Journal of Food Quality and Hazards Control 8 (2021) 96-103

Proximate Compositions and Risk Assessment of Lead in Two Common Fishes (*Labeo rohita* and *Barbonymus gonionotus*) Collected from River and Farms of Bagerhat, Bangladesh

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HIGHLIGHTS

- High nutritional values were found in *Labeo rohita* and *Barbonymus gonionotus* fishes.
- Lipid content was decreased after freezing the fish due to oxidation of lipid.
- Carcinogenic risks were observed due to presence of lead in the fish sample.

Article type
Original article

Keywords
Nutritive Value
Lead
Metals, Heavy
Risk Assessment
Fishes
Bangladesh

Article history
Received: 18 Oct 2020
Revised: 7 Feb 2021
Accepted: 20 Feb 2021

Acronyms and abbreviations
EDI=Estimated Daily Intake
HI=Hazard Index
TCR=Target Cancer Risk
THQ=Target Hazard Quotient

ABSTRACT

Background: Among the local fish species in Bangladesh, *Labeo rohita* and *Barbonymus gonionotus* are two popular fish species. The present work focused on proximate compositions (moisture, protein, fat, and ash) and risk assessment of lead in two common fishes (*L. rohita* and *B. gonionotus*) collected from river and farms of Bagerhat, Bangladesh. Furthermore, effect of freezing condition on fish lipid was studied.
Methods: Proximate compositions of the fish samples were determined according to conventional methods. The lead contents were analyzed by wet digestion method using an atomic absorption spectrophotometer. The health risks models such as Estimated Daily Intake (EDI), Target Hazard Quotient (THQ), Hazard Index (HI), and Target Cancer Risk (TCR) were conducted for health risk assessment of the local people. Data were analyzed using SPSS software (version 16.0).
Results: A positive correlation was found between moisture-protein and lipid-ash of the *L. rohita* fish. Besides, a positive relation was observed in ash-moisture, and lipid-protein for *B. gonionotus*. The lead content in river *L. rohita*, farm *L. rohita*, river *B. gonionotus*, and farm *B. gonionotus* was observed as 9.00, 9.20, 8.29, and 6.39 mg/kg, respectively. The lead content found in the fish species were above the permissible limit. The TCR revealed the carcinogenic effects to the local people due to exposure of lead.
Conclusion: This study reflects some data about proximate values of *L. rohita* and *B. gonionotus* fishes. The concentrations of lead in the fish samples were above the safe limits, and may have carcinogenic effects of the local consumers in Bagerhat, Bangladesh.

Introduction

Fish is an important dietary component that contributes about 16% of animal protein as well as 6% of the total protein for human being. It is also the richest source of essential, non-essential amino acids, and ω-3 polyunsatu-

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To cite: Khan M.A.R., Islam M.S., Mamun M.S.A. (2021). Proximate compositions and risk assessment of lead in two common fishes (*Labeo rohita* and *Barbonymus gonionotus*) collected from river and farms of Bagerhat, Bangladesh. *Journal of Food Quality and Hazards Control*. 8: 96-103.

DOI: 10.18502/jfqhc.8.3.7195 Journal website: http://jfqhc.ssu.ac.ir

rated fatty acids including eicosapentaenoic acid and docosahexaenoic acid (Ayanda et al., 2019; Elnabris et al., 2013; Khan et al., 2018; Njinkoue et al., 2016; Strateva et al., 2021). The polyunsaturated fatty acids show biological functions in human body like prevention of cancers, heart diseases, and rheumatoid arthritis. Minerals in fish maintain acid-base and water balance, and accelerate hemoglobin, bone, and teeth formation. Also, minerals catalyze many biological processes in human body (Clandinin et al., 1997; Duran et al., 2010; Mendil et al., 2010; Raatz et al., 2013).

Beside these, fish tissues also contain non-essential trace elements like heavy metals (Khan et al., 2019; Makwinja and Geremew, 2020). Globally, aquatic bodies are being mostly contaminated by these heavy metals that are not degraded through any biological changes and can persist in nature for long time. The elevated level of heavy metals in aquatic environment is due to rapid growth of industrialization (Bibak et al., 2018; Rahimzadeh and Rastegar, 2017). Moreover, industrial, agricultural, and mining activities may also increase the level of heavy metals. Consequently, these metals are accumulated with the aquatic species (especially fish) and are transferred to consumers (Naghipour et al., 2016). These heavy metals damage different organs (liver, kidney, and heart) in human body (Sadeghi et al., 2015). Among the heavy metals, lead is most concern due to its toxic in nature. Generally, the exposure of lead cause anemia, renal disorder, reproductive problem, disorder of hematopoietic system, disorder of nervous system, kidneys damage, and cancers (Derakhshan et al., 2016; Sayadi et al., 2017).

Among the local fish species in Bangladesh, *Labeo rohita* and *Barbonymus gonionotus* are two popular fish species locally known as Rui and Chinese Punti, respectively (Hossain and Ali, 2014). However, anthropogenic activities are among alarming issues that may enter the toxic metals in aquatic environments in this area. To date, few data is available regarding nutritional value and chemical hazard safety of these two fishes consumed in Bagerhat district of Bangladesh. Hence, the present work focused on proximate compositions and risk assessment of lead in two common fishes (*L. rohita* and *B. gonionotus*) collected from river and farms of Bagerhat, Bangladesh. Furthermore, effect of freezing condition on fish lipid was studied.

Materials and methods

Study area

Bagerhat is a coastal district under Khulna division located in Southern part of Bangladesh. Bagerhat Sadar Upazila has a total area of 272.73 km^2. It is bounded by Fakirhat and Chitalmari Upazilas on the North, Morrelganj Upazila on the South, Kachua Upazila on the East, Rampal and Fakirhat Upazila on the West of country.

Sample collection

During December 2016, fresh fishes, *L. rohita* (Rui) and *B. gonionotus* (Chinese Punti) were collected from the Daratana River in Bagerhat, Bangladesh. The same fish species were also collected from the farm sites locally known as Gher. Physical appearances such as body weight, height, length, and width were measured to ensure the similar characteristics of the fishes. The fish were collected in polyethylene bags and were kept into an icebox. All the fish species were immediately transported to the laboratory, and the proximate compositions were estimated, using fresh fish samples.

Analysis of proximate compositions

Proximate compositions were determined according to conventional methods (Mazumder et al., 2008). For this purpose, the percentage of moisture, protein, fat, and ash of the fish samples were separately determined.

Analysis of lead content

For the analysis of lead content, 15 ml of tri-acid mixture (70% HNO_3, 65% $HClO_4$, and 70% H_2SO_4; 5:1:1; Merck, Germany) was added to the beaker containing a fixed amount of (1 g) dry fish sample. Then, the obtained mixture was digested at 80 ^oC until a transparent solution was obtained. The digested solutions were filtered using Whatman no. 42 filter paper after cooling the solution. The filtrate was diluted to 50 ml with deionized water (RCI Labscan Limited, Thailand) and was analyzed using an atomic absorption spectrophotometer (Shimadzu model AA-7000, Japan) for the quantification of lead in the fish samples (Khan et al., 2019).

Risk assessment of lead

-Estimated Daily Intake (EDI)

The consumption of contaminated foods is the major reason for the exposure of heavy metals to human organs that cause carcinogenic and non-carcinogenic conditions. For this reason, the effects of lead in human body were assessed by the following health risk model. The EDI (mg/kg/day) value of lead was evaluated, using the following equation:

$$EDI=\frac{C_m \times I_g \times C_f}{W_b}$$

[DOI: 10.18502/jfqhc.8.3.7195]

Where, C_m is the concentration of lead (mg/kg dry weight), I_g is the ingestion rate of fish for Bangladeshi people (62.58 g/day), W_b is the average body weight of Bangladeshi people (49.5 kg), and C_f is the conversion factor (Khan et al., 2021).

-Target Hazard Quotient (THQ)

The THQ was calculated, using the following formula:

$$THQ=\frac{EDI}{R_fD}$$

Where, R_fD is the reference dose of lead. The R_fD value of lead was considered as 0.0036 mg/kg/day (Rezaei et al., 2021).

-Hazard Index (HI)

The HI was analyzed by the following equation (Rezaei et al., 2021).

$$HI=\sum THQ=THQ$$

-Target Cancer Risk (TCR)

The TCR ($mg^2/kg^2/day^2$) was calculated by the following formula:

$$TCR=EDI\times S_{csf}$$

Where, S_{csf} is the carcinogenic factor of lead (0.0085 mg/kg body weight/day) according to Ara et al. (2018) and Rezaei et al. (2021).

Analysis of lipid in frozen fish

The fish species *L. rohita* (Rui) collected from river was investigated for the lipid change after several days of freezing. For this reason, fish samples with whole body were preserved in a refrigerator (ECO Plus, China) at -18 °C for 50 days and lipid contents were estimated after 10 days (0, 10, 20, 30, 40, and 50 days) interval based on conventional methods (Mazumder et al., 2008).

Statistical analysis

The proximate compositions of the fish samples were compared using one-way analysis of variance (ANOVA). Moreover, inter-component relationships of proximate compositions of the samples were determined using Pearson correlations. The mean and standard deviations were also calculated. All the data were analyzed using SPSS software (version 16.0). The significance level was considered as $p<0.05$.

Results

The experimental data showed that there was no significant ($p>0.05$) difference between moisture, ash, protein, and lipid content of two analyzed fish species. The moisture, ash, protein, and lipid content in *L. rohita* collected from river were estimated as 76.60, 4.30, 16.19, and 2.06%, respectively. In the same analysis, the percentages of moisture, ash, protein, and lipid in *L. rohita* collected from farm site were found as 76.0, 5.45, 16.19, and 2.36%, respectively. The moisture, ash, protein, and lipid content in *B. gonionotus* collected from river were estimated as 76.2, 4.75, 11.37, and 7.68%, respectively. Also, the percentage of moisture, ash, protein, and lipid was determined as 72.40, 4.60, 14.10, and 8.90%, respectively.

Pearson correlation analysis revealed a positive correlation between moisture-protein and lipid-ash of the *L. rohita* fish (Table 1). Besides, a positive correlation was observed in ash-moisture, and lipid-protein for *B. gonionotus.*

The lipid content of *L. rohita* was estimated after preservation at low temperature. The average value of lipid in fresh fish was determined as 2.06±0.02. The average lipid estimated after 10, 20, 30, 40, and 50 days was noticed as 2.01±0.01, 1.94±0.01, 1.91±0.01, 1.85±0.02, and 1.82±0.01%, respectively. The lipid contents of fresh fish and frozen fish were statistically correlated (Pearson correlation) and it was found that there was no significant correlation between lipid of fresh fish and frozen fish. Negative correlations were observed between lipid of fresh fish-lipid of frozen fish after 20 days ($p=0.333$) and lipid of fresh fish-lipid of frozen fish after 50 days ($p=0.667$) where, correlation is significant at the 0.01 level (2-tailed).

The concentrations of lead in river and farm *L. rohita* fish were 9.00 and 9.20 mg/kg, respectively; whereas the content of this metal for river and farm *B. gonionotus* fish were estimated as 8.29 and 6.39 mg/kg, respectively. Moreover, the THQ values for river *L. rohita*, farm *L. rohita*, river *B. gonionotus*, and farm *B. gonionotus* were obtained as 7.4×10^{-1}, 7.8×10^{-1}, 6.9×10^{-1}, and 6.2×10^{-1}, respectively. Furthermore, the TCR values for the four mentioned fish groups were 6.3×10^{-3}, 6.6×10^{-3}, 5.9×10^{-3}, and 5.3×10^{-1} $mg^2/kg^2/day^2$, respectively. The EDI and HI values of all studied groups are indicated in Table 2.

Discussion

The analysis of main four constituents of fish (protein, moisture, lipids, and ash) is described as approximate composition analysis. Various carbohydrates and non-protein parts are also essential elements in fish compositions, but due to their small quantity sometimes they are ignored during analysis (Ali et al., 2006). In the current study, four main constituents of *L. rohita* and *B. gonionotus* fish collected from Bagerhat, Bangladesh were analyzed which are comparable with some other studies in the literature (Table 3).

[DOI: 10.18502/jfqhc.8.3.7195]

Table 1: Pearson correlations of proximate compositions in two studied fishes (*Labeo rohita* and *Barbonymus gonionotus*) collected from Bagerhat, Bangladesh

	Moisture	Ash	Protein	Lipid
Labeo rohita				
Moisture	1			
Ash	-1.000 *	1		
Protein	1.000 *	-1.000 *	1	
Lipid	-1.000 *	1.000 *	-1.000 *	1
Barbonymus gonionotus				
Moisture	1			
Ash	1.000 *	1		
Protein	-1.000 *	-1.000 *	1	
Lipid	-1.000 *	-1.000 *	1.000 *	1

* Correlation is significant at the 0.01 level (2-tailed).

Table 2: Estimated Daily Intake (EDI) and Hazard Index (HI) of lead for the fish consumers in Bagerhat, Bangladesh

Fish name	Collection area	Concentration of lead (mg/kg)	EDI (mg/kg/day)	HI	Safe limit of lead (mg/kg) *
Labeo rohita	River	9.00	0.00266	7.4×10^{-1}	0.5
	Farm	9.20	0.00279	7.8×10^{-1}	0.5
Barbonymus gonionotus	River	8.29	0.00249	6.9×10^{-1}	0.2
	Farm	6.39	0.00223	6.2×10^{-1}	2

* Source: El-Moselhy et al. (2014)

Table 3: Comparison of proximate compositions of *Labeo rohita* and *Barbonymus gonionotus* fishes in some previous studies

Species	Country	Moisture (%)	Ash (%)	Protein (%)	Lipid (%)	Reference
L. rohita (wild)	Pakistan	75.50-77.56	0.58-0.80	16.62-17.76	1.30-1.94	(Mahboob et al., 2004)
L. rohita (Farm)		71.68- 75.40	1.01- 1.23	17.81- 20.68	2.32- 4.14	
L. rohita (wild)	India	78.93	2.13	17.33	1.60	(Sharma et al., 2010)
L. rohita (Farm)		75.46	2.20	18.00	4.33	
L. rohita	Pakistan	72.10	1.21	23.57	3.11	(Memon et al., 2011)
L. rohita	Bangladesh	77.06	1.24	18.55	1.29	(Akter et al., 2020)
B. gonionotus	Bangladesh	69.16	3.31	17.50	9.38	(Zaman et al., 2014)
L. rohita		77.86	2.76	16.82	2.37	
B. gonionotus	Bangladesh	76.20	1.60	18.40	4.40	(Bogard et al., 2015)
L. rohita		77.70	1.00	18.20	3.00	
B. gonionotus (River)	Bangladesh, Bagerhat	76.20	4.75	11.37	7.68	Present study
B. gonionotus (Farm)		72.40	4.60	14.10	8.90	
L. rohita (River)		76.60	4.30	17.04	2.06	
L. rohita (Farm)		76.00	5.45	16.19	2.36	

Generally, the body composition of fish is suitable indicator for the assessment of fish quality (Ahmed, 2007). In this experiment, farm *L. rohita* possessed higher ash (5.45%) and lipid (2.36%) contents than its river type. But the moisture and protein content of river *L. rohita* were slightly higher than those in farm fish. Generally, the higher protein content is found in farm fishes compared to river ones (Zaman et al., 2014). But

[DOI: 10.18502/jfqhc.8.3.7195]

the findings showed that the protein content of river *L.* due to spawning period of fish (Jim et al., 2017). We also found that *L. rohita* fish contained more lipid and lower moisture than the river *L. rohita* that is predictable. Because, normally, high-lipid fish have less water content than low-lipid fish (Jim et al., 2017). Mahboob et al. (2004) carried an analysis on wild and farm *L. rohita* in Pakistan. It was observed that the ranges of ash and lipid contents were higher in farm *L. rohita* than in wild fish. Moreover, the moisture of wild and farm *L. rohita* were ranged from 75.50-77.56% and 71.68-75.40%, respectively. These results support this study. But the protein content of farm *L. rohita* was comparatively higher than wild species. In another study, Sharma et al. (2010) investigated the proximate compositions of wild and farm *L. rohita* in India. The moisture, ash, protein, and lipid contents were 78.93, 2.13, 17.33, and 1.60% for wild *L. rohita*, and 75.46, 2.20, 18.00, and 4.33% for farm *L. rohita*. They found that only the moisture content of wild species was comparatively higher than farm species.

In this study, the moisture and ash content of river *B. gonionotus* was exceeded the moisture and ash content of farm *B. gonionotus*. High level of body lipid decreases the body moisture and ash contents (Satpathy et al., 2003). In farm *B. gonionotus*, the elevated content of lipid (8.90%) was noticed. Therefore, lower percentage of moisture (72.40%) and ash (4.60%) was found in farm *B. gonionotus* than in river one. Zaman et al. (2014) showed that the percentage of moisture, ash, protein, and lipid was found as 69.16, 3.31, 17.50, and 9.38%, respectively in *B. gonionotus* (Table 3). The percentage of ash and lipid in the present result were fairly closed to this previous study. But, the variations were observed for moisture and protein contents from the study carried by Zaman et al. (2014). On the other hand, the percentage of moisture (76.20%) in *B. gonionotus* conducted by Bogard et al. (2015) was similar to the present findings (76.20% for river).

Fish species can be classified into four categories based on the percentage of fat, including lean fish (<2%), low fat (2-4%), medium fat (4-8%), and high fat (>8%) as indicated by Ayanda et al. (2019). According to the class, *L. rohita* both river and farm are considered as low fatty fish, while river and farm *B. gonionotus* are classified as medium and high fatty fish, respectively. Zaman et al. (2014) showed that higher percentage of protein is found in farm and marine fishes as comparing with the river fish in Dhaka, Bangladesh which is in agreement with findings of the present research. It should be highlighted that the total lipid contents is affected by increasing age, size, weight, and habitant origin of the fish, as well as season (Hussain et al., 2011).

Among four types of studied fishes, the maximum moisture content was estimated in rive *L. rohita* was somewhat high. This variation might be arisen (76.60%), and the lowest amount was noticed in farm *B. gonionotus* (72.40%). This higher moisture content in non-fatty muscles may be resulted from fasting condition due to the utilization of protein content in various metabolic activities. Moreover, the variation of moisture depends on pond ecosystems and fertilization (Sikandar et al., 2020). Moisture is the main ingredients in edible fish parts. Polyunsaturated fatty acids are degraded by microorganisms in presence of higher content of moisture in fish fillet. Consequently, the fish quality is reduced for longer periods of preservation (Olagunju et al., 2012). Therefore, the river *L. rohita* may loss its quality for long period of preservation due to the higher content of moisture.

The lowest (2.06%) and highest (8.90%) lipid content was found in river *L. rohita* and farm *B. gonionotus*, respectively. The lipid content may fluctuate due to seasonal and geographic location of fish species (Akter et al., 2020). The ash content is the measure of minerals like magnesium, calcium, potassium, and zinc in the fish (Ayanda et al., 2019). In the current work, the river and farm *L. rohita* showed the lowest (4.30%) and highest (5.45%) ash content, respectively. Zaman et al. (2014) compared the proximate compositions of two fish species farm *L. rohita* and farm *B. gonionotus*. The results showed that the percentage of ash, protein, and moisture were lower in *L. rohita*, whereas higher percentage of moisture was noticed in *B. gonionotus*. Same results were found in another experiment carried by Bogard et al. (2015) which is indicated in Table 3. The present results showed that river *B. gonionotus* contained lower percentage of moisture and protein, comparing to river *L. rohita*. On the contrary, farm *L. rohita* possessed with higher percentage of ash and protein content. These fluctuations may be due to influence of various factors such as biological variations, seasonal changes, environmental condition, water depth, water quality, feeding rate, geographical locations, and food habit (Ahmed, 2007; El-Naggar et al., 2019; Jim et al., 2017; Yeannes and Almandos, 2003). Even, the body compositions of fish are varied from one species and one individual to another due to sex and age of fish (Njinkoue et al., 2016). So, it is essential to explore the food habit and food organisms of the fish species for the prediction of nutritional value.

The *L. rohita* fish collected from river was investigated for the lipid content change after several days of freezing. In the present research, the average fish lipid in fresh sample was estimated as 2.06±0.02%. The lipid contents after 0, 10, 20, 30, 40, and 50 days were found as 2.06±0.02, 2.01±0.01, 1.94±0.01, 1.91±0.01, 1.85±0.02, and 1.82±0.01%, respectively. From these observations, it was noticed that the decrease of lipid contents were similar in the duration of 10-20 days and 30-40 days,

[DOI: 10.18502/jfqhc.8.3.7195]

whereas similar type of results were observed in the duration of 20-30 days and 40-50 days. The results revealed that the lipid content of fish was decreased after ten days interval. This lipid content might be varied with the change of temperatures and freezing time. During the freezing time, various changes are noticed such as protein denaturation and lipid hydrolysis (Akter et al., 2020). Mainly, the presence of different endogenous enzymes are responsible for the damage of frozen fish (Aubourg et al., 2007). Enzymatic hydrolysis of unsaturated fatty acids is also responsible for the lipid deterioration. The peroxide value, thiobarbituric acid, and free fatty acids are increased during the frozen storage. Furthermore, the lipid oxidized products also influence the soluble proteins in frozen fish (Nazemroaya et al., 2009). From the above results, gradual decrease of lipid contents was found in river *L. rohita* after freezing this species.

The present research manifested that the concentrations of lead in river and farm *L. rohita* fish was 9.00 and 9.20 mg/kg, respectively. At the same time, the content of this metal was found as 8.29 and 6.39 mg/kg in river and farm *B. gonionotus*, respectively. Comparing these values with the permissible limit of lead, it was noticed that the findings were above the safe limit (Table 2). In this study, the level of lead contents in river and farm *B. gonionotus* were comparatively lower than the river and farm *L. rohita*. These variations might be arisen due to feeding as well as habitat behavior of *B. gonionotus*. This fish species intakes algae and submerged plants as a primary consumer at a lower tropic level in the aquatic environments, whereas *L. rohita* is a column-surface feeder in aquatic environments (Sarder et al., 2011; Yaakub et al., 2017). Therefore, due to lower bio magnification might result in lower bioaccumulation of lead content comparing to *L. rohita* (Yaakub et al., 2017).

Mastan (2014) carried an analysis on *L. rohita* in India for the estimation of lead content that the level of lead was found as 0.22 mg/kg. In another study, Adhikary et al. (2019) found the level of lead in *L. rohita* as 0.23-1.84 mg/kg. The present study reflects the higher content of lead in *L. rohita*. Yasmeen et al. (2016) traced the lead content of *L. rohita* as 0.03±0.02 mg/kg. Junejo et al. (2019) showed an analysis on *L. rohita* and estimated the lead content with the range of 2.07-7.26 mg/kg. Kumari et al. (2018) analyzed the lead content in *L. rohita* and it was ranged from 7.78 to 13.73 mg/kg. In another study, the lead content in *L. rohita* was traced as 6.98±0.23 mg/kg (Ahmed et al., 2016). Hashim et al. (2014) quantified the level of lead content in *B. gonionotus* and noticed that the lead content was traced as 0.07±0.12 mg/kg. Yaakub et al. (2017) found the lead content in *B. gonionotus* as 0.006±0.008 mg/kg. From the above results, it was noticed that the lead contents were varied in fish species depending on species, feeding habit, maturity, length, and size of fish species (Kumari et al., 2018).

The lowest values of EDI for lead was recorded in farm *B. gonionotus*, while the highest ones was observed in farm *L. rohita* (Table 2). The EDI values for lead was less than the corresponding reference doses (D_f) for *L. rohita* and *B. gonionotus* collected from river and farm sites. It has been revealed that when the EDI/D_f level is 10 times higher than D_f, there is considerable health risks (Ara et al., 2018). With focus on our results, high health risk of lead for local consumers is obvious. In spite of EDI/D_f level, both HI and THQ values obtained in this study did not exceed than 1, exhibiting no noncarcinogenic health risks. Junejo et al. (2019) showed the EDI of *L. rohita* as 2.69-9.37 μg/kg/day. The safe limit of weekly intake of lead for foodstuffs is 25.0 μg/kg/week recommended by World Health Organization (Junejo et al., 2019). The average THQ value for lead crossed the safe limit (1.0) due to taking *L. rohita*. Moreover, the HI value was ranged from 1.4 to 3.9, indicating higher noncarcinogenic risks for the people, due to intake of metal contaminated fishes, especially *L. rohita* (Kumari et al., 2018). Ahmed et al. (2016) assessed the health risks of lead and other metals due to intake of *L. rohita*. The THQ value of lead for this fish species was found as 0.003, whereas the HI value was noticed as 5.54.

The TCR is the measure of the probability of developing cancer in human body. If TCR value is higher than 1×10^{-4} $mg^2/kg^2/day^2$, prominent carcinogenic risk is observed; when TCR is lower than 1×10^{-6} $mg^2/kg^2/day^2$ value, no carcinogenic risk is observed due to heavy metals; If TCR is between 1×10^{-4} to 1×10^{-6} $mg^2/kg^2/day^2$ value, the exposed people are at threshold cancer risk (Rezaei et al., 2021). Based on our TCR values, it might be stated that lead may pose high carcinogenic risks to inhabitants due to intake of these two fish species collected from Bagerhat, Bangladesh. The TCR value for lead due to consumption of *L. rohita* was estimated as 8.7×10^{-6} $mg^2/kg^2/day^2$, indicating the local people might experience the threshold cancer risks (Ahmed et al., 2016).

Conclusion

The present study reflects that the *L. rohita* and *B. gonionotus* fish species are important sources of protein and lipid. But, frozen of fish degrades the lipid content in river *L. rohita*. According to the results, the concentrations of lead in the fish samples were above the safe limits. Various anthropogenic activities, such as application of fertilizers, and pesticides in agricultural fields, use of waste water might be the possible sources of lead in the fish samples. THQ and HI values were below the standard level (THQ and HI <1.0), indicating no risks of

[DOI: 10.18502/jfqhc.8.3.7195]

noncarcinogenic health implications but from the TCR values, it might be predicted that the local inhabitants are prone to carcinogenic health risks. Thus, necessary initiatives should be taken for the draw of public awareness about heavy metal contamination. The present study will be a database system for further research in this area.

Author contributions

M.S.A.M. contributed to the conceptualization, study design, supervision, and revision of the manuscript; M.A.R.K. assisted in the manuscript preparation and revision; M.S.I. contributed to the fieldwork, methodology, data collection, and analysis. All authors read and approved the final manuscript.

Conflicts of interest

The authors declare that they have no conflicts of interests.

Acknowledgements

The authors wish to express their heartfelt gratitude to Chemistry Discipline, Khulna University for providing all facilities about research purposes. This study did not receive any specific grant from funding agencies in the public, commercial, or non-for-profit sectors.

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