feed industry owners to use tuna as a source of cheap protein in artificial feed manufacturing for the fish and poultry sectors of the country. Further study on the fatty acid profiling and identification of vitamins and minerals in tuna available in Bangladesh will increase its use across a broader spectrum.

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Conflict of Interest

None of the authors present any conflicts of interest.

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