J. Environ. Sci. & Natural Resources, 12(1&2):91-99, 2019 ISSN 1999-7361

Comparative Study on Proximate Composition and Heavy Metal Concentration of Molacarplet (*Amblypharyngodon mola*) and Spotted Snakehead (*Channa punctatus*) Collected from Pond Water and Open Water

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Abstract
A study was conducted on the proximate composition and heavy metal concentration of *Amblypharyngodon mola* and *Channa punctatus* collected from pond water and open water in Mymensingh. The proximate composition analysis result showed -protein, lipid, moisture and ash content (%) of pond water *A. mola* were 20.26±0.63, 6.70±0.17, 66.40±1.51 and 2.55±0.58, respectively and for the fish caught from open water the values were 19.66±0.75, 5.81±0.18, 63.03±0.82 and 2.92±0.15, respectively. On the other hand, protein, lipid, moisture and ash content (%) of pond water *C. punctatus* found 23.83±1.07, 5.91±0.11, 64.44±1.87 and 3.23±0.11, respectively whereas the values for the fish caught from open water were 22.21±0.66, 5.43±0.19, 62.73±1.65 and 3.67±0.47, respectively. Arsenic (As) concentration of *A. mola* was higher in open water fishes (0.23±0.05 µg g-1) than the fishes of pond water (0.14±0.03 µg g-1). Cd concentration of pond water *C. punctatus* was found 0.21±0.04 µg g-1 whereas open water fishes contained 0.28±0.06 µg g-1. Copper (Cu) concentration of pond water and open water *A. mola* was 0.27±0.07 µg g-1 and 0.32±0.04 µg g-1, respectively. Heavy metal concentration of *A. mola* and *C. punctatus* was within permissible limits except Cd. The result revealed that open water fishes had higher concentration of heavy metals in their muscle than the fishes of pond water.

Key words: *A. mola, C. punctatus*, Comparative study, Heavy metal concentration, Proximate composition

Introduction

Bangladesh is rich in her fish fauna supporting at least 265 freshwater fin fish species (Rahman, 2005). The yearly fish production in Bangladesh is about 1,023,991 t (27.79%) from inland open waters and 2,060,408 t (55.93%) from inland closed waters (FRSS, 2016). Small indigenous species (SIS) of fish in our country is considered to those which grow to a maximum length of about 25 cm or 9 inch at maturity (Hossain *et al*., 1999). In the past, various SIS of fish were abundant in the rivers, beels, canals, streams and ponds. These are usually caught by the subsistence fisherman that provided a large portion of the animal protein intake of them. Many of these valuable indigenous species have been threatened or endangered. Since 1970s the abundance of small indigenous fish species has been declining. Both natural and manmade catastrophes, degradation of aquatic environment and the reduction of many wetlands and water areas of Bangladesh have resulted in the disappearance of many available SIS of fish (Wahab, 2003). These makes the sustainability of SIS gradually threatened.

The term “heavy metals” refers to any metallic element that has a relatively high density and is toxic or poisonous even at low concentration (Lenntech, 2004). “Heavy metals” is a general collective term, which applies to the group of metals and metalloids with atomic density greater than 4 g/cm^3, or 5 times or more, greater than water (Huton and Symon, 1986;Battarbee*et al*., 1988; Nriaguand Pacyna 1988; Nriagu, 1989; Garbarino *et al*., 1995, Hawkes, 1997). Freshwater bodies always contain small quantities of heavy metals (e.g. zinc, copper, mercury, cadmium, cobalt, chromium, iron, manganese and arsenic). Of the many different toxic compounds present in aquatic ecosystems the heavy metals are considered to be the most dangerous. They occur in the environment both as a result of natural processes and as pollutants from human activity. Amongst animals, fishes are the inhabitants that cannot escape from the detrimental influence of these pollutants (Clarkson, 1998; Dickman and Leung, 1998; Olaifa *et al*., 2004).

As fish is an important source of animal protein especially to the poor people of the country so it is important to know the level of protein content of fish species individually. Studies on proximate composition analysis of different species of fishes might help us to know the amount of protein, lipid and other necessary minerals present in their muscle. That’s why knowledge of the proximate composition of fish species like *A. mola*, *C. punctatus*etc.is important as these are highly demandable, exportable, nutritionally and economically valuable to the country. On the other hand, fish harvested from polluted water (waste dump area, effluent discharge area, lagoon area) normally contain heavy metal. Fish reared in ponds and lakes with artificial feed may also contain heavy metal. Almost all of the heavy metals cause health hazard to the consumers. Mostly cause renal disease, some cause problem in stomachs. Hg damage central nervous system, Pb cause retarded growth in children. Considering above mentioned facts it is important to know the heavy metal content of fishes of open water as well as closed water (ponds and lakes).

Though some studies are available on some species of fishes but studies on *A. mola* and *C. punctatus* to focus on proximate composition and heavy metals (As, Cd and Cu) comparison collected from pond and open water are scare. Since, it is important to study the proximate composition and heavy metals content of pond and open water *A. mola* and *C. punctatus*, so the present study was initiated to analyze the proximate composition of *A. mola* and *C. punctatus* collected from pond water and open waters and at the same time, to evaluate the status of *A. mola* and *C. punctatus* in terms of heavy metals in pond and open water.

Materials and Methods

The current study was done by collecting samples and studying various parameters. Sample collection, organoleptic assessment, proximate composition analysis (protein, lipid, ash and moisture) and heavy metal concentration (As, Cd, Cu) were done according to the methods described below:

Study area and period

The present study was conducted in the Department of Fisheries Technology, Bangladesh Agricultural University, Mymensingh, Bangladesh. The research work was done in the month of February, 2014. Proximate composition was conducted in Fish Processing Laboratory of Department of Fisheries Technology. Heavy metal concentrations were tested in Agri-Chemistry Laboratory at Bangladesh Agricultural University.

Species selection and sample collection

The research study was done on two species of SIS namely, *Amblypharyngodon mola* and *Channa punctatus*. The experimental fishes were collected from two sources: pond water and open water. Pond water fishes were collected from a pond of nearby village, BAU campus and open water fishes were collected from the fisherman of Brahmaputra River (requested earlier and team members were present there during fish harvesting). All the samples were collected early in the morning. After collection the samples were transported to the laboratory as rapidly as possible. Then organoleptic qualities were assessed. After assessing organoleptic quality, the samples were prepared for testing proximate composition and heavy metals concentration analysis.


Plate 1. Mola (*A. mola*) from pond water **Plate 2.** Mola (*A. mola*) from open water


Plate 3. Taki (*C. punctatus*) from pond water **Plate 4.** Taki (*C. punctatus*) from open water

Organoleptic quality assessment

Physical characteristics such as color, odor, taste, flavor and texture of Mola (*A. mola*) and Taki (*C. punctatus*) were observed by organoleptic method (Howgate *et al.,* 1992). The organoleptic method is a simple and widely used method in selecting quality of fish. Sensory methods are the most accurate and most widely used for organoleptic evaluation. A large number of schemes have been proposed for sensory evaluation of fishes. The evaluation method used in the study was based on the currently in use in various Institutes and Industries by scientists of the world. The following set of guidelines has been prepared to get maximum value from them by being able to compare the results. The method given here using score on the organoleptic characteristics of fish as described by EC (European Commission) freshness grade for fishery products is shown in Table 1 and Table 2. The qualities of the fishes were graded using the score from 1 to 5 according to grading scoring method (Table 1 and 2). The grades were defined in terms of the total number of defects or demerit points. The score points from 2 to less than 5 were judged as good or acceptable conditions, while 5 and above considered as bad or rejected.

Table 1. Quality grade of fresh fish with DPs

Grade	DP	Degree of Freshness
A	<2	Excellent/Acceptable
B	2 to <5	Good/Acceptable
C	5	Rejected

Table 2. Determination of defect points

Characteristics of whole fish	Defect characteristics	Defect point	Grade
1) Odor at neck when broken	a) Natural odor	1	Acceptable
	b) Faint sour odor	5	Rejected
2) Odor of gills	a) Natural odor	1	Excellent
	b) Faint sour odor	2	Acceptable
	c) Slight moderate sour odor	3	Acceptable

	d) Moderate to strong sour odor	5	Rejected
3) Color of gills	a) Slight pinkish red	1	Excellent
	b) Pinkish red or brownish	2	Acceptable
	c) Brown or grey color	3	Acceptable
	d) Bleached; thick yellow slime	5	Rejected
4) General appearance	a) Full bloom; bright, shining; iridescent	1	Excellent
	b) Slight dullness and loss of bloom	2	Acceptable
	c) Definite dullness and loss of bloom	3	Acceptable
	d) Reddish lateral line; dull, no bloom	5	Rejected
5) Slime	a) Usually clear, transparent and uniformly spread	1	Excellent
	b) Becoming turbid, opaque and milky	2	Acceptable
	c) Thick, sticky, yellowish or green in color	5	Rejected
6) Eyes	a) Bulging with protruding lens; transparent eye cap	1	Excellent
	b) Slight cloudy of lens and sunken	2	Acceptable
	c) Dull, sunken, cloudy	3	Acceptable
	d) Sunken eye covered with yellow slime	5	Rejected
7) Consistency of flesh	a) Firm and elastic	1	Excellent
	b) Moderately soft and loss of elasticity	2	Acceptable
	c) Some softening	3	Acceptable
	d) Limp and floppy	5	Rejected

Analytical Procedures

Proximate composition analysis

Proximate composition analysis of crude protein, lipid, moisture and ash were carried out according to the methods given in AOAC (1990) with certain modifications

Determination of heavy metals

Collected tissues were weighed by electronic balance and 5 ml of diacid mixture (5 ml conc. HNO_3: 3 ml 60% $HClO_4$) were added to each sample. The content mixed for overnight. Samples were then digested, initially at 80ºC temperature and later on 150ºC for 2 hours. The completion of digestion was indicated by almost colorless material. The brown fumes also cease to exist at completion of digestion. The samples were separately filtered by using an ash less filter paper and volume made up to 25 ml with 0.5% HNO_3 which prepared for the determination of As, Cd and Cr (Eboh *et al.,* 2006). The samples were subjected to analysis by Atomic Absorption Spectrophotometer (HG-AAS, PG-990, PG Instrument Ltd. UK) at Agri-Chemistry Department, BAU, Mymensingh. The wave length of As, Cd and Cu was 193.7 nm, 217 nm and 383.7 nm respectively. The concentration of As, Cd and Cu in fish samples were calculated by the following formula:

$$\text{Heavy Metal Concentration} = \frac{\text{ppm conc. observed} \times \text{final volume of sample in ml}}{\text{Weight of tisues taken in gm}}$$

Results and Discussion

Organoleptic quality of Amblypharyngodon mola and Channa punctatus

During sample collection organoleptic characters and overall quality of *A. mola* and *C. punctatus* were excellent. *C. punctatus* were live whereas *A. mola* were not live but in fresh condition. Sensory characteristics observation showed the fishes of both species fresh, bright, soft and odor also was fresh. The results of the organoleptic quality assessment during sample collection are presented in Table 3.

Table 3. Organoleptic characteristics of *Amblypharyngodon mola* and *Channa punctatus*

Fish species	Source of fish	Organoleptic quality (Physical characteristics)	Defect point	Overall quality
A. mola	Pond water	Fresh, bright appearance, soft and firm texture with characteristics fresh odor	1.57	Excellent
	Open water	Fresh, bright appearance, soft and firm texture with characteristics fresh odor	1.73	Excellent
C. punctatus	Pond water	Fresh, bright appearance, soft and firm texture with characteristics fresh odor	1.00	Excellent
	Open water	Fresh, bright appearance, soft and firm texture with characteristics fresh odor	1.00	Excellent

It is essential to use sensory assessment wherever standards of quality need to be established, controlled or assured. Since the prosperity of most fish businesses depends on maintaining the quality of their products at a consistently high level, the importance of sensory assessment is obvious (FAO, 1989). The Quality Index Method (QIM) score 2.13 for *A. mola* and 0 for *C. punctatus* freshly caught from river. *C. punctatus* scored the lowest QIM scores (Jha *et al.,* 2010) found that supports the results of the present study.

Proximate composition of Amblypharyngodon mola and Channa punctatus

Proximate composition of *A. mola* and *C. punctatus* were analyzed in the laboratory of Department of Fisheries Technology, BAU. The results of proximate composition are given below:

Protein content of Amblypharyngodon mola and Channa punctatus

The average protein content (%) of *A. mola* collected from pond water and open water were 20.26±0.63 and 19.66±0.75, respectively and the average protein content (%) of *C. punctatus* collected from pond water and river water were 23.83±1.07 and 22.21±0.66, respectively. *C. punctatus* contained more protein than *A. mola*. While source of fish considered, percent protein content found higher in pond water fishes than the fishes collected from open water. The results are presented in Table 4.Ahmed *et al*. (2012) reported the protein content of *C. punctatus, C. marulius* and *C. striatus* was 15.22%, 16.19% and 15.49%, respectively. On the other hand, protein content of *A. mola, P. ticto*, *P. beculis*, *C. nama*, *C. fasciatus* and *C. lalia* was found 17.95%, 18.08%, 15.60%, 17.77%, 15.82% and 16.13%, respectively in the same study. The results showing that protein content of *Channa spp.* is more or less similar but lower than the present study. Protein content of *A. mola* is lower than *P. ticto* but higher than the other species of small indigenous species (SIS) of fishes. This variation might occured due to variations in species, habitat, season, food availability, food type and or water quality. Protein was estimated in *A. mola* (18.46 %), *G. chapra* (15.23 %), *P. chola* (14.08%), *C. nama* (18.26%), *P.atherinoides* (15.84%) and in *A. coila* (16.99%), respectively by Mazumder *et al.* (2008). Their findings showed that *A. mola* have the highest protein content. Their study also revealed that the overall nutrient contents of studied small indigenous fishes were as higher or equal to those of larger fish species. The protein content obtained in the present study for *A. mola* and *C. punctatus* is higher than Mazumder *et al.*(2008). In *C. punctatus* higher content of protein was obtained mainly might be due to food type.*C. punctatus* are carnivorous and consume animal protein whereas *A. mola* is mainly plankton feeder.

Lipid content of Amblypharyngodon mola and Channa punctatus

The average lipid content (%) of *A. mola* collected from pond water and open water were 6.70±0.17 and 5.81±0.18, respectively. On the other hand, the average lipid content (%) of *C. punctatus* collected from pond water and river water were 5.91±0.11 and 5.43±0.19, respectively. *A. mola* contained more lipid than *C. punctatus* (Table 4).The total lipid content of *A. mola* was found to be 5.4% by Bijayalakshmi *et al.* (2014), which supports the results of the present study. Mazumder*et al*. (2008) found lipid content of *A. mola*, *G. chapra, P. chola, C. nama, P. atherinoides* and in *A. coila* as 4.10%, 5.41%, 3.05%, 1.53%, 2.24% and 3.53%, respectively. Their study revealed that the fat content was highest in *G. chapra*. The lipid content of *A. mola*found in their study is near to the result of present study. Ahmed *et al.* (2012) found the lipid content of *C. punctatus,C. marulius,C. striates,A. mola,P. ticto*, *P. beculis*, *C. nama*, *C. fasciatus* and *C. lalia* 1.60%, 1.79%, 1.47%, 2.87%, 3.56%, 2.86%, 2.05%, 2.58% and 4.15%, respectively which are lower than the present study. Begum and Minar (2012) also found lower lipid content in *G. chapra*, *C. soborna* and *A. punctata* than found in the present study. The differences in the values might be due to the differences in species, habitat, season, food availability, food type and or water quality. The results of the present study and other literatures showed that small indigenous species of fish contains lower lipid in their body.

Table 4. Percent protein, lipid, moisture and ash content of *Amblypharyngodon mola* and *Chann apunctatus*

Species	Protein content (%)	
	Pond water	**Open water**
A. mola	20.26±0.63	19.66±0.75
C. punctatus	23.83±1.07	22.21±0.66
	Lipid content (%)	
A. mola	6.70±0.17	5.81±0.18
C. punctatus	5.91±0.11	5.43±0.19
	Moisture (%)	
A. mola	66.40±1.51	63.03±0.82
C. punctatus	64.44±1.87	62.73±1.65
	Ash (%)	
A. mola	2.55±0.58	2.92±0.15
C. punctatus	3.23±0.11	3.67±0.47

Moisture content of Amblypharyngodon mola and Channa punctatus

The average moisture content (%) of *A. mola* collected from pond water and open water were 66.40±1.51 and 63.03±0.82, respectively. On the other hand the average values for *C. punctatus* were obtained 64.44±1.87 and 62.73±1.65, respectively collected from pond water and river water. Among two species of fishes *C. punctatus* contained more moisture than *A. mola* (Table 4). The total moisture content of *A. mola* was found to be 77.19% by Bijayalakshmi *et al.* (2014). This value is higher than the value obtained in the present study for *A. mola*. Ahmed *et al*. (2012) reported moisture content of *A. mola*, *P. ticto*, *P. beculis*, *C. nama*, *C. fasciatus* and *C. lalia* as 76.68% 75.02%, 78.62%, 78.03%, 80.75%, 77.52%, respectively. Islam *et al*. (2012) found percent moisture content of freshly caught whole *A. mola* 75.79±0.88 and the percent moisture content of dried *A. mola* from traditional, rotary and solar tunnel dryer in the range of 12.80 to 26.60 %. Moisture content of *A. mola* was lower in their study. Dried fish contains lower percent of protein because of evaporation of moisture by the action of air and sun.Moisture content was estimated in, *A. mola, G. chapra*, *P. chola*, *C. nama*, *P. atherinoides* and in *A. coila* by Mazumder *et al.* (2008). The highest level of moisture content was found in *C. nama* (78.62%) and the lowest was in *A. coila* (65.88%). The moisture content of *A. mola* and *A. coila* obtained in their study is more or less similar to the present study.

Ash content of Amblypharyngodon mola and Channa punctatus

The average ash content (%) of *A. mola* collected from pond water and open water were 2.55±0.58 and 2.92±0.15, respectively whereas the average ash content (%) of *C. punctatus* collected from pond water and river water were 3.23±0.11 and 3.67±0.47, respectively. *C. punctatus* contain more ash than *A. mola*. Ash contents were found in open water fishes than the fishes collected from pond water (Table 4). Ash content of *C. punctatus,C. marulius* and *C. striates* was found 1.25%, 0.60% and 0.39%, respectively (Ahmed *et al.,* 2012). The ash content of *C. punctatus* obtained in their study is lower than the ash content found in *C. punctatus* collected from pond and open water in the present study. Ash content of *A. mola* was 2.50% (Ahmed *et al.,* 2012) which is similar to the findings of the present study. Ahmed *et al*., (2012) also reported the ash contents of *P. ticto*, *P. beculis*, *C. nama*, *C. fasciatus* and *C. lalia* was 3.34%, 2.92%, 2.15% 0.85% and 2.21%, respectively. The results showed that, ash content of *A. mola* and *C. punctatus* was lower than *P. ticto* but higher than *C. fasciatus* and *C. lalia.* All these results revealed that, small indigenous species of fish (SIS) contains lower ash content in the body. The ash content of *G. chapra*, *C. soborna* and *A. punctata* was 1.70%, 1.68%, and 1.54% respectively (Begum and Minar, 2012). The percent of Ash content of freshly caught whole *A. mola* was 1.60±0.006% and was in the range of 5.93 to 12.19% in dried *A. mola* products obtained from different drying procedures such as traditional, rotary and solar tunnel dryer (Islam *et al.,* 2012). The result found by the authors was lower than the values of *A. mola* and *C. punctatus* found in the present study.

Mazumder *et al.* (2008) estimated ash content in *A. mola*, *G. chapra*, *P. chola*, *C. nama*, *P.atherinoides* and in *A. coila*. The percentage of ash content was highest in *C. nama* (3.92%) and lowest in *G. chapra* (1.55%). This result indicates that, *A. mola* and *C. punctatus* contain lower percent of ash than *C. nama* but higher percent than *G. chapra*. This variations in the ash contents also may be due to variations in species, habitat and or food availability for the fishes.

Heavy metal concentration of Amblypharyngodon mola and Channa punctatus

A great number of anomalies and abnormalities in the fishes are reported due to the concentrations of metals exceed the environmental standards (Shesterin, 2001). Fish living in the polluted water may accumulate higher amount of toxic heavy metals through their food chain (Hadson, 1998). Various factors such as season, physical and chemical properties of water can play a significant role in metal accumulation in different fish tissues (Kargin *et al.,* 1996). Stress due to heavy metals present in the waste water pond, does create hematological disturbances, erythrocyte destruction (hemolysis), and leukocytosis in fish population, affecting the immune system and making the fish vulnerable to diseases (Javed and Osmani, 2013). In the present study As, Cd and Cu were determined in the muscle of *A. mola*and *C. punctatus.*

Arsenic (As) concentration of Amblypharyngodon mola and Channa punctatus

The average As concentration of *A. mola* collected from pond water and open water was 0.14±0.03 µg/g and 0.23±0.05 µg/g, respectively whereas the average concentration of As in *C. punctatus* collected from pond water and open water was Nil. Pond water *A. mola* contained lower As than open water *A. mola* (Table 5). Arsenic is a devastating environmental pollutant that causes severe ground water pollution. Fish is a major source of arsenic exposure. Organic arsenic compounds (such as arsenobetaine) were primarily found in fish by Jarup (2003). Concentration of As is lower in freshwater fish species and below the regulatory maximum level (Olmedo *et al.,* 2013). The concentrations of As in fish muscle tissue collected from North East coast of India and the concentration ranged between 0.02-2.37 µg/g in dry weight (Kumar *et al.,* 2012).

Kumar *et al*. (2011) reported the bioaccumulation pattern of metals in different species of fishes as: *H. molitrix>O. nilotica>L. rohita>O. mossambica>C. marulius>C. catla>P. ticto*and the concentration of heavy metals was in the following order: Cu > As > Cd. The essential metal Cu wasfound in higher concentrations and the non-essential, toxic metals Cd and As was found low. The concentrations of As was in muscle tissue of six marine species of fish collected from north eastern Bay of Bengal, India found in the range of 0.02-2.34 µg g^{-1}. The concentration of heavy metals was species specific and metal specific and varied significantly (Mukherjee and Kumar, 2011). In the present study As was found in *A. mola* but was absent in *C. punctatus*. The As concentration of *A. mola*is nearer to the result of Mukherjee and Kumar (2011).The concentrations of As varied between 44.54±5.69 - 1.23±0.20 mg/kg and exceeded the maximum allowable intake level in eight different marine fish species (Islam *et al.,* 2010). The values obtained in their study is higher than present study carried out with *A. mola* and *C. punctatus*. Total arsenic amount in the rainbow trout muscle (*O. mykiss*) ranged from 0.72 mg/kg to 2.23 mg/kg (Harkabusova *et al.,* 2009). As content in trout muscle is slightly higher than *A. mola* and *C. punctatus* muscles. Open water fishes contain higher concentration of As in their body which is similar to the results obtained by Moody *et al.* (2013).Fish living in polluted waters tend to accumulate heavy metals in their tissues and accumulation depends on metal concentration, time of exposure, way of metal uptake, environmental conditions (water temperature, pH, hardness, salinity), and intrinsic factors (fish age, feeding habits). Various metals show different affinity to fish tissues. Most of the metals accumulate mainly in liver, kidney and gills. Metal distribution in various organs is time-related. Accumulation of metals in various organs of fish may cause structural lesions and functional disturbances (Jezierska and Witeska, 2006).

Cadmium (Cd) concentration of Amblypharyngodon mola and Channa punctatus

Open water *A. mola* contained higher Cd concentration in the muscle than pond water *A. mola*. The average Cd concentration of *A. mola* collected from pond water and open water was 0.39±0.04 µg/g and 0.47±0.05 µg/g, respectively. Pond water *C. punctatus* contained lower concentration of Cd in the body than open water *C. punctatus.* Average Cd concentration of *C. punctatus* collected from pond water and river water were 0.31±0.04 µg/g and 0.38±0.06 µg/g respectively (Table 5). Moody *et al*. (2013) reported, the bioaccumulation of some heavy metals (Lead, chromium and cadmium) in some freshwater fishes (*T. zilli*, *L. coubie*and *S. membranaceous*) were Cr >Pb>Cd. They found high accumulation of some heavy metals in the river fishes. The concentration of Cd in fish muscle tissue ranged between 0.01-1.10 µg/g in dry weight basis (Kumar *et al.,* 2012). In the present study Cd accumulation is lower than Cu accumulation and did not exceed the recommended limits. Cd concentration found lower in pond water fishes had than open water. Cadmium levels usually increase with the age and pollution (WHO, 1992). Toth *et al*. (2012) stated that, the Cd contents in *C. carpio* varied closely. Detected values for individual tissues in muscle ranged between 0.02-0.13, hepatopancreas 0.05-0.14, kidney 0.07-0.24, gonads 0.02-0.13, skin 0.07-0.76, gill 0.26-0.38, fin 0.52-0.84 mgkg^{-1}. Anim*et al.* (2011) investigated the accumulation profile of Cd in five species of fish namely; *H. niloticus*, *C. obscura*, *H. odoe*, *T. zilli*and *C. gariepinus*. They found the trend of heavy metals concentration as: Cr > Zn > Cu > Fe >Mn> Cd >Pb for *T. zilli*, while that of *C. gariepinus* was Cr > Zn > Fe > Cu >Mn> Cd >Pb (Eneji *et al.,* 2011). The concentration of heavy metals was found in the following order: Fe > Zn> Cu >Mn> Ni > As > Hg > Cd by Kumar *et al.* (2011). In the present study, the trend of heavy metals concentration can be represented as: Cu> Cd>As in pond water and open water *A. mola* and in *C. punctatus* Cu> Cd> As collected from pond water and open water The concentration of Cd varied between 0.13– ND (not detected) mgkg^{-1} in a study carried out by Islam *et al.* (2010). The average status of Cd in *Myllus spp.*, *M. merlucius*, *D. labrax* and *S. aurata* in small sized fish (mean weight of 158 g) was found 0.20 mgkg^{-1}in wet weight basis whereas in medium sized fish (mean weight of 245 g) the level was 0.40 mgkg^{-1} (Ozuni *et al.,* 2010). These findings support the results of the present study.

Table 5. Arsenic (As), Cadmium (Cd) and Copper (Cu) concentration of *Amblypharyngodon mola* and *Channa punctatus*

Species	As concentration (µg/g)		Permissible limit
	Pond water	**Open water**	
A. mola	0.14±0.03	0.23±0.05	0.26 µg/g (FAO/WHO, 2011)
C. punctatus	Nil	Nil	
	Cd concentration (µg/g)		0.2 µg/g (FAO/WHO, 2011)
A. mola	0.19±0.04	0.27±0.05	
C. punctatus	0.21±0.04	0.28±0.06	
	Cu concentration (µg/g)		10 µg/g (FAO/WHO, 1984)
A. mola	0.27±0.07	0.32±0.04	
C. punctatus	0.25±0.05	0.29±0.07	

Copper (Cu) concentration of Amblypharyngodon mola and Channa punctatus

Open water *A. mola* contained higher Cu in the muscle than pond water *A. mola*. The average Cu concentration of *A. mola* collected from pond water and open water was 0.27±0.07 µg/g and 0.32±0.04 µg/g, respectively. Pond water *C. punctatus* contained lower concentration of Cu in the body than open water *C. punctatus*. Average Cu concentration of *C. punctatus* collected from pond water and river water was 0.25±0.05 µg/g and 0.29±0.07 µg/g respectively (Table 5). Jezierska and Witeska (2006) reported that, the Cu accumulation is higher than Cd concentration in the fish living in polluted water in their tissues which is similar to the findings of the present study. Krishna *et al*. (2014) found, the order of heavy metal concentration in *M. cephalus* Zn>Pb>Mn>Cu>Cr>Hg and average concentrations of Cu was observed (mgkg-

^{1}) was 32.4, 10.8, 8.9, 6.4, 2.3 and 2.2, respectively in liver and muscle. Javed and Osmani (2014) found the order of accumulation of heavy metals in *C. punctatus* as: liver > kidney > gills > integument > muscle. They also found the accumulation of Fe (140.2 to 1533.08 mg kg^{-1}dw) was highest in all the organs. In their study, the average accumulation of Cu in the muscle and integument was seen 13.65 mg kg^{-1}in dry weight basis. Cu concentration was highest (236.66 mg kg^{-1}) in kidney and least (13.25 mg kg^{-1}) in muscle and the sequence of their presence in organs/tissues were kidney > gills > liver > integument > muscle. The concentration of Cu observed higher in their study than that of found in *A. mola* and *C. punctatu s*in the present study. In another study, Ahmed *et al*. (2010) found highest Cu in *C. punctatus* (5.27 $mgkg^{-1}$) and lowest in *G. chapra* (4.25 $mgkg^{-1}$) in a heavily polluted river of Bangladesh, Buriganga River during pre-monsoon. The Cu levels in liver, gills and muscles of tilapia fish were found 491.30, 3.70 and 1.82 µg/g in dry weight (dw) basis, respectively by Taweel *et al*. (2013) and significant changes occurred in Cu levels in tilapia fish organs. These values are higher than the values obtained in the present study. Javed and Usmani (2012) observed the Cu concentration in *M. armatus*0.86 mg kg^{-1} which is also higher than the values recorded in the present study. Kumar *et al*. (2012) reported the concentrations of Cu in fish muscle collected from North East coast of India was 0.5-28.2 µg/g in dry weight basis. The Cu concentration found higher than Cd concentration in *T. zilli*and *C. gariepinus* in a study carried out by Eneji *et al.* (2011). The concentration of Cu was also found higher than Cd by Kumar *et al.* (2011). All these findings are more or less in agreement with the findings of present study that, Cu concentration found higher in *A. mola* and *C. punctatus* than Cd concentration.

Conclusion

The findings of the present study could be concluded as- sensory quality of freshly caught fish was excellent. The level of proximate composition in *A. mola* and *C. punctatus* was as: moisture>protein>lipid>ash. Heavy metal concentration in *A. mola* and *C. punctatus* collected from pond and open water were below the permeable limits except Cd. There was no accumulation of As by *C. punctatus* in the muscle. In case of open water fishes accumulation of heavy metals in the muscle were found higher than the pond water fishes

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