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Proximate, fatty acid and mineral composition of hilsa, *Tenualosa ilisha* (Hamilton 1822) from the Bay of Bengal and Arabian Gulf

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ABSTRACT

Fish is the best source of n-3 polyunsaturated fatty acids (PUFAs), especially eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA). The objective of this study was to investigate the proximate, fatty acid and mineral composition of hilsa (*Tenualosa ilisha*) from the Bay of Bengal and Arabian Gulf. In general, egg protein and lipid contents were significantly ($p<0.05$) higher than those of the muscle tissues. However, lipid contents of muscle and egg tissues of hilsa from the Bay of Bengal were significantly ($p<0.05$) higher than those of the Arabian Gulf. Iron, zinc and manganese content in eggs were significantly higher than those of muscle tissues, while calcium and potassium in muscle were significantly higher in egg tissues ($p<0.05$). Among the saturated fatty acids (SFA) and monosaturated fatty acids (MUFA) in both tissues**,** palmitic acid (C16:0) and oleic acid (C18:1n-9) were the principal SFA and MUFA, respectively. There was no significant difference between the ∑PUFAs of both muscle and egg tissues and the PUFAs were dominated by both EPA and DHA. Among the ∑PUFAs, ∑n-3 PUFAs constituted about 80%. The result of the study showed that both hilsa muscle and egg represent a very good source of n-3 PUFA for human diet. However, hilsa from the Bay of Bengal could be a better source of n-3 PUFA, because of higher lipid content in its muscle compared to that of the Arabian Gulf.

Keywords: DHA, EPA, Fatty acids, Fish eggs, Minerals, Muscle, n-3 PUFA, *Tenualosa ilisha*

Introduction

The hilsa, *Tenualosa ilisha* (Hamilton 1822), belonging to the family Clupeidae, is locally known as 'ilish' and 'sbour' in Bangladesh and Kuwait, respectively. Hilsa has a wide range of distribution and occurs in marine, estuarine and riverine environments. It is found in the Arabian Gulf, Red Sea, Arabian Sea, Bay of Bengal, Vietnam Sea and China Sea. The riverine habitat covers the Satil Arab, and the Tigris and Euphrates of Iran and Iraq, the Indus of Pakistan, the rivers of Eastern and Western India, the Irrawaddy of Myanmar, and the Padma, Meghna, Jamuna and other coastal rivers of Bangladesh. Hilsa is largely an anadromous species, capable of withstanding a wide range of salinity and capable of migrating great distances upstream. It migrates to freshwater for spawning. Juveniles develop and grow in freshwater, but soon migrate to sea where they spend most of their life. In the Arabian Gulf, it ascends Shatt al-Arab River in Iraq and other rivers in Iran. It has a long spawning season, which may last from May to August (Hussain *et al.*, 1991). In the Bay of Bengal, it has two periods of spawning - one minor during spring warming from February to May and another major spawning that coincides with the heavy monsoon during July to October (BOBLME, 2010). It is one of the most important target species in the drift gillnet and fixed stake-net fishery in Kuwait (Al-Baz and Grove, 1995). Hilsa is the largest single fishery in Bangladesh contributing about 11% of total fish production (2899, 198 metric tons) and 24% of the capture fishery with a biomass of 115,179 metric tons from inland fisheries and 198,574 metric tons from marine fisheries (DoF, 2010). Hilsa is observed as the national fish of Bangladesh, due to its popularity and economic importance. It is marketed and consumed all over Bangladesh. According to a survey, 88% of hilsa is marketed for domestic consumption while the remaining (12%) is exported primarily to the Bangladeshi communities in the Middle East, Europe and USA (Kleih *et al*., 2003).

The nutritional importance of fish consumption to a great extent associated with its protein, unsaturated

essential fatty acids, minerals and vitamins (Sidhu, 2003). In recent years increasing attention has been focused on significance of n-3 polyunsaturated fatty acids (PUFAs) in human nutrition, particularly eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA). The data obtained in epidemiological and experimental studies supported the beneficial effects of these n-3 PUFAs in the prevention of cardiovascular diseases (Sidhu, 2003), reduction in the risk of coronary heart disease (CHD), inflammation, hypertension, hypertriglyceridemic effect, allergies, arthritis, autoimmune disorders and cancers (Von Sckacky, 2003; Mnari *et al*., 2007). Besides, n-3 PUFAs play a vital role in the development and function of the nervous system (brain), photoreception (vision) and the reproductive system (Sidhu, 2003). Humans have limited capacity to synthesise highly unsaturated n-3 PUFAs from shorter chain precursors, and fish have become vitally important as the only significant source of highly unsaturated n-3 PUFAs, particularly in the western food basket (Leaver *et al*., 2008).

The lipid content and fatty acid profiles of fish vary between and within species even in dark muscle and white muscle, which are affected by many factors such as the temperature, salinity, season, size, age, species habitat, life stage, and the type and abundance of food, especially whether a species is herbivorous, omnivorous or carnivorous (Ackman, 1989). Although there are numerous studies which have reported fatty acid profiles of various fish species from different geographical regions, there is limited information of the fatty acid profiles of hilsa. Recently, some studies on the biochemical composition of hilsa from the Sundarban estuarine zone, Godavari River and Hoogly estuarine system and West Bengal coast of India have been reported (Pal *et al*., 2011; Rao *et al*., 2012; Nath and Banerjee, 2012; Mohanty *et al.,* 2012). Fishing of hilsa takes place mainly during the monsoon season (June-August) when the adult fish migrates up the rivers for spawning (Majumdar and Basu, 2009). The availability of hilsa in the markets, both in Bangladesh and Kuwait, is high during August to September and we chose to collect the samples during the month of August. As mentioned earlier, hilsa is popular fish in Bangladesh and there is a common belief among the expatriate Bangladeshi communities in Kuwait that the taste of hilsa from the Bay of Bengal is different from those from the Arabian Gulf. The objective of this study was to determine and compare the proximate composition, fatty acid profile as well as mineral composition of hilsa muscle and eggs from the Bay of Bengal and the Arabian Gulf and also to address the nutritional importance of this species.

Materials and methods

Sample collection and preparation

Five male and five female fresh mature hilsa (*Tenualosa ilisha*), with mean weight 848.9±86.8 g, originating from the Bay of Bengal were collected from a local fish market in Dhaka, Bangladesh in the month of August, 2011. Similarly, ten mature hilsa (5 male and 5 female), with mean weight 791.5±31.9 g, originating from the Arabian Gulf were collected from the Sharq fish market, Kuwait in the same month. Fish were measured individually for their standard length and weight and the mean values and ranges are shown in (Table 1). Bone and skinless muscle tissues collected from both sides of upper dorsal area of the male and female fish, pooled together, divided in to three groups, minced and freeze dried. Freeze dried samples were finely ground, using a mixer grinder (Preeti Model MG 139, India) for further chemical analysis. Similarly, unfertilised eggs of five gravid females of hilsa from both the Bay of Bengal and Arabian Gulf were collected, freeze dried and stored for chemical analyses.

Proximate composition analyses

The proximate composition of fish samples were analysed in triplicate following standard procedures (AOAC, 2000): moisture content by drying in an oven at 105 ^{o}C for 24 h; crude protein content (Nx6.25) by

Table 1. Averages (± SD) and ranges (within parentheses) of standard length and weight of hilsa, *T. ilisha* used in the study

Parameters	Sex	Sources of hilsa	
		Bay of Bengal	Arabian Gulf
Length (cm)	Male	34.1 ± 0.8 (32.0–35.4)	34.4 ± 0.4 (34.0–34.8)
	Female	34.4 ± 2.0 (32.5–36.5)	34.7 ± 0.4 (34.4–35.2)
Mean length (cm)	Male + Female	34.3 ±1.7	34.6 ± 0.4
Weight (g)	Male	802.5 ± 53.5 (744.8–850.5)	777.4 ± 38.7 (734.9–810.5)
	Female	895.3 ± 97.6 (786.5–975.1)	805.5 ± 21.9 (781.2–824.2)
Mean weight (g)	Male + Female	848.9 ± 86.8	791.5 ± 31.9

* There was no significant difference between the respective length and weight of male and female hilsa from both the sources used.

the Kjeldahl method using an Auto Kjeldahl System (Kjeltec™ 2300 Foss Tecator AB, Hoganas, Sweden), lipid by ether extraction (Soxtec System HT6, Tecator AB, Hoganas, Sweden), ash by incineration in a muffle furnace at 600 °C for 6 h.

Fatty acid analyses

Lipid content of samples for fatty acid analysis was extracted by the Bligh and Dyer (1959) method. Fatty acid composition was determined by preparing methyl esters and analysing them by gas chromatography (AOCS, 1992). An HP 6890 gas chromatograph (Hewlett-Packard, Palo Alto, CA, USA) equipped with Chromapack column (CP-Sil 88 50 meter, ID 0.25mm, Varian Inc, Palo Alto, CA, USA) was used for the analysis. Fatty acid methyl ester standard mixture comprising 25 different fatty acids (ranging from C8 to C22:6) were obtained from Altech Associates, Deerfield, USA. Fatty acids were identified by comparison of retention times with a mixture of standards containing all the fatty acids identified in this study. Each fatty acid was quantified by calculating its peak area relative to the total peak area. These values are referred to as fatty acid content (%) throughout the paper. An estimated amount of each fatty acid was calculated from the lipid content and fatty acid content, which approximately corresponds to g fatty acid per 100 g lipid.

Statistical analysis

Paired t-test was performed to see whether there was any significant difference between the respective length and weight of male and female hilsa from both the sources using Microsoft Office Excel 2007 Analysis Tools. Data were also subjected to one-way analysis of variance (Package Super-ANOVA 1.11, Abacus Concepts, Berkley, California, USA) for significant difference of nutrients in muscle and egg tissues of hilsa from two sources. This was followed by Duncan's New Multiple Range Test (Duncan, 1955) to identify the level of significance of variance ($p<0.05$) among the treatment means.

Results and discussion

The ranges and mean (±SD) length and weight of hilsa from the Bay of Bengal and Arabian Gulf used in the present study are shown in Table 1. There was no significant differences ($p>0.05$) between the respective lengths and weights of male and female hilsa from both the sources. However, although the mean lengths of hilsa (male and female) were almost similar in both the sources, the mean weight of hilsa from the Bay of Bengal (848.9 ± 86.8 g) was higher compared to those of the Arabian Gulf (791.5 ± 31.9 g).

The proximate composition of muscle and egg tissues of hilsa is presented in Table 2. In general, the moisture content of muscle and egg tissues of hilsa from the Arabian Gulf was significantly ($p<0.05$) higher than those from the Bay of Bengal. However, in both cases, the moisture of the muscle tissues was significantly ($p<0.05$) lower than the moisture, of the egg tissues. Moisture influences the nutrient content of the fish. Usually the higher the moisture the lower the nutrient content. The fish moisture tends to decrease with the increase of body lipid as observed in many fishes (Parazo, 1990; Majumdar and Basu, 2009). The muscle moisture contents of hilsa obtained in the present study (60.37–67.89%) are within the range (58.82–69.54%) reported by Majumdar and Basu (2009) in hilsa from Bangladesh. Protein is an indispensable nutrient required for the structure and function of all living organisms, including fishes. The egg protein contents (22.27–23.08%) of hilsa were significantly ($p<0.05$) higher than those of the respective muscle proteins (18.16–19.13%). However, although the eggs of hilsa from the Bay of Bengal had significantly ($p<0.05$) higher protein than those from the Arabian Gulf, the muscle protein content of hilsa from the Arabian Gulf was significantly higher than those from the Bay of Bengal (Table 2). This could be related to the lower moisture content of the egg tissues (50.04–60.38%) compared to those of the muscle tissues (60.37–67.89%). Pal *et al*. (2011) reported a much higher protein content of 41.26% (on wet matter basis) in egg tissues compared to that of 34.70% in the muscle tissue of hilsa. However, the muscle proteins in hilsa from the Bay of Bengal and Arabian Gulf are similar to or slightly higher than those 16.80% (Kamal *et al*., 1996), 17.24% (Majumdar and Basu, 2009) and 17.56% (Majumdar and Basu, 2010) but slightly lower than that of 22.69% (Rao *et al.,* 2012) in hilsa from the Bay of Bengal. The muscle protein content of hilsa in the present study, is also similar to the muscle protein contents of some popular cultured marine fishes such as silver pomfret (*Pampus argenteus*), sea bream (*Sparidentex hasta*) and grouper (*Epinephelus coioides*) which ranged between 16.25 and 18.83% (Hossain *et al*., 2012).

Lipids are considered to be the most important constituent of fish egg as a reserve energy source (Pal *et al*., 2011). The high lipid content of the hilsa eggs (14.20–24.23%) than the muscle tissues (11.20–19.94%) found in the present study, is supported by the findings of Pal *et al*. (2011) who reported a lipid content of 19.18% and 11.85% respectively, in the eggs and muscle tissues of hilsa from the Sundarban Estuary of West Bengal, India. However, the lipid contents of muscle (19.94%) and egg tissues (24.23%) in hilsa from the Bay of Bengal in the present study is higher than those of 11.85% and 19.18%

Table 2. Proximate composition (% fresh matter basis) of muscle tissues and eggs of hilsa, *T. ilisha* from the Bay of Bengal and the Arabian Gulf[1]

Parameters	Muscle		Egg	
	Bay of Bengal	Arabian Gulf	Bay of Bengal	Arabian Gulf
Moisture	60.37±0.25^{b}	67.89±0.37^{a}	50.04±0.56^{c}	60.38±0.85^{b}
Protein	18.16±0.06^{d} (45.82)	19.13±0.08^{c} (59.57)	23.08±0.22^{a} (46.20)	22.27±0.49^{b} (56.20)
Lipid	19.94±0.23^{b} (50.31)	11.22±0.17^{d} (34.94)	24.23±0.35^{a} (48.49)	14.20±0.44^{c} (35.84)
Ash	1.34 ±0.05^{b} (3.38)	1.50±0.10^{b} (4.67)	1.97±0.11^{a} (3.94)	2.03±0.06^{a} (5.12)

*Values in parentheses are on % dry matter basis

[1]Values (mean ± SD) in rows with different superscripts are significantly different (Duncan's Multiple Range Test, $p<0.05$).

for the muscle and eggs, respectively reported by Pal *et al*. (2011). On the other hand, the lipid content of the muscle (11.22%) and eggs (14.20%) of hilsa from the Arabian Gulf were slightly lower than those of Pal *et al*. (2011) and Kamal *et al*. (1996) who reported a lipid content of 17.56% in hilsa muscle. Majumdar and Basu (2009), Rao *et al.* (2012) and Nath and Banerjee (2012) reported muscle lipid contents of 20.78%, 20.85% and 17.30%, in hilsa from Bangladesh, downstream Hoogly River, and brackishwater habitat in West Bengal, respectively.

The pattern of changes in lipid composition is governed by the rate of fat metabolism, maturity stage, environmental temperature, food availability, stress and other factors (Sikorski *et al.,* 1990). The higher lipid content found in hilsa from the Bay of Bengal could be related to their foods. The biochemical composition of fish is strongly affected by composition of their foods (Henderson and Tocher, 1987; Orban *et al*., 2007). Hilsa feeds on plankton, mainly by filtering, but apparently also by grubbing on muddy bottom. The hilsa from the Bay of Bengal might have had more abundant food than those from the Arabian Gulf, because many big rivers from the Himalayas such as the Padma, Meghna, and Jamuna merge into the Bay of Bengal bringing huge nutrients that keep the estuaries in the Bay of Bengal very productive. The enormous ingress of water from these big rivers into the Bay of Bengal triggers the movement of hilsa towards the river mouth or estuary wherein the fish spend time to acclimatise and accumulate fat before proceeding to the upstream for spawning migration. In addition to food, other factors such as species, size, reproductive status as well as the environmental characteristics can influence the proximate composition (Piggot and Tucker, 1990). It may be mentioned that the hilsa for the present study were collected during the month of August which falls within their breeding season when hilsa are usually fat. Again, size of hilsa may be another factor, as Mohanty *et al.* (2012) found higher levels of fat in medium sized hilsa (800-100 g) and the size of hilsa (848.9 g) in the present study from the Bay of Bengal falls within this range.

Minerals are essential for growth, bone mineralisation, reproduction and energy metabolism in all living organisms. The major portion of minerals in fish body are concentrated in muscle, scale and vertebrae (Lall, 2002). The prominence of each mineral element in body tissue is closely related to its functional role. The macro-minerals which include calcium (Ca), phosphorous (P), magnesium (Mg), sodium (Na) and potassium (K) occur in body at a concentration ranging from 0.1 to 2.0% of fish mass (Lall, 1995). Most of the trace elements found in terrestrial vertebrates are also detected in fish tissues (Hardy *et al*., 1984). Although the elemental composition of marine organisms are available, there is limited information on the mineral composition of hilsa. The results of the minerals analysed in the muscle and egg tissues of hilsa indicated that this species represents a good source of various essential minerals and trace elements (Table 3). Among the minerals determined in the present study, P is the most abundant one in both muscle and egg tissues followed by K and Ca. The muscle and egg P levels (5.88–8.59 mg g^{-1}) found in the present study are similar to those of 6.85–7.93 mg g^{-1} reported for red seabream (*Pagrus major*) muscle (Hossain *et al*., 2007). But the Ca level of hilsa muscle (1.55–2.04 mg g^{-1}) is much lower than those (9.9–11.4 mg g^{-1}) of red seabream (Hossain *et al*., 2007). Ca and P are the essential nutrients for growth and major constituent of the structural components of skeletal tissues. Mg and Na contents of muscle and eggs tissues of hilsa from the Arabian Gulf were significantly ($p<0.05$) higher than the respective muscle and egg tissues of hilsa from the Bay of Bengal. The Na content (11.13 mg g^{-1}) of the hilsa muscle from the Bay of Bengal in the present study is lower than that of Rao *et al*. (2012) for marine hilsa (1.83 mg g^{-1}) from the Bay of Bengal but higher than that of Godavari hilsa (0.83 mg g^{-1}). This may be due to the fact that hilsa from the Bay of Bengal were from the coastal waters *i.e.,* the Meghna Estuary where the salinity is comparatively low. Muscle tissues of hilsa from the Bay of Bengal had significantly high ($p>0.05$) K content (6.13 mg g^{-1}) which is similar to that of 5.73 mg g^{-1} reported by Rao *et al*. (2012). However, there

Table 3. Minerals (wet matter basis) in muscle and eggs of hilsa, *T. ilisha* from the Bay of Bengal and Arabian Gulf[1]

Minerals	Muscle		Egg	
	Bay of Bengal	Arabian Gulf	Bay of Bengal	Arabian Gulf
P (mg g^{-1})	5.88±0.35^{c}	7.19±0.16^{b}	8.59±0.20^{a}	7.45±0.19^{b}
Ca (mg g^{-1})	1.55±0.17^{b}	2.04±0.21^{a}	1.00±0.09^{c}	1.24±0.07^{c}
Mg (mg g^{-1})	0.85±0.04^{c}	1.29±0.04^{a}	0.40±0.04^{d}	1.03±0.04^{b}
Na (mg g^{-1})	1.13± 0.03^{c}	2.19±0.05^{a}	0.70±0.04^{d}	1.28±0.10^{b}
K (mg g^{-1})	6.13±0.03^{a}	2.58±0.08^{b}	2.45±0.07^{b}	1.68±0.11^{c}
Zn (µg g^{-1})	11.78±0.25^{c}	12.37±0.15^{c}	45.61±2.17^{a}	42.16±0.34^{b}
Fe (µg g^{-1})	15.19±0.96^{c}	25.64±0.24^{b}	35.24±0.46^{a}	33.85±0.88^{a}
Cu (µg g^{-1})	1.16±0.08^{a}	1.17±0.04^{a}	1.24±0.07^{a}	1.23±0.05^{a}
Mn (µg g^{-1})	0.51±11^{c}	1.16±0.04^{b}	2.18±0.07a	2.03±0.8^{a}

[1]Values (mean ± SD) in row with different superscripts are significantly different determined by Duncan's Multiple Range Test ($p<0.05$).

was no significant difference between K content in muscle tissues of hilsa from the Arabian Gulf (2.58 mg g^{-1}) and eggs tissues from that of the Bay of Bengal (2.45 mg g^{-1}).

The zinc (Zn) concentrations of hilsa eggs (42.16–45.61 µg g^{-1}) are more than three times higher than those of the muscle tissues (11.78–12.37 µg g^{-1}). High Zn level in egg tissues is also reported in seabass (*Dicentrarchus labrax*) (43.6–45.1 µg g^{-1}) by Yildiz (2008), while the Zn level of hilsa muscle tissues is comparable to red seabream (12.3–18.7 µg g^{-1} (Hossain *et al*., 2007). Iron (Fe) and Manganese (Mn) levels of hilsa egg tissues are also significantly higher ($p>0.05$) than those of the muscle tissues. However, Fe, Copper (Cu) and Mn levels in hilsa muscle in the present study are lower than those reported for seabass (Yildiz, 2008) and red seabream (Hossain *et al*., 2007). But Zn and Fe levels in the hilsa muscle and egg tissues in the present study are much higher than those reported by Tabinda *et al*. (2010) for *T. ilisha*. The concentration of minerals and trace element levels are known to vary in fish depending on various factors such as their feeding behaviour, environment, ecosystem and migration (Andres *et al*., 2000).

The muscle and egg fatty acid profiles of hilsa from the Bay of Bengal and the Arabian Gulf is presented in (Table 4). In both the muscle and egg tissues, the fatty acid profile was dominated by saturated fatty acids (SFAs) which ranged between 52 and 63%. The total muscle SFA content of hilsa (56.24%) from the Bay of Bengal is similar to that of 56.9% reported by Pal *et al*. (2011) but SFA in hilsa muscle from Arabian Gulf is much higher (62.57%) than that of Pal *et al*. (2011). Similarly, the total SFA contents of hilsa in the present study are also higher than the total muscle SFA content of gilthead bream, *Sparus aurata* (23.3 and 24.9%, cultured *vs* wild) and seabass (31.3 and 29.8%, cultured *vs* wild) reported by Grigorakis (2007). However, these SFA values are comparable to those of 57.06% for wild seabream, 53.05% for wild silver pomfret and 57.57% for wild grouper (Hossain *et al*., 2012). Palmitic acid is the most dominant SFA in muscle and egg tissues of hilsa in both the sources. Ozogul *et al*. (2007) and Ozogul and Ozogul (2007) also reported palmitic acid as the most dominant SFA in freshwater and seawater fishes. In contrast to the total SFA, the total MUFA contents were lower in the muscle and egg tissues (27.02–32.76%) which are comparable or slightly lower than those (23.7% and 39.6% respectively) reported by Paul *et al*. (2011) for hilsa. The dominant MUFA C18:1n-9 constituted about 16–19% of muscle and 19–20% of egg tissues in the present study is comparable to those of wild bluefin seabream (17.08%) and yellowfin seabream, *Acanthopagrus latus* (21.74%) as reported by Hossain *et al*. (2012). The SFA and MUFA are storage lipids in fish preferably used as energy sources. The distinctly higher content of SFA in marine or brackishwater hilsa is obvious as it must accumulate energy reserves during their growth phase in the form of lipids, mainly as triglycerides which are catabolised to provide the energy necessary for anadromous migration and spawning (Rao *et al*., 2012).

The ∑PUFA of muscle (14.03–14.27%) and egg tissues (14.57–14/74%) of hilsa in the present study are very close and similar to those of Pal *et al*. (2011) who reported a ∑PUFA values of 16.1% and 14.2% for hilsa muscle and eggs respectively but lower than that of 22.11% reported in hilsa from coastal waters by Mohanty *et al.* (2012). Hossain *et al*. (2012) also reported similar ∑PUFA values for wild bluefin seabream (16.59%) and silver pomfret (14.29%). There were no significant differences among the ∑PUFAs of both the muscle tissues. The ∑PUFAs were dominated by both EPA and DHA. However, the EPA of muscle tissues were significantly ($p<0.05$) higher than those of the egg tissues while the DHA of the egg tissues were significantly ($p<0.05$) higher than those of the muscle tissues. The contribution of EPA in muscle tissues were higher than DHA. Similar observations were also reported in bluefin sea bream and silver pomfret (Hossain *et al*., 2012) and in hilsa (Pal *et al*., 2011). Rao *et al.* (2012) reported that the EPA and DHA

Table 4. Fatty acid profiles (% of total fatty acids) in muscle tissues and eggs of hilsa, *T. ilisha* from the Bay of Bengal and Arabian Gulf

Fatty acids	Muscle		Egg	
	Bay of Bengal	Arabian Gulf	Bay of Bengal	Arabian Gulf
C14	8.37±0.37[b]	10.04±0.21[a]	7.03±0.20[c]	8.40±0.22[b]
C15	0.38±0.04[b]	0.79±0.06[a]	0.28±0.03[b]	0.32±0.05[b]
C16	40.07±0.65[b]	44.03±0.30[a]	33.27±0.26[d]	36.20±0.42[c]
C17	0.30±0.03[c]	0.88±0.04[a]	0.37±0.04[b]	0.42±0.03[b]
C18	6.68±0.32[b]	6.65±0.15[b]	10.65±0.23[a]	10.88±0.24[a]
C20	0.44±0.04[a]	0.48±0.03[a]	0.20±0.03[c]	0.28±0.03[b]
∑SFA	56.24±0.07[b]	62.57±0.58[a]	51.80±0.14[c]	56.51±0.34[b]
C16:1	4.56±0.25[c]	2.71±0.09[d]	7.82±0.19[a]	6.45±0.17[b]
C18:1n-9	19.02±0.46[b]	15.81±0.19[c]	21.22±0.28[a]	19.25±0.38[b]
C20:1	1.45±0.07[c]	0.88±0.04[d]	2.13±0.10[a]	1.94±0.08[b]
C22: 1n-9	0.18±0.03[a]	0.20±0.01[a]	0.17±0.03[a]	0.20±0.02[a]
C24:1	2.05±0.05[a]	2.10±0.08[a]	1.25±0.04[b]	1.12±0.04[c]
∑MUFA	27.26±0.56[b]	21.70±0.32[c]	31.76±2.41[a]	27.02±0.57[b]
C18:2n-6	0.30±0.02[b]	0.29±0.02[b]	0.53±0.05[a]	0.47±0.04[a]
C18:3n-3	1.28±0.03[b]	1.37±0.04[b]	1.94±0.07[a]	2.05±0.05[a]
C18:3n-6	1.21±0.04[b]	1.23±0.02[b]	1.32±0.07[a]	1.36±0.04[a]
C20:3 n-3	0.44±0.03a	0.46±0.02a	0.44±0.03a	0.48±0.03a
C20:3n-6	0.58±0.03a	0.47±0.01b	0±00c	0±00c
C20:4 n-6	0.41±0.02a	0.38±0.03a	0.36±0.03a	0.40±0.04a
C20:5 n-3. EPA	6.57±0.20a	6.61±0.14a	4.88±0.20b	5.29±0.16b
C22:6 n-3. DHA	3.48±0.22b	3.22±0.08b	5.10±0.18a	4.69±0.21a
∑PUFA	14.27±0.53a	14.03±0.31a	14.57±0.56a	14.74±0.42a
∑n-3	11.77±0.48a	11.66±0.23a	12.36±0.47a	12.51±0.38a
∑n-6	2.50±0.05a	2.37±0.08a	2.21±0.09b	2.20±0.07b
n-3/n-6 ratio	4.70±0.10b	4.92±0.10b	5.59±0.02a	5.69±0.18a
Unknown	2.23±0.04b	1.70±0.58b	3.20±0.12a	1.28±0.18b

[1]Values (mean ± SD) in row with different superscripts are significantly different (Duncan's Multiple Range Test, (P<0.05).

*SFA - saturated fatty acid; MUFA - mono-saturated fatty acids; PUFA - polyunsaturated fatty acids; EPA - eicosapentaenoic acid; DHA - docosahexaenoic acid.

levels were highest in Godavari hilsa than in brackishwater and marine hilsa. In the present study, among ∑PUFA the ∑n-3 PUFA constituted about 80% of the total PUFA while ∑n-6 PUFA, constituted the rest, which is similar to the report of Pal *et al.* (2011). On the other hand, Mohanty *et al.* (2012) reported that ∑n-3 PUFA constituted about 64% of the total PUFA in medium sized hilsa (800-1000 g) from the Kolkata coast, West Bengal, India. Ozogul *et al*. (2007) reported that the level of n-6 PUFA of seawater fish was found to be low, ranging from 0.43% for blue fish to 14.40% for seabass.

The n-3/n-6 ratio has been suggested to be a better index for comparing the relative nutritional value of different species (Piggot and Tucker, 1990). However, this index is of limited value without consideration of which fatty acids are present. Owning to their predominating quantity, two fatty acids namely DHA and EPA are responsible to the greatest extent for changes in the n-3/n-6 ratios, a reliable indicator that enables a comparison of relative nutritive value of lipids. Hossain (2011) reported that the n-3/n-6 ratios of marine fishes vary between 0.6 and 11.5. According to Simopoulos (1989) an n-3/n-6 ratio of 1:1 is considered to be optimal for nutritional purpose. However, higher the n-3/n-6 ratios, the more able the body is to use the n-3 fats. The n-3/n-6 ratios of hilsa muscle (4.70–4.92) in the present study are higher than those (2.62) of Mohanty *et al*. (2012) found in medium sized hilsa but lower than that of 9.7 in hilsa muscle reported by Pal *et al*. (2011). However, the n-3-/n-6 ratios of egg tissues (5.59– 5.69) are similar to those of Pal *et al*. (2011). But these values are higher than those of 2.5–3.0 for hilsa (Nath and Banerjee (2012), 1.7–3.0 for seabream (Hossain *et al*., 2012), 3.4 for silver pomfret (Zhao *et al*., 2010). As mentioned earlier, diet is the main factor affecting the n-3 and n-6 PUFA content in fish, but location, species, season and environmental conditions, such as salinity, may also play a role. Whether the diet is natural or compounded, the fatty acid composition of fish muscle is clearly influenced by their diet (Justi *et al*., 2003). The taste and flavour of many fish depends on their food and feeding habits. The unique taste of hilsa is believed to be attributed to the environment where it lives or to the feed it takes. Hilsa of freshwater origin is tastier than those of the sea. Godavari hilsa is found to be tastier than marine hilsa in the Indian waters of Bay of Bengal (Rao *et al*., 2012). The perceived taste difference between hilsa from the Bay of Bengal and the Arabian Gulf could be related to the types of food intake.

In comparison with other species from both wild and aquaculture, for example, seabream and silver pomfret, hilsa showed slightly lower n-3 PUFA on a percent of total fatty acids, the absolute amount of n-3 PUFA calculated in 100 g wet hilsa muscle (2.35 g in the Bay of Bengal v/s 1.31 g in Arabian Gulf) was much higher than those of seabream (0.58–0.60 g) and silver pomfret (0.99–1.19 g) as reported by Hossain *et al*. (2012) which is mainly due to the higher lipid content of hilsa muscle. On the other hand, Pal *et al.* (2011) found an absolute amount of 1.78 g n-3 PUFA in 100 g hilsa muscle which is lower than those of hilsa from the Bay of Bengal (2.35 g) but slightly higher than those of the Arabian Gulf (1.31 g) in the present study. Mohanty *et al.* (2012) also found a higher amount of PUFA (2.77 g in 100 g muscle) in medium sized hilsa from the coast of West Bengal, India. Despite the slightly lower proportion of n-3 PUFA (12%) in total fatty acids but because of its higher lipid content in muscle (11.22–19.94%) and eggs (22.27– 23.08%), both hilsa muscle and egg represent a very good source of n-3 PUFA in human diet. However, hilsa from the Bay of Bengal could be a better source of n-3 PUFA, because of its higher lipid content in muscle compared to that of the Arabian Gulf.

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References

Ackman, R. G. 1989. Nutritional composition of fats in sea foods. *Prog. Food Nutr. Sci*., 13: 161–241.

Al-Baz, A. F., and Grove, D. J. 1995. Population biology of sbour, *Tenualosa ilisha* (Hamilton-Buchanan) in Kuwait. *Asian Fish. Sci*., 8: 239 – 254.

Andres, S. F., Ribeyre, F., Toureneq, J. N. and Boudou, A. 2000. Interspecific comparison of cadmium and zinc contamination in the organs of four fish species along a polymetallic pollution gradient (Lot River, France). *Sci. Total Environ*., 284: 11–25.

AOAC 2000. *Official methods of analysis of AOAC International*. 17th edn. AOAC International Gaithersburg, MD, USA.

AOCS (American Oil Chemists' Society) 1992. *Fatty acid composition by GLC. Marine oils*. AOCS Official Methods Ce 1b-89, AOCS, Champaign, IL.

Bligh, E. G. and Dyer, W. J. 1959. A rapid method of total lipid extraction and purification. *Can. J. Biochem. Physiol*., 37: 911–917.

BOBLME 2010. Status of hilsa (*Tenualosa ilisha*) management in the Bay of Bengal: an assessment of population risk and data gaps for more effective regional management. *Report of FAO Bay of Bengal Large Marine Ecosystem Project (BOBLME)*, 18 pp.

DoF 2010. *Fisheries Statistical Yearbook of Bangladesh 2009-2010*. Fisheries Resource Survey System, Department of Fisheries, Government of the Peoples Republic of Bangladesh, Dhaka, Volume 27, No.1, 46 pp.

Duncan, D. B. 1955. Multiple range and multiple F-Test. *Biometrics*, 11: 1–42.

Grigorakis, K. 2007. Compositional and organoleptic quality of farmed and gilthead seabream (*Sparus aurata*) and seabass (*Dicentrarchus labrax*) and factors affecting it - A review. *Aquaculture,* 272: 55–75.

Hardy, R. W., Shearer, K. D. and King, I. B. 1984. Proximate and elemental composition of developing eggs and maternal soma of pen-reared coho salmon (*Oncorhynchus kisutch)* fed production and trace element fortified diets. *Aquaculture*, 43: 147–165.

Henderson, R. J. and Tocher, D. R. 1987. The lipid composition and biochemistry of freshwater fish. *Progr. Lipid Res*., 26: 281–347.

Hossain, M. A., Pandey, A. and Satoh, S. 2007. Effects of organic acids on growth and phosphorous utilization in red sea bream *Pagrus major*. *Fish. Sci*.,73: 1309–1317.

Hossain, M. A. 2011. Fish as source of n-3 polyunsaturated fatty acids (PUFAs) which one is better - farmed or wild? *Adv. J. Food Sci. Technol*., 3(6): 455–466.

Hossain, M. A., Almatar, S. M., Al-Abdul-Elah, K. M. and Yaseen, S. B. 2012. Proximate composition and fatty acid profiles of some popular cultured and wild fishes in Kuwait, *J. Appl. Aquacult*., 24: 199–209.

Hussain, M. A., Al-Mukhtar, M. A. and Al-Daham, N. K. 1991. Preliminary investigation on fisheries and some biological aspects of sbour, *Hilsa ilisha* from Shatt al-Arab River, Iraq. *Basrah J. Ag. Sci.,* 4(1&2): 141–151.

Justi, K. C., Hayashi, C., Visentainer, J. V., de Souza, N. F. and Matsuishita, M. 2003. The influence of feed supply time on the fatty acid profile of Nile tilapia (*Oreochromis niloticus*) fed on a diet enriched with n-3 fatty acids. *Food Chem*., 80: 498–493.

Kamal, M., Islam, M. N., Monsur, M. A., Hossain, M. A. and Bhuiyan, M. A. I. 1996. Biochemical and sensory evaluation of hilsa fish (*Hilsa ilisha*) during frozen storage. *Indian J. Mar. Sci*., 25: 320–323.

Kleih, U., Alam, K., Dastidar, R., Datta, U., Oudwater, N. and Ward, A. 2003. Livelihoods in coastal fishing communities and the marine fish marketing systems of Bangladesh. NRI Report No. 2712. Natural Research Institute (NRI), Greenwich University, London, 110 pp.

Lall, S. P. 1995. Macro and trace elements in fish and shellfish. In: Ruiter, A. (Ed.), *Fish and fishery products: comparison, nutritive properties and stability.* Wallingford: CAB International, p. 187–214.

Lall, S. P. 2002. The minerals. In: Halver, J. E. and Hardy, R.W. (Eds.), *Fish nutrition*, 3rd edn. San Diego, CA, Academic Press Inc., p. 259–308.

Leaver, M. J., Bautista, J. M., Bjornsson, B. T., Jonsson, E., Krey, G., Tocher, D. R. and Torsensen, B. E. 2008. Towards fish lipid nutrigenomics: current state and prospects for fin-fish aquaculture. *Rev. Fish. Sci*., 16 (S1): 73–94.

Majumdar, R. K. and Basu, S. 2009. Studies on seasonal variation in the biochemical composition of the Indian shad, *Tenualosa ilisha* (Hamilton 1822). *Indian J. Fish*., 56(3): 205–209.

Majumdar, R. K. and Basu, S. 2010. Characterisation of the traditional fermented fish products Lona islish of Northeast India. *Indian J. Trad. Knowl.*, 9(3): 453–458.

Mnari, A., Boulel, I., Chraief, I., Hammami, M., Romdhane, M. S., El Cafsi, M. and Chaouch, A. 2007. Fatty acids in muscles and liver of Tunisian wild and farmed gilthead seabream, *Sparus aurata*. *Food Chem*., 100: 1393–1397.

Mohanty, B. P., Paria, P., Mahanty, A., Behera, B. K., Mathew, S., Sankar, T. V. and Sharma A. P. 2012. Fatty acid profile of Indian shad *Tenualosa ilisha* oil and its dietary significance. *Natl. Acad. Sci. Lett*., 35: 263–269.

Nath, A. K. and Banerjee, B. 2012. Comparative evaluation of body composition of Hilsa, *Tenualosa ilisha* (Hamilton,1822), in different size groups with special reference to fatty acids, in Hooghly estuarine system, West Bengal, India. *Indian J. Fish.,* 59 (2): 145–146.

Orban, E., Nevigato, T., Masci, M., Di Lena, G., Casini, I., Caproni, R., Gambelli, L., De Angelis, P. and Ramapacci, M. 2007. Nutritional quality and safety of European perch (*Perca fluviatilis*) from three lakes of Central Italy. *Food Chem*., 73:55–60.

Ozogul, Y. and Ozogul, F. 2007. Fatty acid profiles of commercially important fish species from the Mediterranean, Aegean and Black Seas. *Food Chem*., 100: 1637–1638.

Ozogul, Y., Ozogul, F., and Alagoz, S. 2007. Fatty acid profiles and fat contents of commercially important seawater and freshwater fish species of Turkey: a comparative study. *Food Chem*., 103: 217–223.

Parazo, M. M. 1990. Effects of dietary protein and energy level on growth, protein utilization and carcass composition of rabbit fish, *Signus gutatus*. *Aquaculture*, 86: 41–49.

Pal, M., Mukhapadhayay, T. and Ghosh, S. 2011. Proximate, fatty acid, and amino acid composition of fish muscle and egg tissue of Hilsa (*Tenualosa ilisha*). *J. Aquat. Food Prod. Technol.*, 20: 160-171.

Piggot, G. M. and Tucker, B. W. 1990. *Seafood: effects of technology on nutrition*. Boca Raton, FL, CRC press. 337 pp.

Rao, B. M., Murthy, L. N., Mathew, S., Asha, K. K., Sankar, T. V. and Prasad, M. M. 2012. Changes in the nutritional profile of Godavari hilsa shad, *Tenualosa ilisha* (Hamilton, 1822) during its anadromous migration from Bay of Bengal to the River Godavari. *Indian J. Fish.*, 59(1): 125–132.

Sidhu, K. S. 2003. Health benefits and potential risks related to consumption of fish oil. *J. Reg. Toxicol. Pharmacol*., 38(3): 336–344.

Sikorski, Z. F., Kolakowska, A. and Sun Pan, B. 1990. The nutritive composition of the major groups of marine food organisms. In: Sikorski, Z. E. (Ed.), *Seafood: resources, nutritional composition and preservation.* CRC Press. Inc. Florida, p. 30–52.

*S*imopoulos, A. P. 1989. Summary of NATO advanced research workshop on dietary n-3 and n-6 fatty acids: biological effects and nutritional essentiality. *J. Nutr*., 199: 512–528.

Tabinda, A. B., Hussain, M., Ahmed, I. and Yasar, A. 2010. Accumulation of toxic and essential trace metals in fish and prawns from Keti Bunder Thatta District, Sindh. *Pakistan J. Zool*., 42 (5): 631–638.

Von Sckacky, C. 2003. The role of omega-3 fatty acids in cardiovascular disease. *Curr. Atherosclerosis Rep*., 5: 139–145.

Yildiz, M. 2008. Mineral composition in fillets of seabass (*Dicentrarchus labrax*) and seabream (*Sparus aurata*): a comparison of cultured and wild fish. *J. Appl. Ichthyol*., 24: 589–594.

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