FATTY ACIDS AND HEAVY METAL CONTENT OF FIVE COMMERCIAL FISHES IN DHAKA CITY

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ABSTRACT

Fish are a staple food for humans, being a rich source of essential fatty acids and may also be a potential sink for heavy metals in urban food chains like those in Dhaka city. Methods: This study was conducted to assess the fatty acid and heavy metal (Pb, Cd, Zn, Cr) concentration of some of the selected commercially available fish species of Dhaka city. Methodology: Five commonly consumed fish species, *Ompok bimaculatus* (Pabda), *Sperata aor* (Poa), *Otolithoides pama* (Ayer), *Scomberomorus guttatus* (Shurma) and *Chitala chitala* (Chitol) were selected for this study. The fatty acid profile was determined by the gas chromatography method and the heavy metal content by the atomic absorption spectrophotometry method. Results: The total fat content of the five widely eaten fish species varied considerably, with Pabda being the highest and Poa and Shurma the lowest, and Ayer and Chitol in between. The predominant saturated fatty acid was palmitic acid and the major monounsaturated fatty acid was oleic acid, which was highest in Pabda. Total saturated fat comprised about 37-44% of fatty acids, but total monounsaturated fat was highest in Pabda and lowest in Shurma. Polyunsaturated fat was highest in Shurma and lowest in Pabda, and omega-3 fatty acids (particularly EPA and DHA) were high in Shurma, with Poa and Chitol in between, and lowest in Pabda. Essential fatty acids linoleic acid and linolenic acid were species-dependent, with Pabda having the most linoleic acid, and Chitol and Ayer having relatively more linolenic acid. Evaluation of heavy metals revealed non-detectable cadmium and lead, but variable, species-specific nickel, and particularly high chromium. These common fish species showed species-dependent trade-offs between fat content and heart-protective omega-3s, non-detectable cadmium and lead, but variable nickel and particularly high levels of chromium in some species, highlighting the need for species-specific dietary guidelines and monitoring to ensure heart-healthy benefits but also to avoid risks of heavy metal exposure.

KEYWORDS: Fatty acid, lipid, heavy metal, fish, Bangladesh

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Introduction

Fish is a highly consumed animal-sourced food in the world, and constitutes an important part of the diet for millions of people, especially in developing countries, because it is rich in high-quality protein, vitamins, minerals and biologically active lipids[1]. In Bangladesh, fish is the single-most important animal-sourced food and currently contributes some 60% of the total animal protein consumed[2]. Bangladesh has already exceeded the recommended daily intake (60 g/day) of fish, and its daily per capita consumption is currently 62.6 grams[2,3]. The Food and Agriculture Organization report The State of World Fisheries and Aquaculture 2024 indicates that Bangladesh is now the second-largest producer of freshwater fish globally producing approximately 1.32 million tonnes (13.22 lakh tonnes) or around 11.7% of world freshwater production, according to data for 2022 [4].

Fish lipids are important dietary nutrients besides protein. Fish are the major dietary source of long-chain polyunsaturated fatty acids (PUFAs) such as the omega-3 fatty acids eicosapentaenoic acid (EPA; C20:5, ω-3) and docosahexaenoic acid (DHA; C22:6, ω-3), which cannot be produced in sufficient quantities by the human body de novo[5]. These fatty acids are involved in regulating lipid metabolism, lowering blood triglyceride concentration, enhancing endothelial function, and dampening inflammatory responses[6]. There is epidemiological evidence of a clear link between dietary intake of EPA and DHA and lower risk of developing cardiovascular disease, coronary heart disease, rheumatoid arthritis and some cancers[6,7]. Research on the fish species of Bangladesh has confirmed the presence of high levels of unsaturated fatty acids; in freshwater fish, palmitoleic acid is the most abundant unsaturated fatty acids (ranging from 26.02- 46.80%), whereas marine fish have significant levels of oleic acid, palmitoleic acid and linoleic acid, as well as long-chain PUFAs[5,7]. Thus, the profiling of the fatty acid content of fish species for human consumption has significant nutritional and health implications. But the nutritional quality of fish may be significantly compromised by the presence of heavy metals, which are toxic, non-biodegradable contaminants with the potential to accumulate in fish tissues and reach the human food chain[8]. Lead (Pb), cadmium (Cd), arsenic (As), chromium (Cr), mercury (Hg) and nickel (Ni) are well known to have severe adverse health impacts, including neurotoxicity, developmental abnormalities, renal dysfunction, liver toxicity, cardiovascular diseases and cancer[8,9]. These metals are taken up from contaminated water bodies by fish through water, sediment ingestion and food[8]. A 40-year-long study revealed concerning concentrations of heavy metals (As, Pb, Cd, Cr, Mn, Cu and Zn) in the major rivers of the country[10]. A recent study of six major fish species consumed in Dhaka city, sourced from wholesale markets, revealed considerable differences in heavy metal concentrations among species, with the highest concentration of arsenic found in Hilsha, the national fish of Bangladesh[11]. Likewise, studies conducted in the Savar region of Dhaka District have shown a high level of lead (Pb) in several fish species, and the target hazard quotient (THQ) was found to be higher than the standard level in some species[12]. These results highlight the conflicting demands for fish consumers in Dhaka: obtaining maximum nutritional value and avoiding the hazards posed by toxic elements.

Despite the increasing scientific interest, there are few studies on simultaneous and detailed profiling of fatty acid content and heavy metal contamination in the commercially available fish from Dhaka city markets. Existing research has primarily tackled either the nutritional or the toxicological aspect, while very few have focused on the most widely available fish species for urban consumers in Dhaka[7,8,11,12,13,14,15]. Hence, the current research is designed to assess the fatty acid composition and heavy metal content in some commercially important fish species from the retail markets of Dhaka, Bangladesh, and to explore the nutritional benefits and possible health risks to the population due to the consumption of these fish.

Methodology

The fish samples were taken from Rajdhani Matshya Vander Fish Market, Jatrabari and Kawran Bazar Fish Market, Karwan Bazar. The sampling sites have been shown below:

The samples were collected from sampling sites and were taken to the laboratory for further preparation. The fish samples selected for the current study are given as follows:

Local name	Scientific name	No. of samples	Average weight per sample (g)
Pabda	*Ompok bimaculatus*	8	59.28
Poa	*Sperata aor*	7	58.34
Ayer	*Otolithoides pama*	8	190.55
Shurma	*Scomberomorus guttatus*	4	565.23
Chitol	*Chitala chitala*	2	1260.50

The process of sample collection and transport sampling have been described in another paper by Miah et al. (2024)[16]. The sample preparation technique was demonstrated in a previous study of Miah et al. (2024)[16]. The crude fat was determined following the method of Folch et al. (1957)[17] with some modification. FAME (fatty acid methyl ester) was also formed by the method of AOAC-2005[18] (with minor modification). The fatty acid profiling was done by a gas chromatograph (Trace 1300, Thermo Scientific, PA, USA). The method can be found in the study by Miah et al. (2024)[16] and the metals were determined by Atomic Absorption Spectrophotometer (AAS).

Results

The fat content (average percentage) of five widely consumed fish species is given in Table 1. The highest fat content is found in Pabda (6.99 ± 0.05%), suggesting that it is a fairly oily fish. Ayer (3.33 ± 0.29%) and Chitol (3.30 ± 0.19%) have moderate fat contents that are roughly half that of Pabda. Poa (2.15 ± 0.08%) and Shurma (1.76 ± 0.20%) have the lowest fat contents, implying they are lean types of fish.

Table 1. Crude lipid content of the fish samples

Fish Name	Crude lipid (%)
Pabda	6.99 ± 0.05
Ayer	3.33 ± 0.29
Poa	2.15 ± 0.08
Shurma	1.76 ± 0.20
Chitol	3.30 ± 0.19

The muscle of Pabda, Ayer, Poa, Shurma and Chitol fishes contain the individual and grouped percentage of fatty acids shown in Table 2. All species have the highest percentage of palmitic acid (C16:0) as saturated fatty acid and oleic acid (C18:1) as monounsaturated fatty acid, with the highest percentage in Pabda and lowest in Shurma and Poa. Total saturated fat ranges, approximately, from the high 30s to mid-40s, which suggests that all species have a significant amount of saturated fatty acids, while total monounsaturated fat is highest in Pabda and lowest in Shurma. Total polyunsaturated fat is highest in Shurma and lowest in Pabda and nutritionally important omega 3 fatty acids are highest in Shurma, followed by Poa and Chitol, and lowest in Pabda. Of the omega 3s, docosahexaenoic acid (DHA, C22:6) and eicosapentaenoic acid (EPA, C20:5) in particular are much higher in Shurma and Poa than Pabda and Chitol, suggesting that Shurma and Poa are likely to be more effective in promoting good cardiovascular health.

Table 2. Fatty acid composition of the selected fish species

Fatty Acid	Pabda (%) Mean±SD	Ayer(%) Mean±SD	Poa (%) Mean±SD	Shurma(%) Mean±SD	Chitol (%) Mean±SD
C12:0	0.05±0.01	0.09±0.01	0.14 ± 0.03	0.00 ± 0.00	0.18 ± 0.01
C13:0	0.00±0.00	0.06±0.05	0.00 ± 0.00	0.00 ± 0.00	0.09 ± 0.01
C14:0	1.78±0.03	3.12±0.25	3.14 ± 0.11	3.97 ± 0.15	3.22 ± 0.10
C14:1	0.05±0.04	0.83±0.06	0.15 ± 0.02	0.19 ± 0.01	0.74 ± 0.02
C15:0	0.19±0.00	1.12±0.06	0.47 ± 0.03	0.93 ± 0.04	0.95 ± 0.01
C15:1	0.00±0.00	0.41±0.02	0.08 ± 0.01	0.16 ± 0.00	0.28 ± 0.01
C16:0	26.51±0.29	23.24±0.22	30.76 ± 0.74	22.87 ± 0.37	25.51 ± 0.09
C16:1t	0.53±0.02	0.39±0.01	0.12 ± 0.01	0.16 ± 0.02	0.53 ± 0.02
C16:1	3.98±0.06	5.52±0.12	10.69 ± 0.13	4.95 ± 0.12	4.82 ± 0.10
C17:0	0.23±0.00	1.64±0.02	0.60 ± 0.05	1.08 ± 0.08	1.25 ± 0.01

C17:1t	0.00±0.00	0.23±0.01	0.67 ± 0.05	0.22 ± 0.01	0.27 ± 0.01
C17:1	0.19±0.00	0.98±0.02	0.32 ± 0.00	0.46 ± 0.02	0.60 ± 0.01
C18:0	6.81±0.05	6.94±0.26	8.38 ± 0.20	11.17 ± 0.47	7.20 ± 0.11
C18:1 t	0.00±0.00	0.18±0.03	0.10 ± 0.02	0.15 ± 0.00	0.18 ± 0.01
C18:1	34.19±0.42	18.00±0.44	13.88 ± 0.39	8.04 ± 0.08	18.75 ± 0.34
C18:1	0.61±0.10	2.23±0.21	2.18 ± 0.04	3.02 ± 0.08	1.45 ± 0.04
C18:2	14.53±0.28	9.15±0.26	1.88 ± 0.19	1.32 ± 0.11	6.69 ± 0.04
C18:3	0.89±0.02	3.92±0.22	0.51 ± 0.17	0.56 ± 0.02	5.23 ± 0.14
C20:0	0.42±0.01	0.31±0.09	0.21 ± 0.05	0.32 ± 0.14	0.37 ± 0.02
C20:1	1.53±0.01	0.40±0.01	0.67 ± 0.08	0.28 ± 0.02	0.59 ± 0.03
C20:2	0.96±0.02	0.42±0.22	0.10 ± 0.02	0.06 ± 0.06	0.26 ± 0.01
C21:0	1.18±0.05	0.84±0.01	0.22 ± 0.02	0.30 ± 0.01	0.60 ± 0.01
C20:3	0.10±0.00	0.92±0.01	0.45 ± 0.09	0.61 ± 0.01	0.96 ± 0.03
C20:4	0.56±0.01	2.30±0.07	1.70 ± 0.32	2.92 ± 0.11	2.72 ± 0.17
C22:0	0.10±0.01	0.80±0.03	0.28 ± 0.03	0.58 ± 0.04	0.75 ± 0.01
C20:5	0.94±0.05	1.48±0.05	5.43 ± 0.22	5.35 ± 0.18	1.61 ± 0.08
C22:2	0.13±0.01	0.12±0.01	0.13 ± 0.01	0.43 ± 0.03	0.11 ± 0.01
C24:0	0.00±0.00	0.00±0.00	0.03 ± 0.06	0.20 ± 0.05	0.00 ± 0.00
C24:1	0.10±0.00	0.00±0.00	0.26 ± 0.02	0.42 ± 0.03	0.07 ± 0.01
C22:5	0.29±0.02	1.99±0.03	3.05 ± 0.13	3.48 ± 0.16	1.63 ± 0.04
C22:6	1.63±0.17	4.57±0.26	8.19 ± 0.32	20.22 ± 0.40	4.68 ± 0.27
Total Fat (%)	6.99±0.05	3.33±0.29	2.15 ± 0.08	1.76 ± 0.20	3.30 ± 0.19
Total Saturated fat (%)	37.27±0.28	38.17±0.38	44.23 ± 0.92	41.42 ± 1.07	40.11 ± 0.37
Total MU fat (%)	41.18±0.40	29.16±0.51	29.12 ± 0.25	18.06 ± 0.33	28.29 ± 0.46
Total PU fat (%)	20.02±0.42	24.86±0.27	21.45 ± 0.73	34.95 ± 0.60	23.87 ± 0.57
Total omega-3 fatty acid (%)	3.46±0.17	9.96±0.09	14.13 ± 0.40	26.13 ± 0.50	11.52 ± 0.41

N.B.: C12:0 (Lauric acid), C13: 0 (Tridecyclic acid), C14:0 (Myristic acid), C14:1 (Myristoleic acid), C15:0 (Pentadecanoic acid), C 15: 1(Pentadecenoic acid), C16:0 (Palmitic acid), C16:1t (Trans Palmitoleic acid), C16:1 (Palmitoleic acid), C17:0 (Heptadecanoic acid), C17:1t (Trans-heptadecenoic acid), C17:1 (Heptadecenoic acid), C18:0 (Stearic acid), C18:1 t (Elaidic acid), C18:1 (Oleic acid), C18:1 (Vaccenic acid), C18:2 (Linoleic acid), C18:3 (α-Linolenic acid), C20:0 (Arachidic acid), C20:1 (Eicosenoic acid), C20:2 (Eicosadienoic acid), C21:0 (Henicosanoic acid), C20:3 (Eicosatrienoic acid), C20:4 (Arachidonic acid), C22:0 (Behenic acid), C20:5 (Eicosapentaenoic acid), C22:2 (Docosadienoic acid), C24:0 (Lignoceric acid), C24:1 (Nervonic acid), C22:5 (Docosapentaenoic acid), C22:6 (Docosahexaenoic acid).

This figure shows the percentages of linoleic acid (C18:2) and linolenic acid (C18:3) in Pabda, Ayer, Poa, Shurma and Chitol. The fish species are shown on the x axis, and the percentage of fatty acid content on the y axis, with adjacent bars for each fish species representing C18:2 and C18:3, respectively. As shown in the data, the figure displays the highest percentage of linoleic acid in Pabda, but a very low percentage of linolenic acid; in contrast, Chitol and Ayer have relatively higher percentages of linolenic acid than the other fish species. On the other hand, Poa and Shurma have low contents of both linoleic and linolenic acid, suggesting a relatively lower contribution of these particular polyunsaturated fatty acids to the overall fatty acid composition of these fish. Figure 1 shows significant variation in the concentrations of C18:2 and C18:3 among the fish species, with Pabda being a good source of linoleic acid and Chitol and Ayer comparatively higher in linolenic acid.

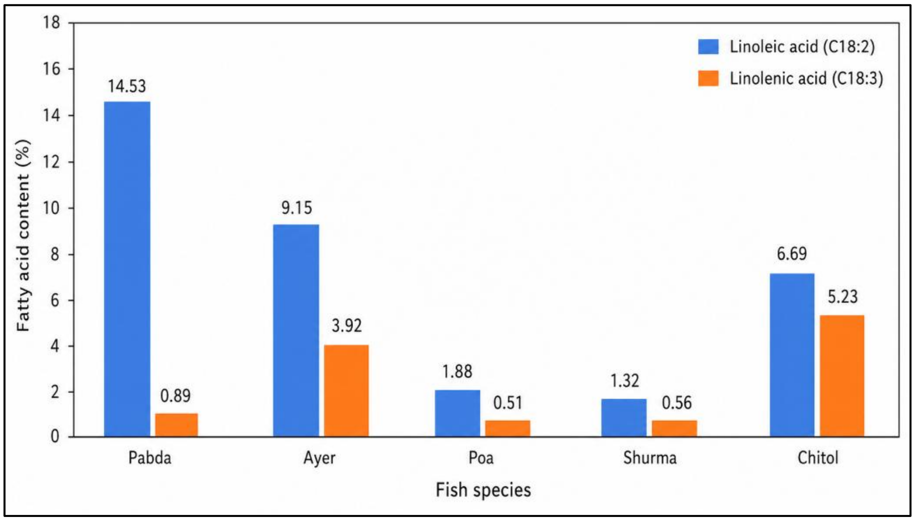

Figure 1. Linoleic acid linolenic acid (EFA) Content of the samples

Table 3 shows the levels of four heavy metals (cadmium (Cd), lead (Pb), nickel (Ni) and chromium (Cr)) in the muscle of five fish species (Pabda, Ayer, Poa, Shurma and Chitol) in ppm. Cadmium and lead were not detected (0.000 ppm) in any of the samples, suggesting that the muscle tissue was free of contamination by these metals. However, nickel and chromium were detected in all species, with concentrations ranging from 0.510 ppm (Chitol) to 0.920 ppm (Pabda) for nickel and 0.373 ppm (Ayer) to 4.140 ppm (Chitol) for chromium. Nickel levels were highest in Pabda, while the highest values of chromium were found in Chitol (compared to other species). Overall, the table shows that while these samples were not contaminated via cadmium or lead, there is significant variation in the nickel and particularly the chromium content of the different species.

Table 3. Heavy metal content of the fish species

Name of the Sample	Cd (ppm)	Ni (ppm)	Pb (ppm)	Cr (ppm)
Pabda	0.00±0.00	0.92±0.06	0.00±0.00	0.41±0.01
Ayer	0.00±0.00	0.55±0.02	0.00±0.00	0.37±0.01
Poa	0.00±0.00	0.55±0.02	0.00±0.00	0.37±0.01
Shurma	0.00±0.00	0.60±0.06	0.00±0.00	1.54±0.01
Chitol	0.00±0.00	0.51±0.09	0.00±0.00	4.14±0.03
Limit	0.5 (FAO, 1983)[19]	0.5 (FAO/WHO,2011)[20]	0.3 (FAO/WHO,2022)[21]	1.0 (FAO/WHO, 2002)[22]

Discussion

Our findings show significant differences in total fat, fatty acid profiles, and heavy metal loads between five popular fish species consumed in Bangladesh. Pabda showed the highest total content of fat, monounsaturated fatty acids (MUFAs), while Poa and Shurma were low in fat, but high in omega-3 polyunsaturated fatty acids (PUFAs), especially eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA). These results are in line with other Bangladeshi studies that show that individual species fall into two broad categories of higher-fat, monounsaturated fatty acid (MUFA)-rich or leaner, polyunsaturated fatty acid (PUFA)-dense fish, even when from the same habitat.[23,24] The dominance of palmitic acid as the principal saturated fatty acid (SFA) and oleic acid as the main MUFA across all species is in line with previous studies of marine and fresh water fish in Bangladesh, where palmitic and oleic acids have been found to constitute the largest fraction of total fatty acids.

In our study, Shurma, Poa and Chitol had significantly greater omega-3 PUFA content than Pabda, despite being leaner overall. This finding is consistent with reports that many Bangladeshi small and medium-sized fish are rich in long-chain n-3 fatty acids per unit of fat, and are effective vehicles for dietary DHA and EPA.[24,25,26] These species are of particular importance in Bangladesh, where fish consumption is high and fish contribute significantly to dietary DHA, iron, zinc and other nutrients. In public-health terms, this justifies species-specific nutrition recommendations that encourage consumption of lean species with high omega-3 content to minimize heart disease risk while limiting total fat intake.[26]

We also observed species-specific variability in the essential fatty acids (linoleic acid, C18:2 and linolenic acid, C18:3), with Pabda being rich in linoleic acid, while Chitol and Ayer were relatively rich in linolenic acid. Similar species-dependent variability of essential fatty acids has been observed in other Bangladeshi marine and estuarine fish species, which may be attributed to differences in their feeding habits, habitat, and food source.[23,25] This highlights the need for dietary diversity in fish consumption to ensure a balanced intake of n-3 and n-6 fatty acids at population level.[26]

In terms of contaminants, both cadmium and lead were undetected, while nickel and chromium were present in variable amounts, with Chitol having the highest level of chromium. Although a number of Bangladesh studies have reported alarming levels of Pb, Cd and other metals in freshwater and market fish, often above international standards, Ni and Cr concentrations are more erratic across species and regions.[27,28] Unlike reports where Pb and Cd often exceed international guidelines,[27] our findings indicate that in these species and sampling location, Cd and Pb were below detection limits, which is encouraging from a toxicological perspective. But the presence of elevated chromium in Chitol is concerning given wider evidence that heavy metals (such as Cr and Ni) are frequently found in native fish and may contribute to non-carcinogenic and carcinogenic risks from chronic ingestion.[28] Overall, our data suggest that widely consumed Bangladeshi fish have considerable nutritional value in terms of essential fatty acid content, including acceptable omega-3 profiles, while also serving as possible vectors for selected metals. From a public-health perspective, this justifies policies that: (i) encourage consumption of omega-3-rich, low-fat species such as Shurma and Poa; (ii) give more sophisticated guidance on high-fat but omega-3-poor species like Pabda; and (iii) prioritize regular monitoring and health-risk assessment for Ni and Cr, especially in species such as Chitol that may be used as bio-indicators of local contamination.[26,27,28]

Conclusion

This study showed that Pabda contained the highest levels of total and monounsaturated fatty acids but the lowest levels of omega-3 polyunsaturated fatty acids, whereas Shurma, Poa, and, to a lesser extent, Chitol were relatively better sources of important omega-3s like EPA and DHA, despite their lower total fat content. Inter-species variation was observed in individual fatty acids, with palmitic acid being the major saturated fatty acid in all species, oleic acid the main monounsaturated fatty acid (highest in Pabda), and the linoleic acid: linolenic acid ratio suggesting Pabda as a strong source of linoleic acid, while Chitol and Ayer were relatively richer in linolenic acid. Metals analysis showed that both cadmium and lead were undetectable in all species, but nickel and chromium were present at varying levels, with Pabda having the highest nickel concentration and Chitol having the highest chromium concentration, indicating that fish can be specifically recommended on the basis of their omega-3 content, and public health advice should include consideration of species with high chromium concentrations.

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Conflict of Interest

The authors declare that there was no conflict of interest.

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