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Spatial variations in the nutritional profiles of young, spent, ripe or gravid hilsa (*Tenualosa ilisha*) flesh and eggs

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ABSTRACT

Hilsa (*Tenualosa ilisha*) being called as 'Machcher-Raja' or 'The King of Fish' has been designated as national fish of Bangladesh. Hilsa is a popular fatty fish containing health beneficial omega-3 PUFAs and rich in other essential nutrients. It plays a significant role in the food, nutrition, culture, cuisine and economy of Bangladesh. The nutritional composition of fish varies greatly from species to species and within the species, depending on age, feed intake, physical activity, sex and sexual changes connected with spawning, environment or geographical localities and season. The present study was designed with an objective to see the spatial changes in proximate composition of mature female hilsa in different stages of life cycle like without eggs (young or spent) and with eggs (ripe or gravid), flesh and eggs during its anadromous migration from the Bay of Bengal to Meghna river. Marine and riverine hilsa were procured from the coast of Bay of Bengal (Chittagong), Payra river (Patuakhali), Kirtonkhola river (Barisal), and Meghna river (Chandpur) respectively. Moisture, crude protein, crude fat and ash content of hilsa sample were estimated using the oven dry, Kjeldahl and Soxhlet method respectively. The ash content was determined by incinerating the dried samples contained in the crucibles in a muffle furnace at 550-600°C for about 6-8 hrs without pre-ashing. The results showed that in mature/young or spent hilsa flesh the moisture content were 64.74%, 61.12%, 63.80% and 65.58% respectively. The protein values were 17.20%, 19.60%, 16.68%, 17.09% respectively. The fat content followed a gradual decrease with 16.07%, 16.94%, 15.24%, 14.43% values respectively and ash percentage were 1.10%, 1.20%, 2.81%, 2.19% respectively. On the contrary, in ripe or gravid hilsa, the moisture content showed decreasing trend with 67.26%, 67.16%, 64.89% and 62.48% respectively. In contrast to moisture, very high protein and fat values with a gradual increase were estimated and observed as 15.74%, 16.29%, 18.07%, 19.44% and 14.38%, 13.84%, 14.67%, 14.33% respectively and ash percentage were 1.01%, 1.23%, 1.28%, 2.45% respectively. In hilsa eggs, the moisture content declined with upward migration and recorded as 65.97%, 68.01%, 62.71% and 62.56% respectively while protein and fat values increased as 13.56%, 15.09%, 15.56%, 15.62% and 16.83%, 14.77%, 18.16%, 18.23% respectively and ash percentage were 2.67%, 1.26%, 2.55%, 2.67% respectively. The proximate composition of hilsa flesh varied quite widely between spent or young and ripe or gravid hilsa of marine and riverine catches during their anadromous migration. The study also revealed that hilsa eggs are valuable nutritional element with higher protein fat and ash contents. It is thus concluded based on lipid content, both flesh and eggs could be used as decent source to nutrition. These results suggest that the proximate composition of hilsa species varies with the stages of maturity.

Key words: Proximate composition, young/spent hilsa, ripe/gravid hilsa, hilsa flesh and eggs, spatial variation

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INTRODUCTION

Bangladesh possesses huge open water resources including both marine and riverine waters abundant in hilsa (*Tenualosa ilisha*), considered as a blessing for this country. It is called *'Machcher-Raja*, The King of Fish' and designated as national fish of Bangladesh. Hilsa is preferable and

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nutritionally unique because of having polyunsaturated fatty acids (PUFAs), especially omega-3 PUFAs which are significant in curing cardiovascular and other important human diseases. Hilsa is also rich in all other essential nutrients and due to its distinctive flavor and taste hilsa gained international fame and Bangladeshis feel proud worldwide. Besides, hilsa eggs are also popular as side dish. In addition, hilsa play critical role in culture and religions of Indian sub-continent particularly in Bengali New Year, Lakshmi and Saraswati Puja. In terms of production and quality exported, hilsa plays a significant role in the economy of Bangladesh. More than 10% of the country's total fish production comes from hilsa. Hilsa contributes a total of 346512 MT (Inland 114475 MT and Marine 232037 MT) in 2011-12 (FRSS, 2013). About 40% fishermen or 2% of total population of the country earn their livelihood depending on hilsa fishery directly or indirectly. Moreover, it is also notable for a lot of export earnings. From these points of view, as a single species hilsa is important economically in an agricultural country like Bangladesh.

Proximate composition generally comprises the estimation of moisture, protein, fat and ash contents of the fresh fish body. The percentage composition of these constituents accounts for about 96-98% of the total tissue constituents in fish (Nowsad, 2007). The measurement of proximate composition such as moisture, protein, lipid, ash and fibre content in fish is often necessary to ensure that they meet the requirements of food regulations in nutrition aspects and commercial specifications (Watermann, 2000). The assessment of the proximate composition of the fish is not only important to know its nutritive value, but also for its better processing and preservation (Mridha, 2005). The percentage of water is good indicator of its relative contents of energy, proteins and lipids. Carbohydrates and non-protein compounds are also important constituents but are present in small amounts and are usually ignored during analysis (Cui and Wootton 1988, Love 1980).

Proximate composition is used as an indicator of fish quality; it varies with diet, feed rate, genetic strain and age (Austreng and Refstie, 1979). The nutritional composition of fish varies greatly from one species and individual to another, depending on age, feed intake, physical activity, sex and sexual changes connected with spawning, the environment or geographical localities and season (Weatherley and Gill 1987). Their values however, vary considerably within and between species, and also with size, sexual condition, feeding, time of the year and physical activity (Ali et al., 2005). Furthermore, the variations in proximate composition of fish are closely related to the feed intake and the water where they live. The processor, the nutritionist, the cook and the consumer all have a direct interest in the composition of fish in order to know the nature of the raw material before chilling, freezing, smoking or canning can be correctly applied (FAO, 2004). Consumers have often wanted to know if there are nutritional differences in various fish species from different sources. This can only be answered through the proximate analysis of various fish species from different sources.

Hilsa (locally called illish) is fatty fish and provide valuable fatty acids which play a significant role in human health particularly in reducing coronary heart diseases, stroke, hypertension, diabetes, brain development, cancer and depression. Quantity of lipid and fatty acid (FA) composition of fish is acknowledged to change between and within the species (Sevim, 2010; Haliloglu et al., 2002). The quantity of Lipid Containing (LC) ω-3 PUFAs vary between species and based on some factors such as habitat, size, age, the stage of maturity, geographical location, salinity temperature, reproductive cycle, season and self-regulation of FA synthesis are thoughts to be main factor (Inhamuns and Franco, 2008; Freites et al., 2002). However fish nutrients are affected to substantial environmental transformation throughout the year and variations in compositions and availability of feed also affects their proximate composition of muscle. It has been accounted that in fish muscle the category and quantity of FA differ mostly by feeding of the fish (Vergara et al., 1999).

Hilsa is anadromous in nature and migrates annually from its ideal residence The Bay of Bengal to deltaic rivers for spawning purposes. Though hilsa is commonly available in many southern districts of Bangladesh, most riverine catches are netted at landing platforms within just two: the Barisal and the Chandpur district, respectively located on the west and east bank of the Meghna. The marine catches are landed in the coastal cities of Chittagong and Cox's Bazar. Fishes from riverine catch is considered to be tastier than those from marine catch (Nowsad, 2012). So there might be variation in nutrients such as proximate composition between marine and riverine catches during pre- and post-spawning (mature/young and spent) condition. Precise information on biochemical composition is useful not only for developing nutrient-balanced, cost-effective human diets, but also for the purpose of post-harvest processing and storage of hilsa and hilsa products for their export and other important means for medicine, specific storage techniques and for industries. Although several studies on the biochemical composition of many commercially important fishes have been reported from many countries of the world, no systematic investigation had so far been made on the nutritive values and biochemical composition of the hilsa stock of Bangladesh during anadromous migration from marine to riverine environment. Considering the above phenomena, the present study was designed with an objective to see the spatial changes in proximate composition of female without eggs (mature/young or spent) and with eggs (ripe or gravid) hilsa flesh and eggs during its anadromous migration from Bay of Bengal to Meghna river.

MATERIALS AND METHOD

Sampling site

Marine and riverine hilsa shad were procured from the coast of Bay of Bengal (Chittagong), Payra river (Patuakhali), Kirtonkhola (Barisal), and Meghna river (Chandpur) respectively.

Fish species sampled

Spent or young and ripe or gravid *Tenualosa ilisha* from each study area were purchased for this study. Sex was determined as per Shafi et al. (1977). Externally, female fish were broader with comparatively larger girth, urogenital opening of the gravid females were flat.

Sample collection and preservation

The raw fish samples were purchased directly from local fisherman and landing centers during January–February, 2014. The samples were packed in separate polyethylene bags to avoid any type of microbial contamination; appropriately labeled, preserved in iced condition (<4°C) in an insulated Styrofoam box and transported immediately to the laboratory and stored in a freezer (at -20°C appox.) until required for analysis.

Sample preparation

Length and weight measurements were made on individual fish, and the mean reported. Prior to analysis, fins and scales of each fish specimen were removed; fish samples were washed thoroughly with distilled water and dressed according to Standard Operating Procedure (Crissey & Spencer, 1998). The muscle tissues (fillet) of each hilsa were obtained manually by cutting the fish using a sharp knife across the body near the gills, along the ventral edge from the gills to the tail and finally across the body near the tail. Care was taken that the cuts were not deep enough to penetrate the egg and viscera. The skin and any bony elements (including pin bones) were removed and fillets were also cut into small pieces and ground with mortar and pestle and then the raw muscle tissues were finely minced and homogenized using a grinder for 2 min at high speed under ambient conditions. The minced muscle tissue and eggs were subsequently used for chemical analysis following standard protocol.

Laboratory analysis

Determination of proximate composition

Triplicate determinations were carried out on each chemical analysis and mean values with standard deviations are showed in the Table 1 & 2.

Moisture content

The moisture content of each hilsa sample was estimated using the oven dry method (AOAC, 1994).

$$\% \text{ of Moisture} = \frac{Weight\ loss}{Original\ weight\ of\ the\ sample\ taken} \times 100$$

Crude fat or total lipid

Crude fat was determined with the help of Soxhlet apparatus.

$$\% \text{ Fat} = \frac{Wf - Wt}{Ws - Wt} \times 100$$

Where,
Wt = Weight of thimble

Ws = Weight of thimble + sample (before extraction)
Wf = Weight of thimble + sample (after extraction)

Crude protein

Crude protein content was calculated by using nitrogen content obtained by Kjeldahl method. A conversion factor of 6.25 was used for calculation of protein content (Anonymous, 1992).

Calculation: Then the amount of nitrogen was calculated according to the following equation:

$$\% \text{ Total Nitrogen} = \frac{(Ts - Tb) \times N \times 0.014}{Sw} \times 100$$

Where,
T_s = Titre (Titer) value of the sample in ml
T_b = Titre (Titer) value of the blank in ml
N = Strength of the HCl (0.1 N HCl)
S_w = Weight of the sample in g.

Then the percent crude protein present in the sample was obtained by multiplying the percent of nitrogen of the sample with an empirical factor 6.25 for the fish as follows:

% Crude protein = % Total Nitrogen × 6.25

Ash (Mineral) content

About 2-3 g of dried fish samples were taken in tared porcelain crucibles and the ash content was determined by incinerating the dried samples contained in the crucibles in a muffle furnace at 550-600°C for about 6-8 hrs without pre-ashing. Then the crucibles were cooled, kept for few minutes in the desiccators and weighed. The difference in weight of the fish samples before and after heating was taken as the ash content. From the weights recorded the percent ash content was calculated using the following formula:

$$\% \text{ of Ash content} = \frac{Wi - Wf}{Wi} \times 100$$

Where,
Wi = Initial weight of sample (before ashing)
Wf = Final weight of ash sample (after ashing)

Statistical analysis

Data collected were subjected to one way analysis of variance (ANOVA) and statistical comparisons between treatments were made by the Tukey honest significant difference (HSD) test using SPSS version 12.0 software for Windows (SPSS Inc. Chicago, IL, USA). The significance of observed differences was tested at $P < 0.05$.

RESULTS AND DISCUSSION

The annual spawning migration is an essential part of the life history of hilsa. A mature hilsa shad with a length ranging from 30-55 cm lays 0.1-2.0 million eggs; the eggs are deposited in fresh water. The upstream migration starts during the main breeding season depends largely on the commencement of the south-west monsoon and consequent flooding of the major rivers of Bangladesh, Burma and India. The migration of hilsa shad from the Bay of Bengal is triggered by the increase in the flow of freshwater from the Meghna river. The massive inflow of freshwater into the Bay of Bengal lowers the salinity in a particular stretch of the Bay of Bengal which may extend deep into the bay. This low salinity path is the ecological trigger that initiates the spawning migration of hilsa shad. The hilsa shad seeks the freshwater path and reaches the river mouth from where it moves upstream to the upper reaches of the river Meghna. The Meghna hilsa reaches up to the Meghna river estuary. They breed upstream in freshwater, the larvae hatch from the free-floating eggs, and immature young stages grow in river channels then descend to the sea, and finally return to the same river as mature breeding adults to complete the cycle. For the convenience of presentation, the results obtained from the present study are presented in Tables and Figures.

Changes in proximate composition

Proximate composition of spent or young and ripe or gravid hilsa flesh

The changes in the proximate composition of the flesh of mature female without eggs and ripe or gravid hilsa during anadromous migration from marine to riverine environment are presented in Table 1 and Figure 1

The moisture content of hilsa flesh during migration from The Bay of Bengal to Meghna river was varied quite widely and moisture content was recorded to be above 50% in all samples analyzed.

Table 1
Changes in the proximate composition of spent or young and ripe or gravid hilsa flesh during anadromous migration from marine to riverine environment during lean period (January-February'14) in Bangladesh.

Proximate composition of hilsa flesh	Marine		Riverine					
	Bay of Bengal, Chittagong		Payra river, Patuakhali		Kirtonkhola river, Barisal		Meghna river, Chandpur	
	Spent/ young hilsa	Ripe/ gravid hilsa	Spent/ young hilsa	Ripe/ gravid hilsa	Spent/ young hilsa	Ripe/ gravid hilsa	Spent/ young hilsa	Ripe/ gravid hilsa
Moisture (%)	64.74 ± 0.45	67.26 ± 0.58	61.12 ± 1.53	67.16 ± 0.64	63.80 ± 0.99	64.89 ± 0.71	65.58 ± 0.87	62.48 ± 0.54
Protein (%)	17.20 ± 0.06	15.74 ± 1.31	19.60 ± 0.07	16.29 ± 0.31	16.68 ± 0.98	18.07 ± 0.50	17.09 ± 0.44	19.44 ± 0.16
Fat (%)	16.07 ± 1.19	14.38 ± 1.85	16.94 ± 0.38	13.84 ± 0.26	15.24 ± 0.70	14.67 ± 0.41	14.43 ± 1.55	14.33 ± 1.29
Ash (%)	1.10 ± 0.09	1.01 ± 0.02	1.20 ± 0.15	1.23 ± 0.03	2.81 ± 0.25	1.28 ± 0.18	2.19 ± 1.0	2.45 ± 1.01

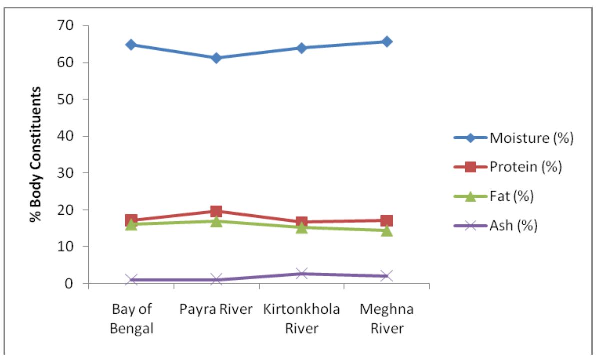

Figure 1
Variation in the proximate composition of spent or young hilsa flesh during anadromous migration.

During periods of heavy feeding, the protein content of muscle tissue increases slightly at first and then the fat content might show a marked and rapid increase. On the other hand, fish may have starvation periods for natural or physiological reasons (spawning or migration) or because of external factors such as shortage of food. In that case, fat content gradually decreases and then a decline in protein may also be seen (Huss, 1988; 1995).

In the present study, the protein content was slightly higher in the flesh of Payra river hilsa (19.60%) when compared to Bay of Bengal hilsa (17.20%) and protein percentage continues to increase during migration to upstream rivers. However, the protein content was noted to be lowest (16.68%) in mature hilsa flesh of Kirtonkhola river in the present study. The gain of protein may occur for changing their habitat as well as feeding habit.

There was enormous variation in the fat content of mature female hilsa during its anadromous migration and followed a gradual decrease. The fat value was reported to be highest in the flesh of Payra river hilsa (16.94%) and lowest in Meghna river hilsa (14.43%). This might be due to that fat are being used for development of eggs with the course of migration. On the contrary, fat of Bay of Bengal hilsa was little less than Payra river hilsa and representing almost similar value (16.07%). The lower percentage of water, greater lipids, protein contents and higher energy density present in the fish. Fat content decrease in spawning period is due to mobilization of fat related to gametogenesis (Sharer, 1994; Bandarra et al., 1997). Saha and Guha (1939) on their study estimated 19.4% fat in hilsa which is very far from our findings.

Ash content showed increasing trend during anadromous migration and interestingly ash of Kirtonkhola river hilsa (2.81%) was found highest followed by Meghna river hilsa (2.19%), Payra river hilsa (1.20%) and Marine hilsa (1.10%). Saha and Guha (1939) found the Ash content of *T. ilisha was* 2.27% which is nearer to the result of ours. Mazumder et al. (2008) in *A. coila* and in *A. mola* also find similar ash percentage varied within 1.6% to 3.2%.

The result more or less coincide with the findings of Minar et al., (2012) who recorded moisture, protein, fat and ash percentage (%) was 66.04 ± 0.3, 18.68 ± 0.27, 24.39 ± 0.19 and ash 1.89 ± 0.06, respectively and Shamim et al., (2011) analyzed protein content was 20.56, 21.89, 20.29, 21.33, 20.87 and 20.50% in dorsal portion (Chittagong region), ventral portion (Chittagong region), caudal portion (Chittagong region), dorsal portion (Khulna region), ventral portion (Khulna region) and caudal portion (Khulna region), respectively. Similarly, the fat content was recorded 18.66, 20.28, 19.71, 18.65, 19.15 and 19.00%. The percentage of ash content was highest (1.55) in ventral portion and lowest in dorsal portion (1.03) of fish body from the Khulna region. The difference in fat and protein content might be because of different catching locations as environmental conditions might cause dramatic variations among the same species living in different locations. In this study considerably higher fat and lower protein contents were observed in hilsa which are in agreement with fluctuations reported by Bandarra et al. (2001). Other components including water and mineral are in good agreement with those reported previously by these researchers.

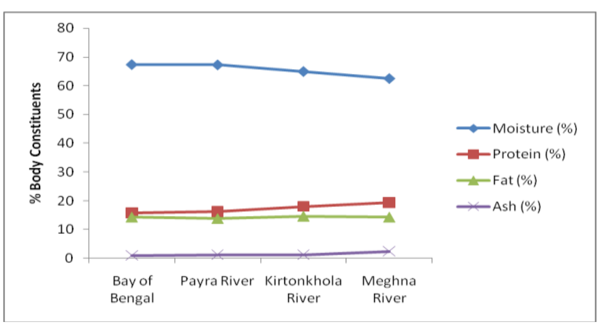

Figure 2
Variation in proximate composition of ripe or gravid hilsa flesh during anadromous migration.

On the other hand, moisture content of ripe or gravid hilsa (mature female with eggs) flesh decreased gradually during migration from Bay of Bengal to the spawning ground in the river. The highest moisture value (67.26%) was found in hilsa flesh of Bay of Bengal, while the lowest (62.48%) was observed in Meghna river. The Payra river hilsa exhibited almost similar result (67.16%) with marine hilsa and surprisingly a sudden decrease (64.89%) observed in Kirtonkhola river hilsa in comparison to hilsa of Payra river and Bay of Bengal. Reduction in moisture percentages may occur because of the accumulation of other relative nutrients required for growth of egg composition.

Protein content of gravid hilsa increased gradually, opposite to moisture content while migrating from marine to riverine habitat. The protein content was slightly higher in the flesh of Payra river hilsa (15.74%) than Bay of Bengal hilsa (16.29%) which was the lowest value. However, the protein content was increased remarkably in Kirtonkhola river hilsa (18.07%) and continued to increase up to (19.44%) in Meghna river hilsa which is the highest value. Likewise protein, ash content also followed gradual increase in gravid hilsa flesh. The present investigation indicates that ash content varied significantly and falls within the range of 1.01 to 2.45% from Bay of Bengal to Meghna river hilsa. The ash percentage of Payra and Kirtonkhola river hilsa were almost nearer and were 1.23% and 1.28% respectively.

However, fat content of hilsa also varied during its anadromous migration. The fat percentage in the Bay of Bengal and Payra river hilsa was 14.38% and 13.84% respectively. Our results suggest that hilsa gains significant fat content throughout upward migration. This is in contrast to other anadromous fishes which accumulate fat in the marine environment and do not feed during their upward migration. Hilsa, being a migratory fish, lipid content varies widely which is evident from the present results. Report shows that the fat content in hilsa of medium size group is 16.35% (Mohanty et al., 2011) which is a little less from the present values. The fat content increased to 14.67% in Kirtonkhola river hilsa. The increase in lipid content during monsoon indicates that the fishes are in mature condition. Hilsa must accumulate energy reserves during their growth phase in the form of lipids, required to provide the energy necessary for anadromous migration and spawning and then proceed upwards into the river Meghna. When animals start migration their fat content is found to be higher (Krapu et al., 1985). On the other hand, fat decreased in Meghna hilsa (14.33%). The Meghna hilsa showed decreasing fat content with time. This can be explained to the consumption of enormous amounts of energy during the migratory movement. These studies favorably fit with Uysal and Aksoylar, (2005); Cejas et al., (2003); Agren et al., (1987) who observed the most significant variation in total FA and lipid content of fish during the reproduction time, at this stage the collected lipids with further dietary components for example vitamins, minerals and proteins from visceral organs, muscle and liver that are transferred to the gonads as a result, the dietary value of flesh may decrease through gonadal development. Jonsson et al., (1997) reported a decrease in lipid content during the course of upward migration of Atlantic salmon. Body lipid decreased by 30-40% during the period of reentry of Arctic Charr to freshwater from sea and the female fish lost 80% of their body lipids during spawning (Josrgensen *et al*., 1997). In several earlier investigations it had been pointed out that the moisture has an inverse relationship with the fat content (Brandes and Dietrich, 1958) which was clearly seen in the present study. The findings of the present investigation also favor with that of Chandrashekar et al., (2004). Generally moisture content shows inverse relationship with lipid content. The inverse relationship has also been reported in marine fishes such as *Mugil cephalus* (Das, 1978). Jacquot (1961) in his experiment found that fatty fish contained 68.6% moisture, semi fatty fish contained 77.2% and lean fish contained 81.8% moisture which showed the inverse relationship between fat and moisture content. The results obtained are in partial agreement with that previously reported by Guner *et al*. (1998). Guner *et al*. (1998) reported that fat content of shad is 15.91% which is higher than what was found in our study. The protein content of shad is reported to be 22.42% by Guner et al. (1998), which is higher than the result obtained in this study. Related results are also in line with Ozyurt and Polat, 2006; Aro et al., 2000; Saito et al., 1999 who found the change in type and quantity of FA in muscle with respect to season, age and size of the fish, geographical place and the maturity period. Piggott (1990) and Tsuchiya (1961) also reported that fat contents vary in fish with season, species and geographical region. Age variation and stage of maturity in the same species contributed significantly to the level of total lipid contents**.** Changes in water and fat indicate that while there was a decline in water content, fat content evidently increased due to heavy feeding during this period, which is in good agreement with previously reported results by Huss (1988; 1995). Nevertheless, studies of Gunther et al. (2007) partially confirm our findings showing that the moisture contents decreased, while protein, lipids, ash and phosphorous increased as weight of lake trout and hybrid F1 (lake trout × brook trout) increased. Oduor-Odote et al. (2008) also found that lipids in fish vary greatly which is related to feed intake, migratory swimming or sexual changes in connection with spawning. Higher lipids may be due to preparation for spawning.

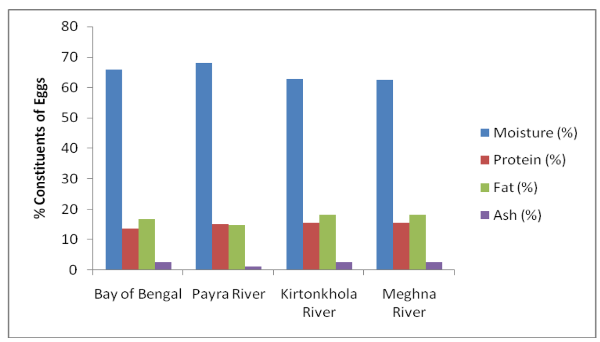

Figure 3
Variation in proximate composition of hilsa eggs collected from four different sources of Bangladesh.

Table 2
Proximate composition of hilsa eggs between marine to riverine environment during lean period (January-February'14) in Bangladesh.

Proximate composition of hilsa eggs	Marine	Riverine		
	Bay of Bengal, Chittagong	Payra river, Patuakhali	Kirtonkhola river, Barisal	Meghna river, Chandpur
Moisture (%)	65.97 ± 0.14	68.01 ± 0.79	62.71 ± 1.9	62.56 ± 0.02
Protein (%)	13.56 ± 0.11	15.09 ± 1.28	15.56 ± 0.57	15.62 ± 0.75
Fat (%)	16.83 ± 1.09	14.77 ± 0.40	18.16 ± 0.74	18.23 ± 1.38
Ash (%)	2.67 ± 0.35	1.26 ± 0.63	2.55 ± 1.05	2.67 ± 0.98

Proximate composition of hilsa eggs

The changes in the proximate composition of hilsa eggs during anadromous migration from marine to riverine environment are depicted in Table 2 and Figure 3.

We also studied proximate composition of hilsa eggs collected from four different locations of Bangladesh particularly from important marine and riverine sources. Our study revealed that, moisture content changed remarkably among eggs of different regions from 62.56 to 68.01%. The Bay of Bengal hilsa was found to contain 65.97% moisture, whereas moisture of Payra river, Kirtonkhola river and Meghna river hilsa was 68.01%, 62.71% and 62.56% respectively.

Greater variations observed in protein content of eggs between marine and riverine hilsa. Protein content of riverine hilsa eggs increased significantly in contrast to marine hilsa eggs. Maximum protein content was estimated in the eggs of Meghna river hilsa (15.62%) and minimum found in Bay of Bengal hilsa (13.56%). The Protein percentage increased gradually in Payra river and Kirtonkhola river hilsa eggs and reported to be 15.09 and 15.56% respectively.

Likewise protein, fat content also increased gradually in riverine hilsa eggs than marine one. Although lowest fat observed in Payra river eggs (14.77%), higher proportions of fat observed in Meghna river hilsa eggs (18.23%) representing their maturity for spawning. The results obtained are in partial agreement with Pal et al., (2011) who recorded the lipid of eggs was 1.2 times higher than that of the muscle tissue. However, fat in Kirtonkhola river hilsa eggs was 18.16% which was very close to highest value, and higher than Bay of Bengal hilsa eggs (16.83%) suggesting that riverine hilsa eggs are very nutritive when it comes to fat content and importance of fatty acids especially ω-3 PUFAs need no further explanation. So from nutritional point of view, our present study suggests that Hilsa eggs are rich in essential nutrients for human being compared to hilsa flesh.

It was found that, ash content of hilsa eggs were also higher than that of hilsa flesh from both marine and riverine sources. Ash of Bay of Bengal, Payra river, Kirtonkhola river and Meghna river hilsa eggs were estimated as 2.67%, 1.26%, 2.55% and 2.67% respectively which are far more than ash of hilsa flesh from those sources also suggesting the superiority of hilsa eggs than hilsa flesh in relation to ash content. Therefore, in view of these facts, hilsa eggs might be an interesting alternative and potential source of nutrition.

Our results are in agreement with previously reported research carried out by Barua and Chakraborty, (2011). During their analysis of Proximate composition of the *Piaractus brachypomus* eggs, they found 62.78±0.01% water, 39.05±2.93% crude protein, 36.56±0.56% Crude fat, 15.25±0.37% ash, 3.72±0.04%. The crude fat content in the eggs was significantly high, but with less crude protein compared to the body composition.

To sum up, Meghna river hilsa can be grouped as fatty fish and the delicate taste of the fish can be attributed to its high fat content in the flesh and egg as reviewed by Nowsad et al. (2012). Fat content is found to vary with period of migration of the hilsa and this might be the reason for the different average fat values (7.5% to 26.93%) reported in *T. ilisha* by several researchers who might have sampled the fish at different times of migration (Pillay and Rosa, 1963; Chandrasekhar and Deosthale, 1994; Rahman et al., 1999; Majumdar and Basu, 2009).

CONCLUSION

The proximate composition of hilsa flesh varied quite widely between mature/young or spent and ripe or gravid hilsa of marine and riverine catches during their anadromous migration. The study revealed that hilsa eggs are valuable nutritional element with higher protein fat and ash contents. It is thus concluded that based on lipid content, the flesh and egg could be used as a decent source to extract the fish lipid. These results also suggest that the proximate composition of this fish species greatly varies due to physiological reasons and changes in environmental conditions, i.e., stage of maturity and feeding condition.

REFERENCES

Agren J, Muje P, Hanninen O, Herranen J and Penttila I (1987). Seasonal variations of lipid fatty acids of Boreal freshwater fish species. Comparative Biochemistry and Physiology, 88: 905–909.

Ali M, Eqbal F, Salam A, Iram S and Athar M (2005). Comparative study of body composition of different fish species from brackish water pond. International Journal of Environmental Science and Technology, 2: 229-232.

Anonymous (1992). Official methods and recommended practices, 4th edition, AOCS. Champaign, Illinois, USA.

AOAC (1994). Official methods of analysis of the association of official analytical chemists, Vols. I & II, Association of Analytical Chemists, Arlington. pp. 1298.

Aro T, Tahvonen R, Mattila T, Nurmi J, Sivonen T and Kallio H (2000). Effects of season and processing on oil content and fatty acids of Baltic herring (*Clupea harengus membras*). Journal of Agricultural and Food Chemistry, 48: 6085–6093.

Austreng E and Refstie T (1979). Effect of varying dietary protein level in different families of rainbow trout. Aquaculture, 18: 145–156.

Bandarra NM, Batista I, Nunes ML and Empis JM (2001). Seasonal variation in the chemical composition of horse mackerel (*Trachurus trachurus*). European Food Research Technology, 212: 535-539.

Bandarra NM, Batista I, Nunes ML, Empis JM and Christie WW (1997). Seasonal changes in lipid composition of sardine (*Sardina pilchardus*). Journal of Food Science, 62: 40-42.

Barua P and Chakraborty S (2011). Proximate composition of egg, stomach content and body composition of Pacu (*Piaractus brachypomus*) collected from aquatic environment of Bangladesh. Current Biotica, 5(3): 330-343.

Brandes CH and Dietrich R 1958: Observation on the correlation between fat and water content and the fat distribution in commonly eaten fish. Veroff Institute Meeresforsch, Bremerh, 5: 299-305.

Cejas JR, Almansa E, Villamandos JE, Badia P, Bolanos A and Lorenzo A (2003). Lipid and fatty acid composition of ovaries from wild fish and ovaries and eggs from captive fish of white sea bream (*Diplodus sargus*). Aquaculture, 216(1–4) 299–313.

Chandrashekar A, Rao P and Abidi AB (2004). Changes in muscle biochemical composition of *Labeo rohita* (Ham.) in relation to season. Indian Journal of Fisheries, 51 319-323.

Crissey SD and Spencer BS (1998). Handling fish fed to fish-eating animals. United States Department of Agriculture: A manual of Standard Operating Procedures. Available Online at http://www.nal.usda.gov/awic/pubs/fishhndl.htm

Cui Y and Wootton RJ (1988). Effects of ration, temperature and body size on the body composition, energy content and condition of Minnow (*Phoxinus phoxinus*). Journal of Fish Biology, 32: 749-764.

Das HP (1978). Studies on the Grey Mullet, *Mugil cephalus* (Linnaeus) from the Goa waters. Ph.D thesis submitted to university of Bombay, pp. 223.

FAO (Food and Agricultural Organization) 2004: The composition of fish, pp. 1-80.

Freites L, Fernandez-Reiriz MJ and Labarta U (2002). Fatty acid profiles of *Mytilus galloprovincialis* mussel seeds of subtidal and rocky shore origin. Comparative Biochemistry and Physiology, 132: 453–461.

FRSS (2013). Fisheries statistical yearbook of Bangladesh. Fisheries Resources Survey System (FRSS), Department of Fisheries, Bangladesh, Volume 29 pp. 44.

Guner S, Dincer B, Alemdag N, Colak A and Tufekci M (1998). Proximate composition and selected mineral content of commercially important fish species from the Black Sea. Journal of the Science of Food and Agriculture, 78 337-342.

Gunther JS, Moccia DR and Bureau PD (2007). Growth and whole body composition of lake trout (*Salvelinus namaycush*), brook trout (*Salvelinus fontinalis* x *Salvelinus namaycush*) from first-feeding to 16 weeks post first-feeding. Aquaculture, 249: 195–204.

Haliloglu HI, Aras NM and Yetim H (2002). Comparison of muscle fatty acids of three trout species rainbow trout, (*Salvelinus alpinus, Salmo trutta fario, Onchorhynchus mykiss)* raised under the same conditions. Turkish Journal of Veterinary and Animal Sciences, 26: 1097–1102.

Huss HH (1988). Fresh fish: quality and quality changes. FAO, Rome, Italy, pp. 132.

Huss HH (1995). Quality and quality changes in fresh fish. FAO, Rome, pp. 348.

Inhamuns AJ and Franco MRB (2008). EPA and DHA quantification in two species of freshwater fish from central Amazonia. Food Chemistry, 107: 587-591.

Jacquot R (1961). Organic constituents of fish and other aquatic animal foods. Fish as Food, Vol-1, Academic Press.

Jonsson N, Jonsson B and Hansen LP (1997). Changes in the proximate composition and estimates of energetic costs during upstream migration and spawning in Atlantic salmon (*Salmo salar*). Journal of Animal Ecology, 66: 425-436.

Josrgensen EH, Johansen SJS and Jobling M (1997). Seasonal patterns of growth, lipid deposition and lipid depletion in anadromous Arctic charr. Journal of Fish Biology, 51: 312-326.

Krapu GL, Iverson GC, Reinecke KJ and Boise CM (1985). Fat deposition and usage by arctic-nesting sandhill cranes during spring. Auk, 102: 362-368.

Love RM (1980). The chemical biology of fishes. Academic Press, II, London, UK.

Majumdar RK and Basu S (2009). Studies on seasonal variation in the biochemical composition of the Indian shad, *Tenualosa ilisha* (Hamilton 1822). Indian Journal of Fisheries, 56: 205-209.

Mazumder MSA, Rahman MM, Ahmed ATA, Begum M and Hossain MA (2008). Proximate composition of some small indigenous fish species (SIS) in Bangladesh. International Journal of Sustainable Crop Production, 3(3): 18-23.

Minar MH, Adhikary RK, Begum MM, Rakeb-Ul Islam M and Akter T (2012). Proximate composition of hilsha (*Tenualosa ilisha*) in laboratory condition. Bangladesh Journal of Progressive Science & Technology, 10(1): 57-60.

Mohanty BP, Das S, Bhaumik U and Sharma AP (2011). *Tenualosa ilisha* - A rich source of Omega-3 fatty acids. Central Inland Fisheries Research Institute CIFRI Bulletin No. 171 pp. 49.

Mridha MA, Lipi SY, Narejo NT, Uddin MS, Kabir MS and Karim M (2005). Determination of biochemical composition of *Cirrhinus reba* (Hamilton-1822) from Jessore, Bangladesh. Journal of Science & Technology University Peshwar, 29(1): 1-5.

Nowsad AKM (2007). Participatory training of trainers, Bangladesh Fisheries Research Forum, Mymensingh, Bangladesh.

Nowsad AKMA, Mohanty BP, Hoq ME and Thilshed S (2012). Nutritional values, consumption and utilization of hilsa *Tenualosa ilisha* (Hamilton 1822). Proc Regional Workshop on hilsa: Potential for Aquaculture. 16-17 September 2012. Dhaka, Bangladesh.

Oduor-Odote PM and Kazungu JM (2008). The body composition of low value fish and their preparation into higer value snack food. Western Indian Ocean Journal of Marine Science, 7: 111–117.

Ozyurt G and Polat A (2006). Amino acid and fatty acid composition of wild sea bass (*Dicentrarchus labrax)*: a seasonal differentiation. European Food Research and Technology, 222: 316–320.

Pal M, Mukhopadhyay T and Ghosh S (2011). Proximate, fatty acid, and amino acid compositions of fish muscle and egg tissue of hilsa (*Tenualosa ilisha*). Journal of Aquatic Food Product Technology, 20(2): 160-171.

Piggott GM and Tucker BW (1990). Effects of technology on nutrition pp. 137–175. Marcel Dekker, Inc. New York

Pillay SR and Rosa HJr (1963). Synopsis on the biological data on hilsa, *Hilsa ilisha* (Hamilton, 1822). FAO Fisheries Biology Synopsis, No 25 pp. 65.

Rahman MA, Hossain MA and Mansur MA (1999). Effects of different salting methods on the nutritional and sensory characteristics of hilsa (*Hilsa hilsa*). Indian Journal of Marine Science, 29: 171-175.

Saha KC and Guha BC (1939). Nutritional invest. Bengal Fish. India. pp. 921-927.

Saito H, Yamashiro R, Alasalvar C and Konno T (1999). Influence of diet on fatty acids of three subtropical fish, subfamily caesioninae (*Caesio diagramma* and *C. tile*) and family siganidae (*Siganus canaliculatus*). Lipids, 34: 1073–1082.

Sevim K, Serkan K, Yesim O and Bekir T (2010). Fatty acid profile and proximate composition of pacific mullet (*Mugil soiuy*) caught in the black sea: fatty acid and proximate composition of pacific mullet. International Journal of Food Science & Technology, 45: 1594–1602.

Shafi M, Quddus MMA and Islam N (1977). Studies of gonad weight, sex-ratio and fecundity of *Hilsa ilisha* (Hamilton-Buchanan) from the river Meghna. Journal of Asiatic Society Bangladesh, 2 51-58.

Shamim MAH, Ahmed MK and Abdullah ATM (2011). Proximate composition of different portion of hilsa, *Tenualosa ilisha* from two regions of the Bay of Bengal in Bangladesh. Dhaka University Journal of Biological Sciences, 20(2): 109-115.

Sharer KD (1994). Factors affecting the proximate composition of cultured fishes with emphasis on salmonids. Aquaculture, 119: 63–88.

Tsuchiya T (1961). Biochemistry of fish oil. In: Borgstrom, G. (ed.), Fish as Foods, pp. 1-58. Academic Press, New York

Uysal K and Aksoylar MY (2005). Seasonal variations in fatty acid composition and the n-6/n-3 fatty acid ratio of pikeperch (*Sander lucioperca*) muscle lipids. Ecology of Food and Nutrition, 44: 23–35.

Vergara JM, Calero LG, Robaina L, Cabellero MJ, Montero D, Izquierdo L and Aksnes A (1999). Growth, feed utilization and body lipid content of gilthead seabream (*Sparus aurata*) fed increasing lipid levels and fish meals of different quality. Aquaculture, 179: 35–44.

Waterman JJ (2000). Composition and quality of fish, Edinburgh, Torry Research Station.

Weatherly AH and Gills H (1987). The biology of fish growth. Academic Press, London. pp. 425.