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# Chemical and mineral composition of *Cyprinus carpio, Labeo rohita* and *Wallago attu* inhabiting river indus in Mianwali district

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## Abstract

The study was carried out to investigate the chemical composition and mineral profile of three fish species namely *Cyprinus carpio*, *Labeo rohita* and *Wallago attu* inhabiting River Indus in Mianwali District. The study followed a 3 x 3 factorial arrangement by involving 3 fish species, each with 3 weight categories ($W1 \leq 1.0$, $W2 \leq 1.5$ and $W3 \leq 2.0$ Kg). Chemical composition was determined by AOAC methods and selected minerals (Ca, K, Mg, Na, P, Cr, Fe, Mn, Ni, Zn, Hg and Pb) in fish muscles were analysed by inductively coupled plasma–optical emission spectroscopy (ICP-OES). It was investigated that crude protein contents in *Labeo rohita, Cyprinus carpio* and *Wallago attu* were 74.92, 75.25 and 79.60%, respectively. Fat was reported as 18.67, 19.52 and 13.33 % in *Labeo rohita, Cyprinus carpio* and *wallago attu*, respectively. Whereas ash was reported as 4.95, 4.67 and 4.46% and total carbohydrates were investigated as 1.46, 0.56, and 2.60 % in *Labeo rohita, Cyprinus carpio* and *Wallago attu*, respectively. Generally metal concentrations increased with increased weight of fish. Cadmium and copper were not detected in any of the analysed fish species. The levels of minerals in selected fish species were within the limits of international standards except Mn, Cr, Hg and Pb. Smaller fishes were high in protein contents and low in fats and minerals, so these should be preferred by the consumers. The higher levels of heavy metals reported in selected fish species are a matter of concern for the health of fish as well as consumers.

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## Introduction

Due to increase in the awareness about the importance and nutritive value of white meat, its demand increases all over the world even in Pakistan. White meat, especially fish meat gained an important place in human diet due to its taste, nutritional quality and convenient price. Fish meat contain the large proportion of protein, vitamin, minerals, healthy fats and in minor quantity carbohydrates which make it good and healthy diet and it is easily digested by human body ( Marcu *et al*., 2010). Fishes are world widely accepted as a source of low fat, high quality protein and minerals along this rich source of poly-unsaturated fatty acids (PUFA). PUFA are not only important for maintenance of the membranes of cells but also important for the formation of prostaglandins in body which regulate inflammation and blood clotting. These fats are also needed to absorb fat-soluble vitamins A, D, E and K from food; and it also regulate cholesterol metabolism in body (Jabeen and Chaudhry, 2011). Fish protein is more beneficial for human body because it has amino acids which are good for human body and also have free amino acids (Buchtova *et al*., 2010). Fish is one of the sources of best quality and quantity of animal protein which is easy to avail and maintain healthy body (Arannilewa *et al*., 2005).

Mineral elements are basic requirement of all living organisms. Some minerals are essential elements but these essential metals may be toxic at their high concentration in body of animals (Tyrrell *et al*., 2005). It is due to the tendency of bio-magnification of these toxic elements in the food chain and ultimately in ecosystem. So, the bioaccumulation of toxic elements in aquatic ecosystems has been taken as an environmental problem globally (Khare and Singh, 2002).The vital factors which disturb the ecosystem by increasing the amount of heavy metals are industrial wastes, sewage disposal, soil leaching, rainfall and the use of metal based fertilizers in agricultural revolution are increased day by day which could result in the rise of metal pollutants in freshwater due to the water flow. Because of all these facts there is a need to study the concentrations of heavy metals in freshwater fish (Al- Bader, 2008; Rauf *et al*., 2009; Yousaf *et al*., 2010).

Fish is a source of macro (Ca, Mg, Na, K, P, Cl, S), micro or trace (Fe, Zn, Mn, Cu, I, Co, Ni, F, V, Cr, Mo, Se, Sn, Si) and also some toxic elements (Hg, As, Pb, Cd). Fish usually contains small amounts of these minerals, some of which are essential nutrients, some are components of many enzyme systems and metabolic mechanisms, and as such contribute to the growth of the fishes. The important mineral elements of fish are calcium, magnesium, potassium, phosphorus, iron and chlorine while many others are important in trace amounts. Their deficiencies cause a lot of malfunctioning, such as it reduces productivity, and causes disorders such as inability of blood to clot, osteoporosis and anaemia. One of the major problems is pollution that poses serious health risk and environmental concern, which results from heavy metals bioaccumulation. Analysis of proximate composition (protein, fat, carbohydrates, minerals and dry matter) of fishes is necessary for information of the nutritional quality of fish (Hei and Sarojnalini, 2012).

The body nutrients composition and quality of nutrients in flesh of most fishes is reliant on their food type and feeding habit (Fawole *et al*., 2007). The values of these nutrients though, deviate extensively within and between species, and with size, sexual condition, feeding, time of the year and physical activity (Ali *et al*., 2006). The analysis of chemical composition of fish muscles can give awareness about age classes of the same species or can compare nutritional differences between and among the species. These values also give assessment of food composition of fish, its physiological condition and can serve as guide for any future feed formulations for fish in captivity (Dempson *et al*., 2004). Sometimes it can help in genetic selection of better traits. These values can also give a good estimate of seasonal nutritional variations, which can help consumer's choices and preferences for fish consumption.

In view of above facts, the study was conducted on the commercially important and widely consumed three fish species of the River Indus in Mianwali District viz., *Labeo (L) rohita, Walllago (W) attu* and *Cyprinus* (*C*) *carpio* in order to assess their proximate compositions and mineral contents prior to their consumption. These fish species are selected on the difference in their food niche. *W. attu,* are robust carnivores and feed on fishes, shrimp and molluscs other than living organisms it also hungrily feeds on dead fishes or other animals present in the surrounding environment while *y*oung ones are insectivores (Hossain *et al.*, 2008). *L. rohita,* on the other hand are herbivorous fast growing fishes. *C. carpio* are omnivorous eat water plants, scavenge the bottom for insects, crustaceans, crawfish and benthic worms. The study was aimed to assess the chemical composition (moisture, crude protein, fat, ash, carbohydrate contents and energy value) and mineral profile including macro (Mg, Na, K, P and Ca), micro (S, Zn, Mn, Fe, Cu, Cr and Ni) and toxic (Hg, Cd and Pb) elements in the selected fish species.

## Materials and methods

*Importance of Study Site*

Present study was carried out on three freshwater fish species inhabiting the River Indus in District Mianwali. Mianwali is situated in the Punjab province of Pakistan and covers an area of 5,840 km$^2$. It is rich in minerals, argillaceous clay, coal, dolomite, fire clay, gypsum, limestone, salts, silica sand and rocks. The district has extreme hot and cold weather with an average rainfall of about 25mm. The inland fisheries in Pakistan are heavily dependent upon the River Indus, which is one of the world's largest rivers for its drainage basin area (970,000 km$^2$), discharge and sediment load as it flows from the Northern mountains to the Southern plains before it falls alongside other rivers into the Indian Ocean in the Sindh province (Jabeen and Chaudhry, 2011a,b).

*Sampling*

The fish species were selected on the basis of trophic level including carnivores (*W. attu),* herbivorous (*L. rohita*) and omnivorous (*C. carpio*) species as well as on the basis of consumer's preferences with respect to taste and price. The study followed a 3 x 3 factorial arrangement by involving three fish species, each with three dead weights. The fish samples were collected with the help of local fisherman. Thirty samples of each fish species were selected from three weight groups (W1≤1.0, W2≤1.5 and W3≤2.0 Kg) on the basis of their routine weights at which they are caught and sold in the study area. Ten samples of each fish species for each weight group and total 90 replicates were collected. The samples were transported to the Research Laboratory of the Department of Zoology, GC University Faisalabad under chilled conditions where further investigations were made.

*Fish Dissection and Preservation*

After morphometric measurements, each fish was dissected and filleted. The fish muscles were then cleaned and transferred into marked sterilised polythene bags and stored in a freezer at -20 °C until further analysis. The samples were freeze dried by using manifold freeze-dryer (Christ, Alpha 1-4 LD, Germany, Lypholyzer), at -50 °C.

*Chemical Composition*

Freeze dried ground fish muscles were used for chemical analysis. AOAC (2005) methods were used to determine dry matter (DM), ash (A) and crude fat (F), whereas total nitrogen (N) (N × 6.25 = crude protein, CP) was analysed by Elementar Vario Macro Cube (Elementar, Hanau Germany). Total carbohydrates were determined by subtracting the sum of % fat (F), % CP and % ash contents (A) from 100 (Onyeik *et al.*, 2000) by using the equation: Total carbohydrates (%) = 100-(F+CP+A). Gross energy value of each sample was determined by multiplying the percentage CP, F and total Carbohydrate (C) contents with their respective energy values of 4, 9 and 4 kcal per 100 g of fish sample to obtain the caloric values of these samples by using the equation: Caloric value= (4CP+9F+4C) kcal/100 g weight.

Minerals were analysed on a Varian Vista-MPX CCD by simultaneous inductively coupled plasma–optical emission spectroscopy (ICP-OES) (Varian Inc., Australia) by following the extraction procedure as described by jabeen and Chaudhry (2010a,b) Briefly, about 0.5 g of sample was weighed in a conical flask and 9 mL of nitric acid added and kept overnight before 1 mL of perchloric acid was added. The mixture was then heated gradually to 150 °C on a hot plate in a fuming hood until red $NO_2$ fumes turned colourless and the volume was reduced to around 1 mL. After cooling, the digested content was dissolved with distilled water, filtered (Whatman paper no. 541), and transferred into a 25 mL volumetric flask. Further dilutions were made with demineralized water as required to suit the standard curve calibrations. Commercial Ca, Zn, Ni, Hg and Cu solutions (May and Baker Ltd., Dagenham, UK), Mg, Mn, Fe and Pb solutions, Cd (cadmium coarse powder), Cr, Na solutions (BDH Chemicals, UK), P (sodium phosphate ≥99%) (Sigma-Aldrich) and K (potassium chloride, 99.8%) (Fisher Scientific) were used to prepare standard solutions at either 0–1.0 mg/kg to represent lower, or 0–50 mg/kg for higher ranges of sample mineral concentrations.

*Statistical Analysis*

Minitab 16 software was used to test the main effects of fish species (Sp), weights (W) and their interaction (S x W) on different nutrients and mineral profile for significance at $P<0.05$. Here S x W was studied to monitor if any potential variations among fish species for these components were linked to the variations between three weights categories of fish. These effects were declared significant if $P < 0.05$ and highly significant if $P < 0.01$. Tukey's test was used if there were more than two means to compare by using relevant standard errors of means (SEM).

## Results

Table 1 shows the mean length, width and chemical composition viz., dry matter (DM), fat, ash, crude protein, carbohydrates and energy value and standard error of means for species, weights and species into weight interactions of three fish species from the River Indus in Mianwali District. Both morphometric and chemical variables showed highly significant differences among species sampled from the River Indus in Mianwali District ($P<0.001$; Table 1). The mean length of fish species was calculated as 418.70 (*C. carpio*), 364.20 (*L. rohita*) and 519.10 cm (*W. attu*). The mean width was recorded as 123.70 cm (*C. carpio*), 117.00 cm (*L. rohita*) and 102.40 cm (*W. attu*). Significant differences were found in the length and width of all fish species ($P<0.05$).

**Table 1.** Mean length, width and chemical composition viz., dry matter (DM), fat, ash, crude protein, carbohydrates and energy value and standard error of means and their significance for three fish species.

| Variables | *C. carpio* | *L.rohita* | *W. attu* | SEM and Significance | | |
|---|---|---|---|---|---|---|
| | | | | sp | w | Sp x w |
| Length (cm) | $418.70^{b}$ | $364.20^{c}$ | $519.10^{a}$ | $0.95^{***}$ | $0.80^{***}$ | $0.78^{***}$ |
| Width (cm) | $123.70^{a}$ | $117.00^{b}$ | $102.4^{c}$ | $1.54^{***}$ | $1.30^{***}$ | $1.14^{***}$ |
| DM (%) | $22.13^{a}$ | $21.16^{b}$ | $18.89^{c}$ | $1.11^{NS}$ | $1.15^{NS}$ | $1.09^{NS}$ |
| Ash (%) | $4.67^{ab}$ | $4.95^{a}$ | $4.46^{b}$ | $1.25^{***}$ | $1.19^{***}$ | $1.20^{***}$ |
| Fat(%) | $19.52^{ab}$ | $18.67^{b}$ | $13.33^{c}$ | $2.47^{***}$ | $1.57^{***}$ | $1.41^{***}$ |
| Proteins (%) | $75.25^{b}$ | $74.92^{b}$ | $79.60^{a}$ | $0.83^{***}$ | $0.90^{***}$ | $0.96^{***}$ |
| Carbohydrates (%) | $0.56^{c}$ | $1.46^{b}$ | $2.60^{a}$ | $0.68^{***}$ | $0.40^{***}$ | $0.14^{***}$ |
| Energy (kcal/100g) | $478.90^{a}$ | $473.60^{a}$ | $448.8^{b}$ | $1.15^{***}$ | $1.08^{***}$ | $1.06^{***}$ |

There was a significant difference in the dry matter of three fish species ($P<0.05$). The mean ash contents in fish muscles were 4.67, 4.95 and 4.46% in *C. carpio, L. rohita* and *W. attu,* respectively. It was observed that ash contents differed significantly among the species ($P<0.05$; Table 1). The highest ash contents were found in *L. rohita*. The fat contents estimated for *C. carpio, L. rohita* and *W. attu* were 19.52, 18.67 and 13.33%, respectively (Table 1). *W. attu* showed the lowest fat contents ($P< 0.05$; Table 1). The crude protein contents in muscles of these freshwater fish species were 75.25, 74.92 and 79.60% in *C. carpio, L. rohita* and *W. attu*, respectively. Statistically significant differences were observed in crude protein contents ($P< 0.05$; Table-2). Total carbohydrate contents were recorded as 0.56% in *C. carpio,* 1.46% in *L. rohita* and 2.60% in *W. attu*. There was significant difference in the carbohydrate contents. The energy values were significantly different in different species and recorded as 478.90, 473.60, and 448.80 kcal/100g in *C carpio, L. rohita* and *W. attu*, respectively ($P<0.05$; Table 1).

**Table 2.** Mean concentration (mg/Kg DM) of macro elements in muscles of *Cyprinus carpio*, *Labeo rohita* and *Wallago attu* from the River Indus together with SE and main effects.

| | *Cyprinus carpio* | | | *Labeo rohita* | | | *Wallago attu* | | | SE and Main effects | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | W1 | W2 | W3 | W1 | W2 | W3 | W1 | W2 | W3 | Sp | w | spxw |
| Ca | 334 | 2252 | 3548 | 2104 | 3885 | 5181 | 362 | 536 | 10796 | $53.79^{***}$ | $53.79^{***}$ | $93.29^{***}$ |
| K | 2824 | 3184 | 3420 | 3046 | 3213 | 3711 | 3134 | 3180 | 3210 | $74.88^{NS}$ | $74.88^{NS}$ | $129.85^{**}$ |
| Mg | 959 | 1079 | 1561 | 1171 | 1387 | 1494 | 807 | 945 | 1264 | $19.85^{***}$ | $19.85^{***}$ | $34.42^{***}$ |
| Na | 847 | 892 | 913 | 1091 | 1150 | 1475 | 992 | 1205 | 1631 | $6.18^{***}$ | $6.18^{***}$ | $10.71^{***}$ |
| P | 9692 | 10965 | 14243 | 11158 | 14937 | 14996 | 10434 | 10631 | 17301 | $307.77^{***}$ | $307.77^{***}$ | $533.70^{***}$ |

In all freshwater fish species dry matter, ash, oil, energy values, length and width were increased with the increase in weight for W1, W2 and W3 groups, respectively while protein contents were decreased with increasing weight (Fig. 1-3). While dry matter was not significantly different among W1, W2 and W3 groups for three freshwater fish species from the River Indus (Fig. 1-3). Ash and carbohydrates were found in very little amount (Fig. 1-3).

**Table 3.** Mean concentration (mg/Kg DM) of micro elements in muscles of *Cyprinus carpio*, *Labeo rohita* and *Wallago attu* from the River Indus together with SE and main effects.

| | *Cyprinus carpio* | | | *Labeo rohita* | | | *Wallago attu* | | | SE and Main effects | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | W1 | W2 | W3 | W1 | W2 | W3 | W1 | W2 | W3 | Sp | w | spxw |
| Cr | 1.31 | 2.77 | 3.15 | 2.49 | 2.82 | 5.90 | 4.03 | 4.33 | 1.95 | $0.02^{***}$ | $0.02^{***}$ | $0.04^{***}$ |
| Fe | 27.84 | 27.87 | 39.99 | 34.37 | 43.60 | 25.11 | 25.13 | 53.11 | 74.17 | $0.39^{***}$ | $0.39^{***}$ | $0.68^{***}$ |
| Mn | 0.56 | 0.79 | 0.85 | 1.56 | 5.04 | 8.48 | 0.53 | 1.07 | 2.04 | $0.01^{***}$ | $0.01^{***}$ | $0.01^{***}$ |
| Ni | 1.50 | 1.81 | 2.25 | 1.37 | 1.76 | 2.02 | 1.13 | 1.47 | 2.97 | $0.03^{***}$ | $0.03^{***}$ | $0.05^{***}$ |
| Zn | 15.32 | 21.44 | 32.32 | 35.83 | 48.11 | 40.69 | 16.98 | 30.47 | 46.09 | $0.84^{***}$ | $0.84^{***}$ | $1.46^{***}$ |

Table 2 shows the mean concentration (mg/Kg DM) of macro elements in muscles of *C. carpio*, *L. rohita* and *W. attu* from the river Indus together with SE and effects of species, weight and species x weight interactions. Highly significant differences were observed in concentration of all selected minerals for species, weight and species x weight interactions ($P<0.01$) except K ($P>0.05$). All macro elements were found in appreciable amounts (Table 2). The order of macro element concentrations in *C. carpio* and *L. rohita* was P> Ca> K >Mg>Na and in *W. attu* was P>Ca>K>Na>Mg. The concentration of minerals increase with increase in weight (Table 2).

Mean concentration (mg/Kg DM) of micro elements in muscles of *C. carpio*, *L. rohita* and *W. attu* from the river Indus are shown in the Table 3. All the micro elements were significantly different in each fish with relation to weight and species ($P<0.05$). The order of concentration was as follow Fe>Zn>Cr>Ni>Mn in *C. carpio* and *W. attu,* whereas Fe>Zn>Mn>Cr>Ni in *L. rohita*.

Mean concentration (mg/Kg DM) of toxic elements (Hg, Pb, Cd) in muscles of *C. carpio, L. rohita* and *W. attu* from the River Indus is presented in Table 4. Concentration of Hg was significantly different in species and weight categories. Among toxic metals Pb was detected at higher concentration. Cd was not detected in any sample of any fish species (Table 4).

**Table 4.** Mean concentration (mg/Kg DM) of toxic elements in muscles of *Cyprinus carpio*, *Labeo rohita* and *Wallago attu* from the River Indus together with SE and main effects.

| | *Cyprinus carpio* | | | *Labeo rohita* | | | *Wallago attu* | | | SE and Main effects | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | W1 | W2 | W3 | W1 | W2 | W3 | W1 | W2 | W3 | Sp | w | spxw |
| Hg | 0.48 | 0.81 | 1.21 | 0.47 | 0.71 | 0.95 | 0.66 | 1.22 | 1.32 | $0.05^{***}$ | $0.05^{*}$ | $0.09^{***}$ |
| Pb | 1.21 | 1.96 | 2.36 | 1.21 | 1.58 | 2.03 | 1.43 | 1.89 | 3.71 | $0.17^{*}$ | $0.17^{***}$ | $0.29^{NS}$ |
| Cd | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | | | |

**Discussion**

This study assessed the chemical composition and mineral profile of three commercially important fish species viz., *C. carpio, L. rohita,* and *W. attu* from the River Indus in Mianwali District. These fish species were selected on the basis of difference in their food niche as well as on the food preferences of the consumers and economic costs of the fish species.

The chemical composition of *C. carpio, L. rohita* and *W. attu* showed high crude protein contents recorded as 75.25, 74.92 and 79.60%, respectively (Table 1). These finding are in accordance with the findings of FAO (2015) for freshwater fish. The relatively high to moderate percentage of crude protein may be attributed to the fact that these fishes are good source of protein but the differences observed among the selected species could be as a result of fish consumption or absorption capability and conversion potentials of essential nutrients from their diets or their local environment. Similar findings were revealed by Onyia, *et al.* (2010), Jabeen and Chaudhry (2011) and Fawole *et al.* (2007). Protein contents were decrease with increase in weight as large fish require low level of proteins and higher level of energy than small fish which is in agreement with the findings of Jimmy *et al.* (1973).

The fat contents were higher in *C. carpio* (19.52%) and lower in *W. attu* (13.33%). The differences in fat levels in the fish tissues could have been due to the impact of food (Oniya *et al.,* 2010). There was a positive relationship between increase in fat contents and the body weight of fish which is in agreement with the study of Naeem and Salam (2010). The ash contents in *C. carpio, L. rohita,* and *W. attu* were recorded as 4.67, 4.95 and 4.46%, respectively which is in good agreement with the previous studies (Naeem and Salam, 2010; Kalita *et al.,* 2008). The ash content in the analysed Indus fishes is an indication of copious amount of mineral contents in fish which is in harmony with the findings of Oniya *et al.* (2010). There was a significant difference in the energy value (kcal/100g) of selected freshwater fish species. The values of energy ranged from 448.80 (*W. attu*) to 478.90 (*C. carpio*) Kcal/100g which is in line with the study of Jabeen and Chaudhry (2011) and Oniya *et al.,* (2010). It was also observed that with increase in weight energy value also enhanced; this is in harmony with the findings of Mohamed *et al.,* (2010). Carbohydrates formed a slight percentage of the total composition of the fish muscles. The low values of carbohydrates recorded in the present study could be because glycogen in many freshwater fishes does not add much to the reserves in the body. Similar findings were also reported by Babalola *et al.,* (2011) and Effiong and Fakunle (2011).

All the fish samples examined in this study contained appreciable concentrations of macro elements like phosphorus, sodium, potassium, magnesium and calcium suggesting that these fishes could be used as good sources of minerals. Na, K and Mg are the essential minerals in human nutrition. The presence of appreciable concentration of Na, K and Mg recorded in this study suggests that Indus fishes are good source of Na, K and Mg. The concentration of Na, K and Mg reported in this study was within the limits of FAO (2015) values of Na, K and Mg range for fish muscles. These findings were in harmony with the finding of Hei and Sarojnalini (2012). The macro element concentrations recorded in all selected freshwater fish species were within the range of FAO (2015) values for fish muscles.

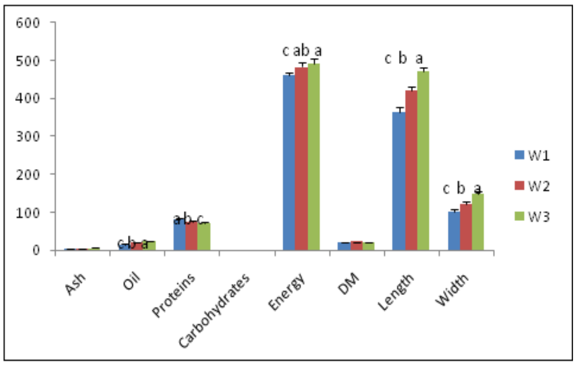


**Fig. 1.** Length, width and chemical composition of three weight groups of *C. carpio*.

The level of Mn in this study exceeded the maximum permissible levels of food fish (0.01-0.05 mg/kg) given by FAO (2015), WHO (1985) and FEPA (2003) standards. These findings suggested that consumption of selected fish are a cause of concern as it pose health risks it can cause Mn-related disorders in the consumers. There are many hazardous effects of Mn on vertebrates, its high bio accumulation interferes with the central nervous system by inhibiting the formation and action of dopamine, Na regulation in fish is disrupted by Mn and it may cause death of fish when accumulate in the liver (Jabeen and Chaudhry, 2010a).

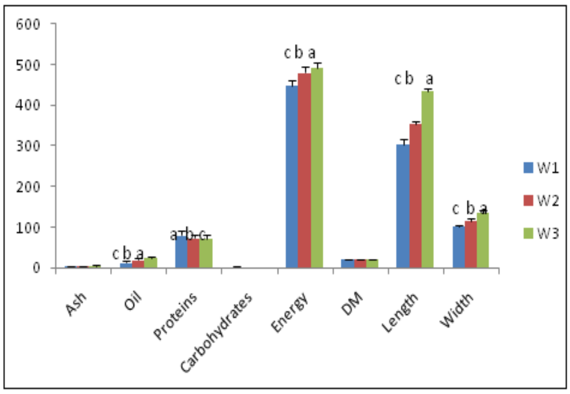


**Fig. 2.** Length, width and chemical composition of three weight groups of *L. rohita*.

Copper was not detected in the present study so the fish of Indus River was safe for human consumption because the presence of Cu affects growth, reproduction and behaviour of fish and ultimately the bioaccumulation of Cu affects the consumers (Jabeen and Chaudhry, 2010a).The Zn contents in different fish species of this study were under the recommended maximum limits of 50 mg/kg in fish (WHO 1985; FAO 1983). So the consumption of these fishes of the Indus River does not produce Zn-induced health hazards. Zn levels reported in this study were also in agreement with the previously reported levels of Zn in River Ravi Pakistan (Javed, 2005) and Indus River (Jabeen and Chaudhry, 2010a).

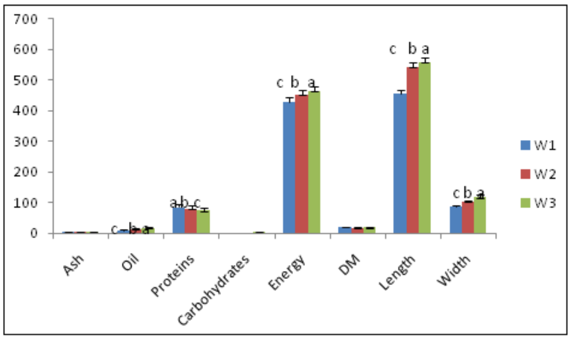


**Fig. 3.** Length, width and chemical composition of three weight groups of *W. attu*.

Fish is the major source of Fe in adults and children and its deficiency causes anaemia. Iron is an important trace mineral for all living organisms, but its high concentration is toxic and inhibits the enzymatic function. Fe was detected in all selected freshwater fish species and its concentration varied as 31.9 mg/kg in *C. carpio*, 34.36 mg/kg for *L. rohita*, 50.80 mg/kg in *W. attu* which agreed well with the findings of Jabeen and Chaudhry (2010b). The Fe levels reported in this study fall within the range of Fe concentration reported by FAO for fish muscles.

Cr levels exceed the allowable limit 0.05–0.15 mg/kg in food fish (WHO, 1985; FEPA, 2003). Cr levels (0.97 to 33.7 mg/kg) were high when compared to standard limits of 0.05–0.15 mg/kg in food fish (WHO 1985; FEPA 2003). The higher Cr levels in fish tissues arise through bio magnification, as all three fish species have excessive amount of Cr which refer the biomagnification at each trophic level (Forstner and Wittmann 1981). In view of the higher levels of Cr, when compared to WHO limits, it could be inferred that consumption of these fish could lead to health hazards in humans. High levels of Cr bioaccumulation in fish tissues could be due to chromite deposits in the close vicinity of the study area (Jabeen and Chaudhry, 2010a,b).

Mercury is recognized as a highly toxic metal and stringently regulated by waste discharges. Fish obtained methylated mercury through dietary uptake, which could be influenced by size, diet, ecological and environmental factors. Hg concentration reported in *C.carpio, L. rohita* and *W. attu* in this study exceeded the allowable concentration of Hg for food fish (0.01-0.5) according to EU and WHO standards). These findings are in good agreement with the findings of Jabeen and Chaudhry (2010a). The level of mercury in this study agreed with the literature (Houserova *et al.,* 2006; Dusek *et al.,* 2005; Jabeen and Chaudhry, 2010b). As *C. carpio* is omnivorous and *L. rohita* is herbivorous both have phytoplankton in their diets so in fresh water these small plankton and small organisms convert naturally occurring inorganic mercury into organic methyl mercury. As fish eliminate mercury at a much slower rate, it accumulates in fish tissues and organs where it cannot be removed by filleting or cooking and so accumulate in the skin and fat.

Lead is non-essential and toxic mineral. It is proved that human activities increase the Pb content in aquatic environment. Lead commonly enters the aquatic environment through erosion and leaching from soil, lead-dust fallout, combustion of gasoline, municipal and industrial waste discharges, street runoffs and precipitation Jabeen and chaudhry (2010b). In present study the levels of Pb varied among different fish species and different weight categories of these fishes (Table 3 and 4). The Pb in different fish species varied as 1.84, 1.60 mg/kg in *C. carpio, L. rohita* respectively, which was lower than the maximum allowable limit of 2 mg/kg for food fish (WHO 1985; FEPA 2003) but in case of *W. attu* (2.34mg/kg) exceeded the allowable limit which agree with the finding of Jabeen and Chaudhry (2010b); Wagner and Boman (2003). Lead bioaccumulation induces the reduced intellectual performance in children and increased blood pressure and cardiovascular diseases in adults (EC 2006).

When considering the heavy metals concentrations in fish species, the most important aspect is their toxicity to humans suitable for human consumption. The results of this study revealed that consuming fish from the study area may be risky to consumers because detected levels of Mn, Cr, Hg and Pb exceeded the permissible limits of food fish defined by FAO/WHO/FEPA for human consumption.

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