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Nutritional qualities and trace metals concentration of six fish species from Oba reservoir, Ogbomoso, Nigeria

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The nutritional qualities and concentration of trace metals (Pb, Fe, Cu, Zn, and Cd) in six fishes (*Hemichromis fasciatus, Siluranodon auritus, Sarotherodon galileaus, Tilapia zilli*, *Chrysichthys nigrodigitatus,* and *Hepsetus odoe*) obtained from Oba reservoir in Ogbomoso, Nigeria were evaluated. The value ranges of 55.95 to 68.80, 16.91 to 26.18, 5.46 to 18.18, 0.51 to 9.05, 7.67 to 10.14 and 0.97 to 1.41% were obtained for moisture, protein, fat, carbohydrate, ash and fibre contents, respectively. Highest protein and fat contents were obtained from *H. odoe.* The trace metals in fishes were found at various concentrations ($P \leq 0.05$). High levels of essential metals; Fe, Cu and Zn, were found in the fishes. The concentrations of Pb and Cd were also high in the fishes, but not detected in the water sample from the reservoir. A positive correlation was observed between fat and fibre ($P \leq 0.01$) as well as Zn and Pb ($P \leq 0.05$) while fat and iron were negatively correlated. The results show that the fishes evaluated are rich in essential nutrients. However, prior exposure of the fishes to pollutants was not unlikely as shown by Pb and Cd levels. There is the need to initiate further study to identify sources of these pollutants and their effects on biota from Oba reservoir.

Key words: Fish, nutrient, environment, pollutant, reservoir.

INTRODUCTION

Fish is widely acceptable in global menu due to its palatability, low cholesterol level and tenderness of its flesh (Eyo, 2001). It also receives an increased level of attention because of its potential source of animal protein and some essential nutrients for human diets (Zenebe et al., 1998). It is the cheapest source of animal protein and other nutrient required in human diets. Fish meal contains significantly low lipids and higher water than beef and chickens and it is greatly favoured over all white and red meats (Nestel, 2000). The nature and quality of nutrients in most animals depends largely on the type of food consume. The feeding habit of an individual fish species greatly affects its body nutrient composition.

The measurement of some proximate and nutrient profiles such as protein contents, lipid, ash content, nitrogen free extract and crude fibre including some essential heavy metals, such as copper, zinc and iron to mention a few, are very important to know the nutritional quality of the fish. Proximate composition is a good indicator of physiology which is needed for routine analysis of fisheries (Cui and Wootton, 1988). Evaluation of fishes to determine the concentration of many other heavy metals, that are non-essential and may be body burden to human due to accumulation from fish consumption, is often necessary to ensure that they meet the dietary requirements and commercial specifications (Watermann, 2000).

Report has shown that heavy metals are major pollutants that pose serious health risk and environmental concerns (Onyia et al., 2007). Pollution of the aquatic environment with heavy metals has become a worldwide problem because they are indestructible and most of

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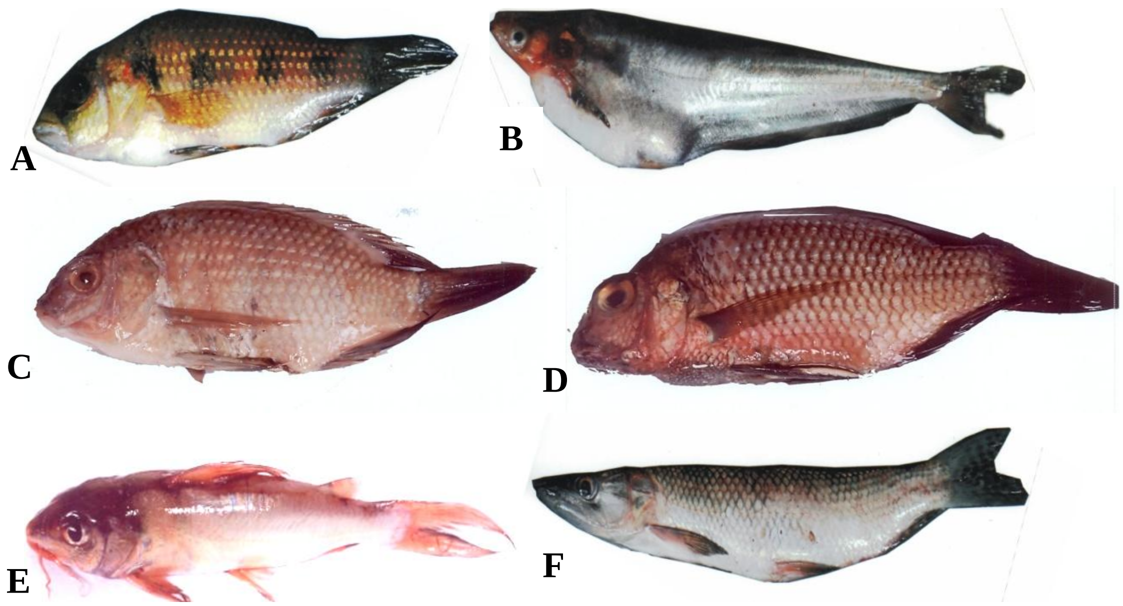

Figure 1. Some fresh water fishes of commercial importance obtained from Oba reservoir, Ogbomoso. **A.** *Hemichromis fasciatus.* **B.** *Siluranodon auritus.* **C.** *Sarotherodon galileaus.* **D.** *Tilapia zilli.* **E.** *Chrysichthys nigrodigitatus.* **F.** *Hepsetus odoe.*

them have toxic effects on aquatic organisms (Sen et al., 2011). Among environmental pollutants, metals are of particular interest, due to their potential toxic effects and ability to bioaccumulates in aquatic ecosystems (Gledhill et al., 1997). Transport of metals in fish occurs through the blood where the ions are usually bound to protein (Kaoud and El-Dahshan, 2010). Some animals have ability to accumulate heavy metals to levels higher than the ambient metal concentrations without any detectable adverse effects on their normal physiological functions (Otitoloju et al., 2007). High concentrations of heavy metals in human body often result in severe damage to vital organs and systems. Reported damages include enhanced lipid peroxidation, DNA damage, enzyme inactivity and the oxidation of protein sulfydryl groups (Taiz and Zeiger, 1998). Toxic heavy metal can also cause dermatological diseases, skin cancer and internal organs cancers, cardiovascular disease, diabetes and anaemia, as well as reproductive, developmental, immunological and neurological effects in the human body (Kaoud and El-Dahshan, 2010). The toxicity of these elements is due to their ability to cause oxidative damages to living tissues (Kaou and El-Dahshan, 2010)

Information on the chemical composition of freshwater fishes is invaluable in different aspect of food science. The nutritional components of the freshwater fishes differ greatly between species, sexes, seasons and geographical localities (Zenebe et al., 1998) and also found to be influenced by post-harvest processing (Clement and Lovell, 1994). However, nutritional content of fish is ultimately a function of the food that is available for the fish to feed on and the assimilative capacity of individual fish. Fresh water fishes from Oba reservoir in Ogbomoso (N8° 7' 59. 9442; E4° 14' 59. 9238) are being sold to the populace. Despite the long existence of Oba reservoir, only few studies have reported the aspect of fish biology (Fawole and Adewoye, 2004; Fawole et al., 2003) while information on the nutritional quality of some fishes in the area is yet to be reported. The fact that the reservoir receives water from different tributaries, majorly from Afon and Asa rivers, makes it vulnerable to pollution especially through the water sources as well as run off. In view of this, we assessed six selected fish species (*Hemichromis fasciatus, Siluranodon auritus*, *Sarotherodon galileaus, Tilapia zilli*, *Chrysichthys nigrodigitatus* and *Hepsetus odoe*) of commercial importance from Oba reservoir to determine their nutritional qualities and possible bioaccumulation of heavy metals.

MATERIALS AND METHODS

Collection of water and fish samples

Water sample from Oba reservoir used for physicochemical analysis was collected into pre-cleaned plastic container (200 ml). Six fishes (n=6) were sampled with each species collected separately into polythene bag from Oba reservoir located in Ikose, Orire Local Government area of Ogbomoso. The fish species (Figure 1 A-F) were identified as *Hemichromis fasciatus* (Peters 1858), *Siluranodon auritus* (Geoffroy St. Hiaire, 1808-09), *Sarotherodon galileaus* (Linnaeu, 1758), *Tilapia zilli* (Gervais, 1848), *Chrysichthys nigrodigitatus* (Laceépède, 1803) and *Hepsetus odoe* (Bloch, 1794).

Preparation and digestion of fish samples

The fish samples were blotted dry and weighed, then each fish wrapped in foil and oven dry at 105°C until constant weight was

Table 1. Physicochemical properties of water from Oba reservoir.

Parameter	Oba reservoir	Aqua culture standard[b]
pH	6.8	6.7-8.5
Total hardness	14.0	-
Dissolved Oxygen	11.05	5-10
BOD	6.20	≤10
Alkalinity	325	50- 3000
Total dissolved solid	67.0	≤500
Total suspended solid	12.0	-
Total solid	79.0	-
Salinity	0.06	-
Sulphate	2.06	-
Nitrates	3.947	-
Fe	0.89	-
Pb	ND	-
Cu	ND	-
Cd	ND	-

Unit: mg/L except pH. [b]Chaudhary et al., (2004).

obtained. The fish were homogenized using blender (MC- 320B). Sample digestion was as described by Kumar et al. (2010), with slight modification. Briefly, 1.0 g of homogenized powdered of fish sample was placed in a Teflon beaker and digested with few drops of sodium chloride solution (30%) and a 10 ml mixture (1:5) of concentrate nitric acid (65%) and concentrated perchloric acid (70%). The free chlorine developed loosen the chemical bonds in organic compounds after gentle heating (at 70±5°C) in a water bath for 12 h and destroys the organic matter in order to transfer the metals into the solution. The digested samples were centrifuged and the supernatant was analyzed for lead, cadmium, copper, zinc and iron using atomic absorption spectrophotometer (Buck 210 AAS, 2005, USA).

Proximate analysis

The proximate components were analyzed using AOAC (1990). Fish samples were analyzed for the following.

Moisture content: The fish moisture content was determined by drying the sample in a hot air oven at 105°C until constant weight was obtained. The percentage difference due to loss of water was then calculated.

Protein content: It was determined by Kjeldahl method which involves digestion of organic nitrogen of 1 g of grand fish sample using concentrated teraoxosulphate (VI) acid which converts it to ammonium teraoxosulphate VI. It was then diluted and made alkaline with sodium hydroxide, followed by distillation. The liberated ammonia was collected in a boric acid solution and was determined via titration. The percentage concentration of protein in the sample was then calculated.

Ash content: It was determined using drying ashing procedure by burning off 1 g of homogenized dried sample in a muffle furnace at 550 to 600°C, until the residue become completely white. The percent of ash was calculated as:

Percentage (%) of ash = (Weight of ash / Weight of Sample) × 100

Fat content: This was estimated using 1.0 g of completely dried fish sample, placed in the Soxhlet extractor and extracted with a nonpolar solvent, ethyl ether. After extraction, the solvent was evaporated and the extracted materials were weighed. The percentage of fat content was calculated as follows:

Percentage (%) of fat = (Weight of extract/Weight of sample) × 100

Fibre content: A 1.0 g of dried sample was digested with 0.128 M H_2SO_4 with two drops of octanol to prevent foaming. The content was boiled for 30 min, and then filtered and washed to remove acid. The residue was boiled with 0.223 M KOH for 30 min, and then washed in boiling water and acetone. The residue was dried and ignited in muffle furnace. The loss of weight represents the crude fibre.

Carbohydrate content: This was determined by the percentage difference of other contents.

Physicochemical parameters

The following physicochemical parameters were determined from water samples collected; pH, total hardness, dissolved oxygen, alkalinity, total dissolved solid, salinity, sulphate, nitrate, total suspended solid. All parameter were measured in mg/L except pH and salinity (psu) using standard method (APHA, 1995). Trace metals: Zn, Fe, Pb, Cu and Cd were also analyzed.

Statistical analysis

Data collected were subjected to statistical analysis using One-way analysis of variance (ANOVA) at 0.05 level of significant. Further analysis was done using Duncan Multiple Range Test. Spearman correlation was used to evaluate the relationships between the proximate parameters and heavy metals analyzed. The $P \leq 0.05$ and $P \leq 0.01$ were considered to indicate statistical significance. SPSS version 15 software was employed.

RESULTS

The result of the physical and chemical parameters of water sample from Oba reservoir is shown in Table 1. The non-essential heavy metals; cadmium and lead were not detected. The proximate composition of the fishes analyzed is shown in Table 2. The moisture content values obtained for the fishes ranged from 55.95 to 68.80%. The least moisture content value was obtained in *S. galilaeus* while highest in *C. nigrodigitatus.* The protein values obtained for the fishes showed that *H. odoe* and *H. fasciatus* had similar values which were significantly higher than in *S. auriatus, T. zilli, S. auriatus and C. nigrodigitatus* but similar to *S. galilaeus.* Protein value range was between 16.9 and 26.18%. The values of fat content of all the six species were in the order of *H. odoe* > *H. fasciatus* > *S. auritus* > *S. galilaeus* > *C. nigrodigitatus* > *T. zilli*, with significant difference among the values except those obtained for *C. nigrodigitatus, S. galilaeus* and *T. zilli*. The carbohydrate content of the fishes range from 0.51 to 9.05% with the highest value obtained for *S. auriatus* significantly different from other values, while the values obtained for *H. fasciatus, T. zilli* and *C.*

Table 2. Proximate analysis of selected fish species from Oba reservoir.

Fish sample	Moisture	Protein	Fat	Carbohydrate	Ash	Fibre
Hemichromis fasciatus	59.79 ±2.61[b]	25.42 ±0.80[a]	9.78 ±0.41[b]	0.51 ±0.08[d]	10.14±0.47[a]	1.41 ±0.01[a]
Siluranodon auriatus	64.12 ±1.52[a]	16.91c±120[c]	7.81 ±0.06[c]	9.05 ±2.14[a]	9.89 ±0.69[a]	1.19±0.03[a]
Sarotherodon galilaeus	55.95 ±1.20[c]	23.05 ±1.26[ab]	6.72 ±0.31[cd]	3.79 ±1.56[c]	9.43±0.25[a]	1.06 ±0.08[ab]
Tilapia zilli	61.95 ±1.22[ab]	21.31 ±1.55[b]	5.46 ±0.12[d]	1.13 ±0.03[d]	9.18 ±0.41[a]	0.97 ±0.12[b]
C. nigrodigitatus	64.80 ±0.41[a]	18.32 ±0.65[c]	5.72 ±0.18[a]	0.53 ±0.12[d]	9.15 ±0.04[a]	1.03 ±0.02 [ab]
Hepsetus odoe	59.53 ±1.11[b]	26.18 ±0.18[a]	18.18 ±0.18[a]	7.52 ±0.36[b]	7.67 ±0.77[b]	1.28 ±0.02 [a]

Measurements were done in percentage. Different alphabets along column indicate significant difference using ANOVA and Duncan's multiple range tests (P≤0.05).

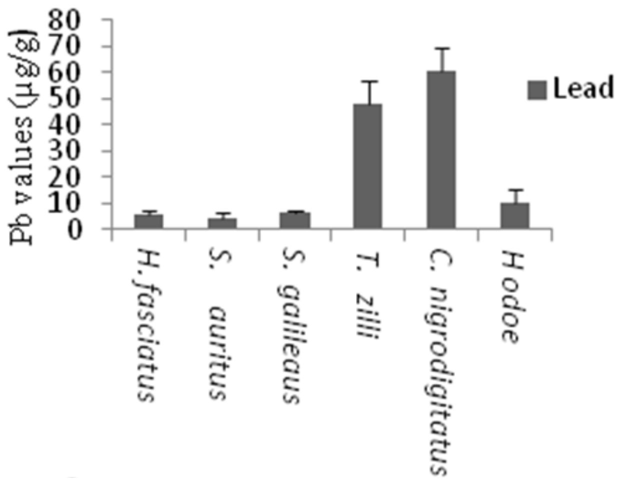

Figure 2. Lead concentrations obtained from selected fishes from Oba reservoir.

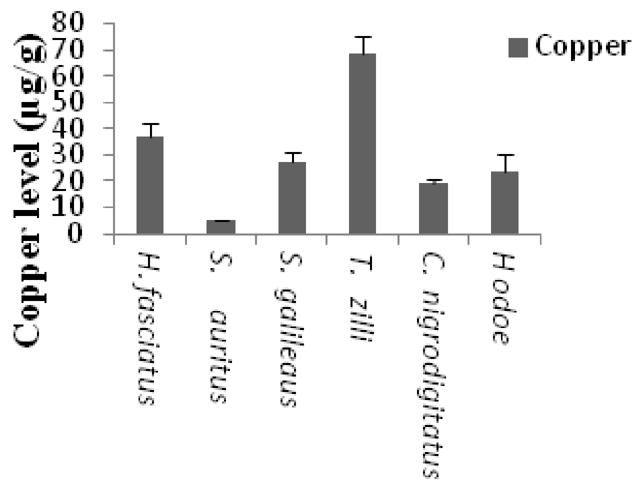

Figure 4. Zinc concentrations obtained from selected fishes from Oba reservoir.

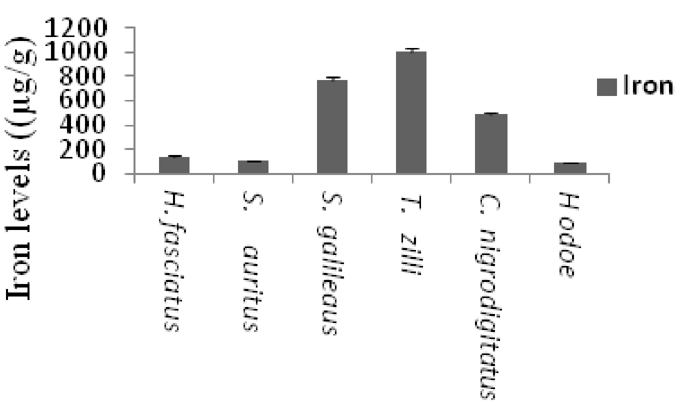

Figure 3. Iron concentrations obtained from selected fishes from Oba reservoir.

nigrodigitatus were similar (Table 1). Similarity was observed in the values obtained for the ash content of the fishes without significant difference except only in *H. odoe* with lowest value compared to other fishes. The highest ash content was seen in *H. fasciatus*. The fibre content was within the range of 0.97 to 1.41% with the lowest value obtained for *T. zilli* but similar to *S. galilaeus* and *C. nigrodigitatus.*

The concentrations of the selected metals obtained in different fish species are shown in Figure 2 to 6. Lead values (Figure 2) ranged from 4.42 to 60.35 µg/g with the highest obtained in *C. nigrodigitatus.* There was significant difference in the Pb values among the fishes with similarity in the values of *H. fasciatus, S. auriatus* and *S. galilaeus*. The values of Fe (Figure 3) and Zn (Figure 4) were significantly higher in *T. zilli, C. nigrodigitatus* and *S. galilaeus* compared to other three *fishes* (P≤0.05). The highest value of Cu (Figure 5) was obtained in *T. zilli* while the least value was obtained in *S. auriatus* and the range was 5.04 to 68.29 µg/g. Compared to all other metals evaluated, the values obtained for Cd (Figure 6) were the least in all fish species. Mean values of Cd showed variation among the fish species with values ranging from 0.07 to 2.85 µg/g.

Table 2 shows the Spearman correlation between the proximate parameters and the heavy metals evaluated. Significant positive correlation was found between fat and

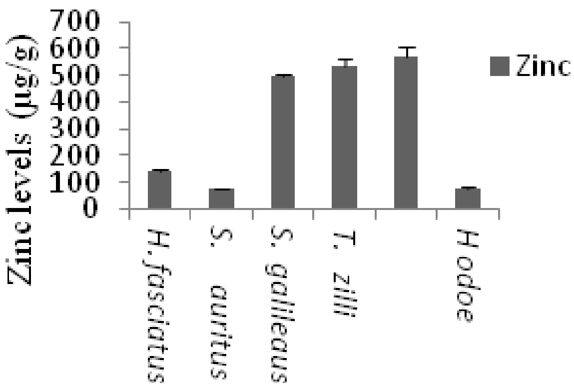

Figure 5. Copper concentrations obtained from selected fishes from Oba reservoir.

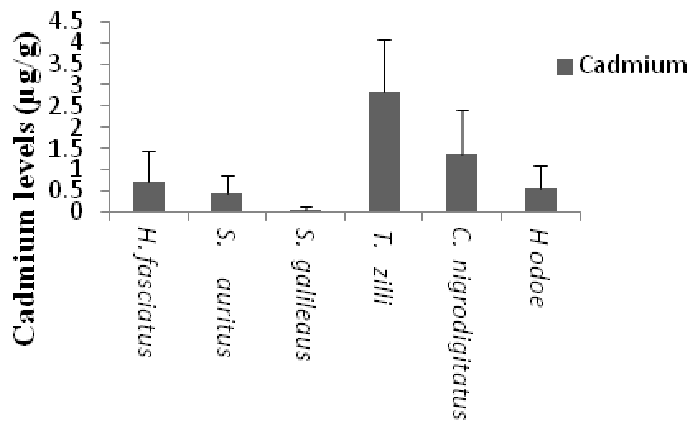

Figure 6. Cadmium concentrations obtained from selected fishes from Oba reservoir.

fibre (P≤0.01), Zn and Pb (P≤0.05) while fat and Iron were negatively correlated (P≤ 0.05)

DISCUSSION

Fish is widely acceptable for consumption because of its high palatability, low cholesterol and tender flesh (Eyo, 2001) and also a cheap source of protein. The demand for fresh water fishes can still be improved on, if information dissemination on the valuable nutritional composition of fishes reaches the grass route. Besides this, there is the need to raise consumer awareness to ensure that contaminated fishes are avoided. This will relieve the body of the burden of these toxic chemicals. Although physicochemical properties of water from Oba reservoir favours production of fishes which conforms with standard for aquaculture (Chaudhary et al., 2004) and with heavy metals like Pb and Cd not detected. However the high concentration of non essential heavy metals in some of the fishes evaluated (*T. zilli, C. nigrodigitatus and H. odoe*) is a source of concern. This trend could probably be due to the prior exposure of these fishes to toxicants from polluted water body before swimming down to the reservoir since they are pelagic fishes. Mersch et al. (1993) linked the accumulation of the toxicants in the fish to the possibilities of the fish to accumulate metals and thus could serve as indicators of pollution.

Report has shown that Fe is one of the most abundant metals in the earth crust (Ibrahim and Tayel, 2005). The high value of Fe observed in this study compared to other metals may be due to increase in total dissolved iron in the Oba reservoir. The values of Fe were in the order: *T. zilli* > *S. galilaeus* > *C. nigrodigitatus.* High concentration of Fe was reported in fish organs (El-Naggar et al., 2009) and was reported as the most abundant in *C. nigrodigitatus* compared to other fishes evaluated (Asuquo et al., 2004). However, the values obtained for Fe in this study were lower compared to freshwater fishes in China (Du et al., 2012). Copper, in its many forms is regarded as the third most common minerals in human body. It is a fundamental micronutrient to all forms of life in enzyme activity or random rearrangement of natural protein (Bower, 1979). High values were observed in all fish evaluated with the least value in *S. auriatus.* The high value obtained could be due to elevated metal– binding protein synthesis. Similar observation of high value of copper in fishes attributed to elevated metal binding protein synthesis has also been reported (Yacoub, 2007).

Zinc is known to be involved in most metabolic pathways in humans and zinc deficiency can lead to loss of appetite, growth retardation, skin changes and immunological abnormalities (Malakootian et al., 2011). Fish takes up Zn directly from water, especially via mucous and gills. The maximum zinc level permitted for fish is 50 mg/kg according to Food Codex. The values of Zn obtained were significantly high in *T. zilli*, *S. galilaeus and C. nigrodigitatus*, compared to the other fishes but lower compared to Zn values reported for freshwater fishes in China (Du et al., 2012). United States environmental protection agency and the European Commission (US-EPA and EC) have not considered any standards or limits for the zinc concentrations in fish(WHO, 2008).

Lead is non-essential element that constitutes body burden and a great threat to life if present in substantial quantity. It is toxic even at low concentrations and has no known function in biochemical processes (Burden et al., 1998). The values of Pb were very high in the fishes. The standard level Pb was reported to be 0.5 mg/kg dry weight (FAO, 1983). Similar to Pb, Cadmium was not detectable in the water but fairly high value observed in the fishes and highest in *T. zilli*. The standard permissible level of 0.05 to 5.5 mg/kg fish dry weight was reported for Cd (FAO, 1983). None detection of Pb and Cd in the water body and high values of these metals in the fishes call for further research on the reservoir in order to determine the source(s) of these pollutants.

Copper is an essential element in the body and is

Table 3. Relationships between proximate analysis and heavy metals evaluated from six selected fishes in Oba reservoir, Ogbomoso.

Item	Moisture	Protein	Fat	Carbohydrate	Ash	Fibre	Lead	Iron	Copper	Zinc	Cadmium	Weight
Moisture	1											
Protein	-0.771	1										
Fat	-0.486	0.600	1									
Carbohydrate	0.257	-0.200	0.257	1								
Ash	-0.429	-0.200	0.086	-0.200	1							
Fibre	-0.600	0.543	0.943**	0.029	0.371	1						
Lead	0.429	0.029	-0.543	-0.371	-0.771	-0.657	1					
Iron	0.029	-0.257	-0.886*	-0.429	0.086	-0.771	0.429	1				
Copper	-0.600	0.486	-0.257	-0.543	0.143	0.143	-0.200	0.600	1			
Zinc	0.257	-0.143	-0.771	-0.657	-0.314	-0.714	0.829*	0.771	0.371	1		
Cadmium	0.377	-0.116	-0.464	-0.638	0.290	-0.406	0.696	0.319	0.319	0.638	1	
Weight	0.029	0.257	-0.086	0.340	-0.657	-0.314	0.429	0.143	-0.086	0.257	-0.348	1

Spearman's correlation: **Correlation is significant at the 0.01 level (2-tailed).*Correlation is significant at the 0.05 level (2-tailed).

required for different functions. Standard level of 20 mg/kg dw (dry weight) has been reported (TFC, 2002). However, after new regulation in 2008, no maximum level was specified for Cu in the fish species and sea foods (TFC, 2008). Also, there is no guideline on acceptable levels of Cu in fish suggested by European Economic Community or FAO/WHO (Mol et al., 2010). The level of Cu in the evaluated fishes is considerably high.

Body composition is a good indicator for the physiological condition of fish. The percentage of water is a good indicator of its relative content of energy, proteins and lipids. The lower the percentage of water, the greater the lipid and protein contents, and the higher the energy density of the fish (Dempson et al., 2004; Ali et al., 2005).This pattern was observed in this study although not consistent for all the fishes evaluated. Protein and fat are the major nutrient in fish and their level help to define the nutritional status of a particular organism (Aberoumad and Pourshafi, 2010). The chemical composition of fish varies from one individual to another depending on age, sex, environment and season with protein level ranging from 16 to 21%, lipid from 0.1 to 25 %, ash 0.4 to 1.5%, moisture content of 60 to 80 % with extreme of 96% having been reported (Muraleedharan et al., 1996). Also, moisture content range of 65.88 to 78.62 (Mazumder et al., 2008), 77.93 to 82.7% (Ravichandran et al., 2011) and 68.6 to 77.1% (Aberoumand and Pourshafi, 2010) were reported for fishes. The values we obtained for the proximate composition where within the the reported ranges with higher percentage in the case of fibre. The result obtained for percentage of crude protein in this study shows that the selected fishes are good source of protein.

In view of the importance of fish in human diet, it is necessary that biological monitoring of the fish meant for consumption should be carried out regularly to ensure safety. WHO (1995) reported that heavy metals must be controlled in food sources in order to assure public safety. Excessive concentration of food heavy metals is associated with the etiology of a number of diseases, especially cardiovascular, renal, neurological and bone diseases (Chailapakul et al., 2008). A major reason to monitor levels of toxic metals in foods follows from the fact that contamination of the general environment has increased (Heidarieh et al., 2013). Information on the proximate and heavy metal composition of fresh water fishes is of particular importance for the determination of their nutritive values as well as for investigating the level of pollution or contamination. Although, high levels of some of the selected metals were observed in the fishes, the water analysis indicates that Oba reservoir might not be polluted. Further study is however required for verification.

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