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Food Chemistry 93 (2005) 439–443
Food Chemistry
www.elsevier.com/locate/foodchem

Selected elemental composition of the muscle tissue of three species of fish, *Tilapia nilotica*, *Cirrhina mrigala* and *Clarius batrachus*, from the fresh water Dhanmondi Lake in Bangladesh

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Received 19 January 2004; received in revised form 13 October 2004; accepted 13 October 2004

Abstract

Because lead pollution was recently reported in the fresh water Dhanmondi Lake, in Bangladesh the concentration of selected elements in the flesh of three species of fish, *Tilapia nilotica*, *Cirrhina mrigala* and *Clarius batrachus*, were investigated. The elemental concentrations were determined using atomic absorption spectrometry and the following results (in μg/g-dry weight) were obtained: calcium 4999, sodium 3183, magnesium 2193, iron 131, zinc 60.1, manganese 17.5, copper 5.07, lead 2.08 and nickel 1.91. Since the commission regulation setting maximum lead level for the muscle meat of fish, released from the European Communities (EC), followed by the European Union (EU), is 0.2 mg/kg wet weight, corresponding to 0.96 μg/g dry weight, considerable attention should be paid to the lead content in freshwater fish species in Bangladesh. Furthermore, continuous monitoring of heavy metal concentration in edible freshwater fish will be needed in Bangladesh.

Keywords: Elemental concentration; Freshwater fish; Dhanmondi Lake; Lead contamination

1. Introduction

Concern about the effects of anthropogenic pollution on the freshwater ecosystems is growing. Heavy metals from man-made pollution sources are continually released into aquatic ecosystems. The contamination of heavy metals is a serious threat because of their toxicity, long persistence, bioaccumulation and biomagnification in the food chain (Eisler, 1988). Fish samples can be considered as one of the most significant indicators in freshwater systems for the estimation of metal pollution level (Barak & Mason, 1990; Evans, Dodoo, & Hanson, 1993; Rashed, 2001). In recent years, much attention has been directed to the concentrations of some inorganic elements in freshwater fish and other aquatic organisms (Farkas, Salánki, & Specziár, 2003; Mansour & Sidky, 2002; Moiseenko & Kudryavtseva, 2001). The commercial and edible species have been widely investigated in order to check for those hazardous to human health.

Information on the oral intake of metals from various foodstuffs and other consumables can play a dominant role in controlling and maintaining health. The main foodstuffs of Bangladesh include rice, wheat, vegetables, fruits, meat, fish, eggs, milk and tea. In Bangladesh, fish production has been estimated to be nearly 538,000 ton in 1998 (FAO, 2000). Fish consumptions *per capita* in Bangladesh were 33 g/day in 1963–64 and

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doi:10.1016/j.foodchem.2004.10.021

21 g/day during 1990–91 (Rahman & Haque, 1991). Dhanmondi Lake, which is located in densely populated central Dhaka city, is one of the large lakes of Bangladesh. People near Dhanmondi Lake daily take their freshwater fish from the lake. As Dhaka city becomes more industrially developed, the degree of the pollution in Dhanmondi Lake seems to rapidly become worse. Recently, Ali, Ahsanuzzaman, Badruzzaman, & Rahman (1998) have reported the lead pollution of Dhanmondi Lake. The contaminated fish from this lake may become a public health concern. Therefore, in order to assess the metal contamination of the aquatic environment of the lake, information on elemental concentration in fish species in Dhanmondi Lake becomes of great importance.

In the present work, the concentrations of major-to-trace elements in edible freshwater fish species in Dhanmondi Lake are reported. Moreover, the measured data of this study were assessed by comparing estimates of dietary exposures with recommended dietary allowances (RDA) recommended by the national research council (NRC).

2. Materials and methods

2.1. Sample collection

The freshwater fish species were sampled in May 3, 1999 and May 5, 2000 by a professional fisherman at two stations (Hazaribag and Lalmatia), located at both ends of Dhamnondi Lake. Although a variety of freshwater fish species inhabits this lake, the generally edible ones, *Tilapia nilotica* (Telapia), *Cirrhina mrigala* (Mrigal) and *Clarius batrachus* (Magur), were chosen for the present work. The fish samples were put in plastic bag/containers and transported to the laboratory on the same day. The internal organs, heads and tails of fish, which Bangladeshi in general do not consume, were removed and the edible portions (muscle) were washed with distilled water. After cutting into small pieces with a cleaned stainless steel knife, the small pieces were cleaned several times with demineralized pure water. The samples were dried in an oven at 65 °C for 48 h and were homogenized with a mortar. The powdered samples were dried again at 105 °C in the oven to a constant weight. Finally, the fine samples were preserved in clean and dry polyethylene bottles.

2.2. Chemical analysis

Accurately weighted fish samples (about 2 g) were treated with 10 ml of 14 M nitric acid, 5 ml of 13 M perchloric acid and 5 ml of demineralized pure water in a Teflon decomposition vessel. The vessel was put in a stainless steel container and heated for 2 h at 150 °C in an electric oven. After decomposition, the solution was evaporated down to about 5 ml in a Teflon beaker by heating with a hot plate. Finally, the solution was transferred to a 100 ml volumetric flask and diluted to volume with demineralized pure water. The elemental concentrations in the solution were measured with a Pye Unicam SP-2900 flame atomic absorption spectrophotometer with hollow cathode lamp (calcium, copper, iron, magnesium, manganese, nickel and sodium) and electrodeless discharge lamp (lead and zinc). The standard solutions were prepared in 0.1 N perchloric acid.

Table 1
Analytical results of standard reference materials MA-A-2 (TM) and MA-B-3 (TM) from IAEA

Metal	Concentration (µg/g-dry wt)		Relative variance (%)
	Observed	Certified value	
MA-A-2 (TM)			
Fe	52.3 ± 0.8	54.0 ± 1.0	−3.2
Zn	33.5 ± 0.5	33.0 ± 1.0	+1.5
Mn	0.80 ± 0.01	0.81 ± 0.04	−1.2
Cu	4.13 ± 0.03	4.0 ± 0.1	+3.3
Pb	0.60 ± 0.03	0.58 ± 0.07	+3.5
Ni	1.08 ± 0.03	1.10 ± 0.20	−1.8
MA-B-3 (TM)			
Ca	3550 ± 100	3490 ± 210	+1.7
Na	2225 ± 125	2160 ± 155	+3.0
Mg	1115 ± 70	1130 ± 80	−1.3
Fe	98.80 ± 4.70	95.40 ± 9.95	+3.6
Zn	103.2 ± 4.6	109.2 ± 2.78	−5.5
Cu	3.17 ± 0.45	3.08 ± 0.36	+2.9
Pb	4.80 ± 0.57	4.62 ± 0.64	+3.9

$n = 3$.

The analytical performance was evaluated using two standard reference materials, fish flesh homogenate MA-A-2 (TM) and fish tissue (lyophilized) MA-B-3 (TM), from the international laboratory of marine radioactivity of IAEA, Monaco. The elemental concentrations determined in standard reference materials were in good agreement with the certified values, as shown in Table 1.

3. Results and discussion

Although many researchers have presented the elemental contents in various tissues, such as liver, kidneys, gills, gonads and muscles, of fish (Moiseenko & Kudryavtseva, 2001; Mzimela, Wepener, & Cyrus, 2003), in the present work only fish muscles were evaluated for the elemental concentration since Bangladeshis do not habitually consume other parts. Calcium, copper, iron, lead, magnesium, manganese, nickel, sodium and zinc were selected as the analyte elements from the viewpoint of the industry type near the lake and the metal pollution anticipated. Table 2 presents the elemental concentrations in muscle tissues of freshwater fish in Dhanmondi Lake. The rough content orders were: cal-

Table 2
Elemental concentration in freshwater fish samples in Bangladesh

Sample No.	Scientific name	Local name	Sampling site	Ca	Na	Mg	Fe	Zn	Mn	Cu	Pb	Ni
Sampling date: May 3, 1999												
1	*Telapia nilotica*	Telapia	Site A	4580 ± 90	4030 ± 50	2090 ± 20	110 ± 5	56.3 ± 1.3	17.8 ± 0.5	5.57 ± 0.25	2.10 ± 0.20	1.25 ± 0.13
			Site B	3650 ± 100	3730 ± 70	2060 ± 20	71 ± 7	52.8 ± 1.6	17.2 ± 0.1	4.80 ± 0.21	1.97 ± 0.14	1.87 ± 0.15
2	*Cirrhina mrigala*	Mrigal	Site A	6220 ± 110	3210 ± 90	2350 ± 30	131 ± 5	73.4 ± 1.6	19.6 ± 1.1	4.26 ± 0.01	2.55 ± 0.27	1.88 ± 0.15
3	*Clarius batrachus*	Magur	Site B	4030 ± 130	2950 ± 120	2120 ± 30	112 ± 9	47.2 ± 1.6	8.8 ± 0.3	5.23 ± 0.01	0.75 ± 0.01	2.76 ± 0.37
Sampling date: May 5, 2000												
1	*T. nilotica*	Telapia	Site A	4230 ± 120	3530 ± 150	2200 ± 30	134 ± 6	60.0 ± 2.1	15.9 ± 0.9	5.50 ± 0.43	2.25 ± 0.16	1.88 ± 0.15
			Site B	5030 ± 110	4580 ± 180	2120 ± 30	99 ± 3	64.3 ± 2.5	19.6 ± 0.9	6.12 ± 0.28	2.70 ± 0.18	0.93 ± 0.07
2	*C. mrigala*	Mrigal	Site A	5480 ± 170	3810 ± 160	2060 ± 20	128 ± 3	70.5 ± 2.2	19.1 ± 0.1	3.55 ± 0.01	2.63 ± 0.18	1.98 ± 0.01
			Site B	6570 ± 80	4130 ± 90	2170 ± 50	186 ± 4	59.2 ± 2.3	19.8 ± 1.1	3.95 ± 0.19	2.78 ± 0.21	1.89 ± 0.01
3	*C. batrachus*	Magur	Site A	5430 ± 160	4580 ± 160	2560 ± 30	176 ± 4	60.6 ± 2.7	14.0 ± 1.8	6.10 ± 0.19	1.50 ± 0.12	2.77 ± 0.30
			Site B	4770 ± 100	3580 ± 100	2200 ± 40	163 ± 7	56.4 ± 1.9	23.5 ± 0.9	5.57 ± 0.52	1.58 ± 0.13	1.94 ± 0.20
			Range	3650–6570	2950–4580	2060–2560	71–186	47.2–73.4	8.8–23.5	3.55–6.12	0.75–2.78	0.93–2.77
			Mean	4999 ± 940	3813 ± 535	2193 ± 155	131 ± 36	60.1 ± 7.8	17.5 ± 4.0	5.07 ± 0.89	2.08 ± 0.64	1.91 ± 0.56

Unit: μg/g dry weight.

cium > sodium > magnesium > iron > zinc > manganese > copper > lead and nickel. These sequences were the same as those obtained in Malibu Lagoon, California (Moeller, MacNeil, Ambrose, & Hee, 2003). The elemental concentrations in *Telapia nilotica* and *Cirrhina mrigala* at the sampling site A in 1999 were very similar to those in 2000. This means that the water quality near the site A hardly changed during the year. The broad distributions of concentration were lead with a relative standard deviation (RSD) of 31%, nickel with 29% and iron with 27%. On the other hand, narrow distributions were magnesium with 7%, zinc with 13% and sodium with 14%. The broad distributions of lead and nickel in freshwater fish in Dhanmondi Lake may be associated with the main sources of them in Dhanmondi Lake which are anthropogenic, for example, motorized vehicles using leaded gasoline. The ranges of international standards for fish are: zinc approximately 192–480, copper 48–480, lead 2.4–48 μg/g-dry weight (Yamazaki, Tanizaki, & Shimokawa, 1996), provided that the conversion factor (wet/dry weight) is 4.8. The elemental concentration levels of freshwater fish in Dhanmondi Lake seem to be close to the international standards.

In order to evaluate the elemental concentrations in the freshwater fish muscle tissues in Dhanmondi Lake, we tried to compare the measured values with those in muscle tissues obtained at other places, as shown in Table 3. The elemental concentrations in the freshwater fish of different rivers in Bangladesh were investigated in 1993 (Sharif, Alamgir, Mustafa, Hossain, & Amin, 1993). The results were similar to our values. However, the concentrations of iron, zinc, manganese, copper, lead and nickel in the freshwater fish in Dhanmondi Lake was much higher than those in Lake Kasumigaura, Japan.

In Bangladesh, the recent average *per capita* consumption of both freshwater and sea fish species was 21 g/person/day for males and females of all ages (Rahman & Haque, 1991). Since only the elemental concentration in the muscle of freshwater fish was measured in the present study, the dietary intake of elements from fish for Bangladeshi people can not be estimated. However, so as to know the contribution of the dietary intake from fish to RDA, the estimation was forced to use a calculation employing the recent average *per capita* consumption (21 g). The results are shown in Table 4. Compared to RDA proposed by the NRC and the World Health Organization (WHO), the estimated dietary intake from fish will constitute 0.55–6.3%. Therefore, it seems that the contributions of the dietary intake from fish to RDA do not become a serious problem. However, the European Communities (EC, 2001), followed by the European Union (EU), released a commission regulation, setting maximum levels for certain contaminants in foodstuffs, which included 0.2 mg/kg wet weight

Table 3
Comparison of elemental concentrations in freshwater fish muscle

Metal	Elemental concentration (μg/g dry wt)								
	Dhanmondi Lake (present work)	Rivers[a] (Bangladesh)	Kola Region[b] (Russia)	Duy Minh[c] (Vietnam)	Ataturk Dam Lake[d] (Turkey)	Nasser Lake[e] (Egypt)	Kolleru Lake[f] (India)	Malibu Lagoon[g] (California)	Lake Kasumigaura[h] (Japan)
Ca	4999	16,924	–	560	–	–	–	7600–22,000	–
Na	3813	3192	–	–	–	–	–	360–4000	–
Mg	2193	1760	–	–	–	–	–	270–1400	–
Fe	131	133	–	51	0.23–29.4	2.18	–	23–90	3.43
Zn	60.1	76.8	20–34	29	2.06–27.8	0.63	37–43	3.2–66	5.44
Mn	17.5	15.7	0.78–2.77	2.6	0.10–16.4	0.03	–	2.1–22	0.24
Cu	5.07	5.34	1.58–2.40	1.8	0.05–4.29	0.26	28–38	1.7–6.0	0.29
Pb	2.08	2.66	–	0.25	BDL	–	1.84–2.11	0.3–4.1	0.03
Ni	1.91	2.43	0.69–1.95	0.3	BDL	0.06	0.18–0.24	0.3–1.0	0.04

BDL, below detection limit.
[a] Sharif et al. (1993).
[b] Moiseenko and Kudryavtseva (2001).
[c] Wagner and Bomam (2003).
[d] Karadede and Ünlü (2000).
[e] Rashed (2001).
[f] Sekhar et al. (2003).
[g] Moeller et al. (2003).
[h] Alam et al. (2002).

Table 4
Comparison of the dietary intakes of metals from fish with the recommended dietary allowances

Metal	Concentration (μg/g-dry wt)	Estimated intake (mg/day/person)	Dietary allowance[a]		Contribution (%)
			(mg/day/person)	References	
Ca	4999	24.0	800[a]	NRC (1989)	3.0
Na	3813	18.3	1100–3300[b]	NRC (1989)	0.55–1.7
Mg	2193	10.5	300–350[a]	NRC (1989)	3.0–3.5
Fe	131	0.629	10–18[a]	NRC (1989)	3.5–6.3
Zn	60.1	0.288	15[a]	NRC (1989)	1.9
Mn	17.5	0.084	2.0–5.0[b]	NRC (1989)	1.7–4.2
Cu	5.07	0.0243	1.5–3.0[b]	NRC (1989)	0.81–1.6
Pb	2.08	0.00998	0.21[c]	JECFA (1993)	4.2
Ni	1.91	0.00917	0.30[d]	WHO (1996)	3.1

The average *per capita* consumption of fish was 21 g-wet wt/person/day. Conversion factor (wet/dry weight): 4.8.
[a] Recommended dietary allowance.
[b] Estimated safe and adequate daily dietary intake.
[c] Provisional tolerable intake 60 kg body weight.
[d] Average daily intake from food.

lead level for the muscle meat of fish. Since, the lead content in the muscle of freshwater fish corresponded to 0.43 μg/g-wet weight, careful attention should be paid to edible freshwater fish species in Bangladesh. Moreover, continuous monitoring of metals such as lead and nickel will be needed because lead pollution of Dhanmondi Lake has been reported (Ali et al., 1998).

The concentrations of major-to-trace elements in edible freshwater fish species in Dhanmondi Lake, Bangladesh were investigated. The elemental lead contents in the freshwater fish muscle tissues were close to the range of international standards of fish. The broad distributions of concentrations in freshwater fish muscle tissues were: lead with RSD of 31%, nickel with 29% and iron with 27%. Because the pollution level of Dhanmondi Lake seems to become worse as Dhaka city becomes more industrially developed, information on the background levels of metals in the common fish species will continue to be needed, contributing to the effective monitoring of both environmental quality and the health of organisms inhabiting the lake ecosystem.

Acknowledgements

The authors are grateful to the Chairman, Department of Applied Chemistry and Zoology, University of Dhaka, and also to the Director of Training Institute for Chemical Industries (TICI), Ghorasal, Bangladesh for providing the laboratory facilities during the progress of this work. A part of the present work was performed at Mie University, Satellite Venture Business laboratory (SVBL).

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