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Metals in Commercial Fish Species of Ijebu North Local Government Market, Ogun State, Nigeria

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Abstract

Fish are good source of high quality protein, but may accumulate significant amount of metals. Heavy metals concentrations (Mn, Zn and Cu) in two commercially available imported fish species vis Atlantic Mackerel (*Scromber scombrus*) and Blue whiting (*Micromesistius poutassous*), in Ijebu-Igbo markets, Ijebu-Igbo, Ogun State, Nigeria were investigated. The fish morphomeristics features were carried-out using standard methods. Liver, gill and flesh of each fish species were removed, digested and analyzed for the metals concentration using Atomic Absorption Spectrophotometer following standard recommended procedures. One-way analysis of variance showed the significant and differential levels of the accumulated metals in each organ. Results showed that Mn concentration found in ranges between 2.88 ± 0.40 mg/kg and 46.69 ± 28.80 mg/kg in flesh and liver of *S. scombrus* respectively. Also, concentration of Cu ranges from 1.62 ± 0.30 mg/kg in gills to 21.02 ± 19.03 mg/kg in liver of *S. scombrus*. Meanwhile, Zinc ranged from 17.68 ± 6.24 mg/kg in flesh of *M. poutassous* to 102.61 ± 43.28 mg/kg of in the gills of *S. scombrus* species. However, heavy metals were detected in all the tissues and organ of the fish species with *S. scombrus* accumulated higher metals than *M. poutassous* and they were all found above standard recommended acceptable limit. Thus, imported fish from the study area is unsafe for human consumption. Meanwhile, further studies should be carried-out on bioaccumulation of these metals in the study fish species and other fishes for human safety.

Keywords: Ijebu Igbo, Metal Pollution, Human Safety, Morphomeristics, Imported Fish

1. Introduction

The contamination of water with a wide range of pollutants has become a matter of concern over the last few decades (Amin *et al.,* 2015). The natural aquatic systems may extensively be contaminated with trace metals due to the alarming situation of rapid economic growth. According to Paquin *et al.,* 2003, the coastal or river waters are contaminated by the clumping of industrial wastages, domestic and other man-made activities, recent works have shown that the higher level of metal concentration will bring shattering effects to the ecological balance by altering the range of organisms in the water.

Metals are in extremely small quantities that reside in or present in animals and plant tissues through natural and also artificial (anthropogenic) through such natural processes as weathering and dissolution and also through artificial means such as agricultural (from fertilizers, pesticides, etc) and industrial activities (Gaseous, liquid and solid waste) (Niloofar *et al.,* 2013; Emmanuel *et al.,* 2015; Jenyo-Oni and Oladele, 2016). Metals are natural components of the earth's crust, the stable and persistent, contamination of coastal water and sediments. They are serious pollutants due to their toxicity by forming persistence and bioaccumulation problems (Pekey, 2006). They exhibit toxicity by forming complexes with organic compounds and active sites of enzymes.

In many countries, industrial wastes, geochemical structure and mining of metals create potential source of trace metals pollution in the aquatic environment. Under certain environmental conditions, trace metals might accumulate up to a toxic concentration and cause ecological damage (Sivaperumal *et al.,* 2007). Metals cannot be degraded, as they are deposited, assimilated or incorporated in water, sediment and aquatic animals (Abdel *et al*., 2011).

Trace metals are normal constituents of marine environment that occur as a result of pollution principally due to the discharge of untreated waste into rivers by many industries. Trace metals gain access into the aquatic system from natural anthropogenic sources and get disturbed in water body, suspended solids and transportation (Olajire and Imeokparia, 2000). The trace metals pollution of aquatic ecosystem is usually obvious in sediments and aquatic biota than in elevated concentration in water.

Bioaccumulation of trace metals in tissues of marine organisms has been identified as an indirect measure of the abundance and availability of metals in the marine environment (Kucuksegin *et al*., 2006). Metals could be accumulated in water, sediment. Multiple factors including season, physical and chemical properties of water can play significant role in metal accumulation in different fish tissue (Hayat *et al.,* 2007).

The pollution of aquatic ecosystem by trace metals is an important environmental problem, as they constitute some of the most hazardous substances that could bioaccumulate (Zweig *et al.,* 1999).Toxic substances may knock down the immune, reproductive, nervous and endocrine system in animals and those effect can be at organ ,tissue and cell levels (Orebiyi *et al.,* 2010). The accumulation of metals in an aquatic environment has direct consequences on man and the ecosystem (Fatoki *et al*., 2002). Human beings are affected negatively as a result of their accumulations.

Fishes are at the top of the aquatic food chain and they accumulate trace metals form the surrounding waters. Fishes could take up take up metals ions in the water and store them in their tissues. Fishes are the inhabitants that cannot escape from the detrimental effects of these pollutants (Olaifa *et al.,* 2004). Some environmental factors affect the growth and survival of fishes in their natural habitats and these factors therefore cause depletion in their population.

Determination of the levels of heavy metal concentration in commercial fish species has received considerable attention in different countries in the region and around the world. Such interest aimed at ensuring the safety of the food supply and minimizing the potential effect on human health which this research justifies. The research was aimed to examine metals (Mn, Cu and Zn) concentrations in two imported fish species (*Scomber scombrus* and *Micromesistius poutassou*) in Ijebu-Igbo Market, Ijebu Igbo, Ogun State, Nigeria.

2. Materials and Methods

2.1 Description of the Study Area

Ijebu North Local Governments had her head quarter as Ijebu Igbo, Ogun State, Nigeria. It has the largest land mass of all Ijebus, and in Ogun state, Nigeria. It extends to, and has three important boundary points at Ibadan, Ikire, and Ondo (Fig. 1). Its geographical coordinates are latitude 6° 58' 0" North, and longitude 4° 0' 0"

East (Fig. 1). Ijebu Igbo is divided into five clans: Oke-Sopen, Oke-Agbo, Ojowo, Atikori, and Japara with an Oba (king) enthroned to govern each of these clans.

2.2 Samples Collection

A total of 60 adult fish species of Atlantic Mackerel (*Scromber scombrus*) and Blue Whiting (*Micromesistius poutassous*) at 30 each was purchased from retailers at Ijebu Igbo market, Ijebu Igbo, Ogun State, Nigeria in June, 2017. They were immediately placed in a sterile polythene bags, labeled and kept in an icebox before taken to the laboratory for proper weighing, measuring and analysis. In the laboratory after morphomeristic analysis of each sample, their liver, gill and flesh was removed through guided laboratory dissection with sterilize dissecting kit and put separately into a glass bottle before metal analysis. They were digested and analysed for metals immediately.

Figure 1: Map of Ijebu Igbo, Ogun State, Nigeria
Source; Google Map.

2.3 Measurement of Morphometric and Meristic Features

At first, morphomeristic features of each fish species obtained were carried out. Morphometric features were done using standard calibrated measuring board in centimeter (cm) and Metler balance in gram (g) respectively. Meanwhile, the meristics features were counted using office pin and hand lens. They were mopped on a filter paper before being weighed to remove excess water from their body in order to ensure accuracy.

Morphometric features measured were weight (W), total length (TL), head length (HL), fork length (FL), standard length (SL), pectoral fin length (PFL), pelvic fin length (PvFL), caudal pedaunce length (CPL), caudal pedaunce depth (CPD), body depth (BD), tail length (TaL), eye diameter (ED) and snout length (SnL). While, meristic features measured were dorsal fin spine (DFS), dorsal fin ray (DFR) pectoral fin spine (PFS), pectoral fin ray (PFR) and caudal fin count (CFC).

2.4 Determination of Heavy Metals

Prior to digestion, each labeled samples were separately dried in the oven at 65°C to obtain a constant dry weight of 5g from each sample. The dried samples were ground to powder, using laboratory ceramic mortar and pestle, and sieved with 2mm sieve. Two grams of each dry sample were weighed, transferred into polyethylene tubes; 10 ml of freshly prepared nitric acid (HNO_3) were then added and left overnight at room temperature. The samples were digested and put in a water bath set at boiling water temperature (100^{0}C) with a contents boiled for about 2hrs until all the samples dissolved.

The samples were transferred in a tube and placed in heating blocks and digest for 15min at 150°C after which the temperature is raised to 230^{0}C. Any ‘cold spots’ in the heating block of the rotating tubes were observed so that the nitric acid is driven off as uniformly as possible and when all tubes reached the dense white fume stage, this stage is not reached until essentially all the nitric acid have been driven off. This digestion continued for 30mins, then, the tube were removed from digesting block and allow to cool with addition of 5ml water volume while mixed thoroughly. The digests were then allowed to cool, filtered and transferred to 25ml volumetric flasks and made up to mark with 1% nitric acid (AOAC, 2005).

The digests were kept in a plastic bottle and the heavy metal concentrations were determined using an Atomic Absorption Spectrophotometer (VGB 210 Bulk Scientific). Working calibration standards for manganese, zinc and copper were prepared by serial dilutions of concentrated stock solutions in accordance to manufacturer's specification and instruction (Merck, Germany). The actual concentrations of each metal were read and calculated using the formula (Mansour and Sidky, 2002):

Actual concentration of metal in sample = ppmR × dilution factor

Where;

ppmR= AAS Reading of digest and

Dilution Factor = Volume of digest used ⁄ Weight of sample digested.

2.5 Statistical Analysis

Data obtained were subjected to statistical analysis using the Statistical Package for Social Sciences (SPSS) version 20.0 (IBM Corp, 2011). Analysis of Variance (ANOVA) and descriptive statistics were used to check the differential accumulation in the concentrations of heavy metals in the tissues of fish species. Their means were presented as Mean ±Standard error of mean and separated using Student-Newman-Keuls (SNK). Pearson correlation was used to compare the relationship among the fish morphomeristics parameters in relation to their metal accumulation. *P* – value was set at 0.05.

3.0 Results and Discussion

3.1 Morphomeristic Features

The morphometric features of the study fish species, *M. poutassou* and *S. Scombrus* are shown in Table 1. Mean weight, pectoral fin length, pelvic fin length, caudal peduncle length, body depth, tail length and snout length were significantly higher ($p < 0.05$) in *M. poutassou* than *S. scombrus*. On the other hand, there was no significant difference ($p > 0.05$) in the mean of total length, head length, fork length, standard length and eye diameter between *M. poutassou* and *S. scombrus*. However, these values (except eye diameter) were higher in *M. poutassou* than *S. scombrus*.

The meristic features of *M. poutassou* and *S. scombrus* were presented in Table 2. The dorsal fin spine, dorsal fin ray and the caudal fin count were significantly higher ($p > 0.05$) in *M. poutassou* than *S. scombrus*. On the other hand, no significant difference ($p > 0.05$) was recorded in the values of pectoral fin spine and pectoral fin ray between the two study fishes.

3.2 Length-Weight Relationship

Table 3 represents the length-weight relationship of *Micromesistius poutassou* and *Scomber scombrus* recorded in this study. The length-weight relationship was significant ($p = 0.01$) in the two fish species. Similarly, length-weight relationship was very strong in the two fish species.

3.4 Heavy Metals Concentration in the Fish Species

The levels of manganese (Mn), copper (Cu) and zinc (Zn) in the gills, flesh and liver of *Micromesistius poutassou* and *Scomber scombrus* are presented in Table 1. Gill level of Zn was observed to be significantly higher ($p <0.05$) in *S. scombrus*. The gill levels of Mn and Cu recorded in this study were however not significantly different ($p > 0.05$) between the two fish species. Flesh level of Mn was significantly higher ($p < 0.05$) in *M. poutassou* (Table 4). On the other hand, flesh concentration of Cu was significantly higher in *S. scombrus*.

There was however no significant difference ($p > 0.05$) in the flesh level of Zn between the two fish species. *S. scombrus* recorded significantly higher ($p < 0.05$) liver levels of Mn and Cu. There was no significantly difference in the liver level of Zn between the two fish species.

Table1: Morphometric Parameters of *Micromesistius poutassou* and *Scomber scombrus*

Parameter(s)	*M. poutassou*	*S. scombrus*	Sig.
Weight (g)	367.26±40.12	222.40±25.59	0.01*
Total length (cm)	32.56±1.00	31.06±1.74	0.13
Head length (cm)	8.14±0.96	6.84±1.27	0.10
Fork length (cm)	20.20±1.81	19.14±0.54	0.24
Standard length (cm)	26.82±1.14	26.30±1.06	0.47
Pectoral fin length (cm)	5.36±0.45	2.54±0.17	0.01*
Pelvic fin length (cm)	5.18±0.89	3.04±0.53	0.01*
Caudal peduncle length (cm)	8.66±9.44	1.30±0.20	0.01*
Caudal peduncle length (cm)	1.74±0.13	1.00±0.00	0.01*
Body depth (cm)	7.48±1.79	5.56±0.09	0.04*
Tail length (cm)	6.08±0.40	4.66±0.27	0.01*
Eye diameter (cm)	2.02±0.04	2.20±0.30	0.22
Snout length (cm)	1.86±0.05	1.56±0.11	0.01*

Mean significantly different between the two fish species at $p < 0.05$; Sig. = P value.

Table 2: Meristic Features of *Micromesistius poutassou* and *Scomber scombrus*

Parameter(s)	*M. poutassou*	*S. scombrus*	Sig.
Dorsal fin spine	12.80±1.10	8.80±0.45	0.01*
Dorsal fin ray	11.60±0.55	7.60±0.89	0.01*
Pectoral fin spine	15.80±0.45	19.40±4.83	0.13
Pectoral fin ray	16.20±0.45	16.20±2.77	1.00
Caudal fin count	28.80±0.84	22.00±1.41	0.01*

*Mean significantly different between the two fish species at $p < 0.05$; Sig. = P value

Table 3: Length-Weight Relationship of the Study Fish Species

Parameter(s)	***Micromesistius poutassou***	***Scomber scombrus***
TL (cm)	32.56±1.00	31.06±1.74
Weight (g)	367.26±40.12	222.40±25.59
A	23.673	16.648
B	0.024	0.065
r	0.967	0.955
R^2	0.935	0.913
P –value	0.01*	0.01*

*Relationship significant at $p < 0.05$;

Key;

TL = Total length; R^2 = Coefficient of determination; r = Correlation co-efficient; A = Rate of change of weight with length (intercept); B = weight at unit length (slope)

Table 4: Heavy Metals Concentrations in *Micromesistius poutassou* and *Scomber scombrus*

		Mn (mg/kg)	Cu (mg/kg)	Zn (mg/kg)
Gill	*M. poutassou*	6.87±0.78	1.67±0.28	37.86±11.69*
	S. Scombrus	6.38±0.55	1.62±0.30	102.61±43.28
Flesh	*M. poutassou*	5.38±1.81*	1.97±0.42*	17.68±6.24
	S. Scombrus	2.88±0.40	3.38±0.37	23.74±4.57
Liver	*M. poutassou*	3.78±1.72*	2.11±0.99*	54.22±24.36
	S. Scombrus	46.69±28.80	21.02±19.03	69.87±13.98
	WHO, 2004	2.5	-	150
	USEPA, 2007	0.05	1.0	5.0

*Mean significantly different between the two fish species in the respective organs at $p < 0.05$; Sig. = P value

DISCUSSION

Heavy metals have been considered as dangerous substances causing serious health hazards to human beings and other living organisms through progressive irreversible accumulation in their bodies. There is a relation between accumulation of heavy metals and different tissues of the fish species (Huang, 2003; Dung *et al.,* 2013), that it may be related to dietary habits and potential bioaccumulation in any species (Farkas *et al.*, 2000).

Ukoha *et al.,* (2014) studied the potential health risk assessment of heavy metals (Cd, Cu and Fe) concentration in some imported fish species consumed in Nigeria. Manganese activates several enzymatic systems and supports the utilization of vitamin C, E and B (Underwood, 2002). Its inadequate content in the body can result to critical conditions such as myasthenia gravis (loss of muscle strength). All the fish species in this study showed high mean concentrations of Mn with minimum and maximum concentration of 2.88mg/kg and 46.69mg/kg as detected in flesh and liver of *S. scombrus* respectively. WHO, (2004) and USEPA, (2007) identified the maximum tolerable limit of Mn consumption in fish to be 2.5mg/kg and 0.05mg/kg respectively.

Flesh accumulates low metal concentrations in relation liver and gills and highest concentrations were accumulated in the liver which was in accordance with Christopher *et al.* (2009) on studies on the distribution of Pb, Zn, Cd, As and Hg in bones, gills, livers and muscles (flesh) of *O. niloticus*from Henshaw town beach market in Calabar. This highest value might be due to the importance of these organs for their functional role in a living animal while the least in gills may be as a result of just ordinary contact with the water during respiration.

Iron was found to be significantly ($p < 0.05$) highest in liver for all the fish samples which may be as a result of liver being the organ for excess glucose storage, centre for deamination and blood production (Jenyo-Oni and Oladele, 2016). It is very difficult to compare the metal concentrations even between the same tissues or organs in different species because of the different factors in the aquatic environments, types and level of water pollution, feeding habits (omnivorous or carnivorous), level of fish presence in water and habitat (pelagic or benthic) (Yilmaz, 2009). Kamaruzzaman *et al.* (2010) indicated that there were relationship among metal concentrations and several other intrinsic factors in fish such as its size, genetic composition and age.

This study clearly revealed that different fish species contained different concentrations of a certain metal across the organ which Kalay *et al*. (1999) reported that different fish species accumulate metals in their tissue in significantly different values. Also, Canli and Atli (2003) reported that levels of heavy metals in fish vary in various species and different aquatic environments.

Liver has the highest copper concentration in all the sampled fishes and tissue/organ which might be as a result of Cu being a valuable element to human being and nutrients for healthy living, but if present in levels above certain limits, they constitute a potential hazard to health (Asuquo *et al*., 2004). Copper is an essential element in human metabolism but can cause anemia, disorders of bone and connective tissues and liver damage of essential levels. The toxicity of copper depends upon the hardness and pH of the water, and therefore, it is more toxic in soft water and in water with low alkalinity (Taha, 2008).

The maximum acceptable level of copper is 1.0mg/kg for human consumption by USEPA (2007). However, the concentration of copper in these fish species slightly higher in gills of *M. poutassou,S. scombrus* and flesh of *M. poutassou* than the recommended value, while the flesh of *S. scombrus* and liver of *M. poutassou* and *S. scombrus* were far above the permissible limit (Table 4).

Zinc appears to have a protective effect against the toxicities of both cadmium and lead. The main Sources of Zn pollution in the environment are zinc fertilizers, sewages, sludges, and mining (Bradi, 2005). The Maximum permissible limit in Zinc is 50mg/kg for consumption by USEPA (2007). The results shows that Zinc in the liver were found highest than that of gill and Flesh. A deficiency of Zinc is marked by retarded growth, loss of taste and hypo-gonadism, leading to decreased fertility. Zinc toxicity is rare, but at concentration in water up to 4mg/l, may induce toxicity, characterized by symptoms of Irritability, muscles stiffness and pain, loss of appetite and nausea (Bradi, 2005).

Heavy metals in this study were found above the findings of Emmanuel *et al.* (2015), who studied the bio-concentration of Hg, Pb and Cd in the bones and muscles of *Citharinus citharus* and *Synodontis clarias* from the Amussoma Axis of River Nun, Niger Delta, Nigeria. The study found that low concentration of these meals were found in the bones and muscles of the fish species, as well as the water and sediment samples of River Nun. It was also noted that the presence of trace heavy metal pollutants in diet create serious health problems ranging from neuro-,nephro-, carcino- to immunological disorder, if ingested over a long period of time.

The results of this study indicate high values of the heavy metals which might be due to the discharge of industrial effluents, agricultural and urban pollution of rivers and streams, especially in the downstream river. This was in agreement with Niloofar *et al.,* (2013), which investigated the accumulation of heavy metal Cd, Pb and Zn in liver and muscles tissues of *Capoeta trutta* fish from Dez River, Southwest Iran.

The concentrations of metals in this study was found against the findings of Al-Waher (2008), Olowu *et al.,* (2010) and Raham (2011), which investigated the level of Cd, Cu and Zn in three fish species, *Oreochromis aureus, Cyprinus carpio and Clarias lazera,* collected from the Northern Jordan valley. He found out that the levels of these heavy metals in muscles of the three fish species were within acceptable limits except for the Zn concentration in muscles of *Oreochromis aureus* which were attributed to the increase of agricultural influx and some anthropogenic activities in that area.

Conclusions

In the study, heavy metals were detected in all the sampled fishes and tissues/organs with the concentrations found above maximum acceptable level set by USEPA, 2007 and adopted by many countries. It also revealed that consuming of imported fishes obtained from Ijebu Igbo market is becoming unsafe for consumptions. But, this does not pose any immediate threat to the health of the fish consumers in the public for now.

However, it is important to understand that presence of heavy metal pollutant in non ideal concentrations could create serious health hazard ranging from neuro-, nephro-, carcino- to immunological disorder, if ingested over a long period of time. In addition, continuous consumption of these contaminated fishes may result in public health hazard through progressive irreversible accumulation of such toxic pollutants in human body.

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