Condition factor, heavy metals and polychlorinated biphenyls (PCBs) in the muscle of fishes in Lagos, Nigeria

Oyelowo Oluwakemi1*, Awobajo Funmileyi1, Samuel Titilola1, Sogbesan Teniola1, Fayiga Adewale1, Mofolorunso Adekunle1

Department of Physiology, Faculty of Basic Medical Sciences, University of Lagos, Nigeria, Department of Biochemistry, Faculty of Basic Medical Sciences, University of Lagos, Nigeria *Corresponding author's email:

Received: 113 November 2019
Accepted: 5 February 2020

ABSTRACT

Fish is an important part of the human diet, is at the top of the aquatic food chain with a high propensity to accumulating contaminants like heavy metals and polychlorinated biphenyls (PCBs) which are toxic to humans. This study evaluated the relationship between condition factor (physiologic wellbeing) of the fishes, PCBs, and heavy metal accumulation. Ten adult fish species three each of Chrysichthys nigrodigitatus, Trachinotus teraia, Liza dumerilli, Tilapia guineensis, Pseudolobithus elongatus, Pomadasys jubelini, Polydactylus quadrifilis, Caranx hippos, Sphyreana barracuda, Arius heudoloti, were acquired at Epe Lagoon. Ten adult fish species three each of Argentina silus, Gadus chalcogrammus, Gadus morhua, Atlantic mackerel, Micropogonias undulatus, Urophycis sp., Chrysichthys nigrodigitatus, Oreochromis niloticus, Clupea harengus, Trachurus trachurus, imported into Lagos were purchased. The fish species' condition factor was determined. The heavy metals were determined using AAS while PCB level was determined using GC-MS. Iron, mercury, zinc, arsenic, nickel and copper levels correlated positively with the condition factor in the local fishes while in the imported fishes, cadmium, iron, zinc, nickel, copper and lead levels correlated positively to the condition factor. The levels of PCBs in both the local and imported fishes were non-detectable. It is concluded that the lead, copper, arsenic, zinc, mercury and cadmium in both the imported and local fishes were within permissible limits compared with the FAO/WHO maximum allowed limits. The positive correlation of some heavy metals to the fishes' condition factor infers that these metals might be altering physiologic activities in the fishes.

Keywords: Condition factor; Heavy metals; Polychlorinated biphenyl; Fish

INTRODUCTION

Condition factor defines the physiological welfare of fishes (Voight, 2003; Muchlisin et al., 2010). These physiological conditions take into cognizance the feeding, length, weight, and general well-being, as well as the build-up of metals in fishes, resulting from the pollution in the aquatic environments (Voight, 2003; Sfakianakis et al., 2015; Muchlisin et al., 2017). The aquatic ecosystem as with other biospheres experiences pollution as a result of rapid urbanization, industrialization which affects the food chain. These persistent particles in the environment such as metals, dioxins and polychlorinated biphenyls (PCBs) and other contaminants would move into filter-feeding organisms and other invertebrates and will eventually reach higher trophic levels. The heavy metals get into the fish system through the gastrointestinal tract as a result of the consumption of contaminated food and water and through other non-dietary means across permeable skins like its gills. There have also been reports of human contact to PCBs due to the eating of fish (Faroon and Ruiz, 2016).
The assessment of the habitat of the fish, a major source of protein in human nutrition requires frequent evaluation and monitoring. Such monitoring is of great significance for decision-making regarding the health characteristics in connection with fish as food for human and animal consumption. Besides that, monitoring of the water body contributes to the description of the environmental state. Studies have shown that the consumption of contaminated fish is linked to a decrease in gestation and birth weight in humans (Rylander et al., 1998; Buck et al., 2003). Animal studies, on the other hand, reported that in utero exposure of rats, mice and monkeys to polychlorinated biphenyls (PCBs) resulted in the decrease in growth and gestation length of the animals. Researches have shown that unintentional environmental exposures from polyhalogenated hydrocarbons resulted in adverse effects on foetal birth size and ectodermal indices (Buck et al., 2003). All these suggest that eating fish by humans is a common dietary way of exposure to PCBs (Buck et al., 2003).

Lagos state is a commercial and industrial region of Nigeria. This state has the population of approximately 20 million people (Osho and Adishi, 2019), and therefore, the environmental concerns associated with the state. There is over sixty percent of Nigeria’s industries located in the state, and each industry discharges its industrial wastes comprising of heavy metals and organic chemicals into both the terrestrial and aquatic environments within the state. The lagoon system in Lagos state is made up of Badagry, Epe, Lagos, Lekki, and Ologe which act as a reservoir receiving wastes from drainages through different parts of the hinterland and metropolis (Oyewo et al., 2003). The Epe lagoon is located between the Lagos lagoon (brackish water) in the west and the Lekki lagoon (freshwater) in the east. Fish accounts for forty percent of the animal protein in the diet of Nigerians. It is thus a highly valued food that contains well-adjusted levels of polyunsaturated fatty acid (PUFA), amino acid, vitamin B12, etc. Sea fisheries provide an average of 92.2% yearly, of the total fish production and they are reliant on riverine, lagoon and sea bodies (Atta et al., 1997). Heavy metals, which are environmental contaminants are of concern, because of their lethal effect and ability to bio-accumulate in marine ecologies causing several health problems (Timib and Dzifa Afua, 2013). This research was thus conducted on fishes from Epe lagoon, an important source of fishery in Nigeria and those imported into Lagos state. The main objective of this study is to determine the condition factor, heavy metal content and polychlorinated biphenyl levels in fish species found in Epe Lagoon as well as in those imported into Lagos state.

MATERIALS AND METHODS

Area of Study

The study was carried out at Epe lagoon situated in Epe Town, Lagos, southwest Nigeria. The lagoon is located between the Lagos lagoon and Lekki lagoon, in the west and in the east of Lagos State respectively. The vegetation surrounding the Lagoon is predominantly mangrove and freshwater swamps. It opens into the Gulf of Guinea through Lagos Harbour and is characterized by high sea flow and low freshwater input. Epe Lagoon (Latitudes 6°29′, 6°38′N; Longitudes 3°30′, 4°05′E) is fed by River Osun. The characteristics of the lagoon are as follows. The depth is 6m, a large area that is relatively shallow with a depth of 1m, and a surface area of about 225 km². The activities occurring at Epe lagoon apart from fishing include sand mining, refined crude oil product bunkering, and location of the Egbin thermoelectric power plant.
**Sampel Collection**

Adult fish (three each species) of *Chrysichthys nigrodigitatus*, *Trachinotus teraia*, *Liza dumerilli*, *Tilapia gueensis*, *Pseudotolithus elongatus*, *Pomadasys jubelini*, *Polydactylus quadrifilis*, *Caranx hippos*, *Sphyraena barracuda*, *Arios hondoleti*, freshly harvested, were acquired from fishermen at Epe Lagoon over a period of three months. The fish species were kept in sterile polythene bags and moved to the laboratory that day, in an ice chest on ice, and were kept under frozen condition until analysis. Also, adult species (three each) of *Argentina silus*, *Gadus chalcogrammus*, *Gadus morhua*, *Atlantic mackerel*, *Micropogonias undulatus*, *Urophycis sp.*, *Chrysichthys nigrodigitatus*, *Oreochromis niloticus*, *Clupea harengus*, *Trachurus trachurus*, imported into Lagos, were bought from ice-cold stores at the Mushin market in Lagos and also kept in sterile polythene bags and were also transported the same day to the laboratory in an ice chest, on ice, and were kept under frozen condition until analysis.

**Physiological Condition Assessment**

The fish samples were placed on aluminium foils and the weights and length were measured using a weighing balance and a measuring board respectively. The total length was measured as the distance from the snout with the mouth closed to the tip of the caudal fin. The condition factor of fish (Voight, 2003) was calculated using the equation:

$$CF = \frac{W \times 100}{L^2}$$

Where, $W = $the fish wet weight (g), $L = $the fish total length (cm), $CF = $the condition factor

**Determination of Heavy Metals in the Fish samples**

Fish samples were processed according to the AOAC method (Cunniff 1995). The heavy metal levels in the digested samples were determined by means of the Atomic Absorption Spectrophotometer (AAS) (Analyst 200 AAS; Perkin Elmer). The calibration of standards was prepared from certified commercial standards (Perkin Elmer). Commercial analar grade 1000 ppm stock solutions of lead, copper, nickel, arsenic, zinc, mercury, iron, cadmium was diluted in 25cm$^3$ standard flask and made up to the mark with deionized water in order to obtain the working standard solutions of each metal ion. A pure blank (control) was also prepared to check the quality of the samples.

**Polychlorinated Biphenyls Analysis**

Fish sample (2g each) was weighed into a 250ml conical flask, while 10ml of dichloromethane was added to the sample. The mixture of the sample and dichloromethane was shaken vigorously on the shaker for about 45minutes. It was then transferred to an ultrasonic bath for ultrasonic extraction for 2hours. The isolation of Polychlorinated biphenyls from the lipid matrix was done by solid-phase extraction in a normal phase mode. Activated silica gel was loaded onto a glass chromatographic column (i.d 20 mm, height 400 mm) and conditioned with dichloromethane. The effluents were then concentrated using a rotary evaporator and the samples were thereafter dissolved in 1 ml acetone and transferred to a viral bottle for Gas chromatography (GCMS) analysis.

**GCMS Analysis**

Analyses were done with Agilent Tech model 7890A gas chromatograph system coupled with an MS Agilent Tech 5975C VL MSD using the principle of the separation technique. The separation technique is in 2 phases. The carrier gas used in the mobile phase was helium (99.9% pure) while the stationary phase was equipped with an HP-5MS column with dimensions (30 m in length; 25 mm internal diameter; 0.25 µm film thicknesses) equipped with an Agilent EM 5973 detector, at 150 °C. The carrier gas used was helium, at a flow rate of 1 mL/minute and the split ratio was 2:1. The column temperature was initially 60 °C for 3 minutes and it was gradually increased.

http://jurnal.unsyiah.ac.id/ AJAS
to 170 °C, at 3 °C/minute. The temperature was maintained at 1 minute. Afterward, the temperature was raised to 330 °C, at a rate of 10 °C/minute and maintained for 10 minutes. The injector temperature was 330 °C and 1 µL of the organic phase were injected twice.

**Statistical Analysis**

Data were subjected to statistical analyses and expressed as mean ± standard error of the mean (SEM) and were analyzed with Graphpad software version 3.05 (San Diego, California, U.S.A.) using one-way ANOVA for multiple comparisons between groups, followed by the Student-Newman-Keuls test, differences between groups were considered significant at P<0.05.

**RESULTS**

The lead, copper, arsenic, zinc, mercury and cadmium in both the imported and local fishes were within permissible limits compared with the FAO/WHO maximum permissible limits while nickel and iron had levels higher than the FAO/WHO maximum permissible limits (Table 1). Local fishes *Chrysichthys nigrodigitatus*, *Liza dumerilli*, *Tilapia gniensis*, *Pseudolitius elongatus*, *Pomadasys jubelini*, *Caranx hippos*, *Sphyreana barracuda*, and *Arius hendoboti*, had condition factors less than 1, while *Trachinotus teraia*, *Polydactylus quadrifilis*, had condition factors greater than 1. The imported fishes *Argentina silus*, *Gadus chalcogrammus*, *Merluccius bilinearis*, *Atlantic mackerel*, *Micropogonias undulatus*, *Urophycis sp.*, *Chrysichthys auratus*, *Clupea harengus*, had condition factors less than 1 while *Oreochromis niloticus*, *Trachurus trachurus* had condition factors greater than 1. The levels of PCBs in both the local and imported fishes were non-detectable in all fish species.

In the imported fishes, cadmium, iron, zinc, nickel, copper and lead levels correlated positively to the condition factor while mercury and arsenic correlated negatively to the condition factor in the imported fishes (Figure 1a-h). Iron, mercury, zinc, arsenic, nickel and copper levels correlated positively to the condition factor in the local fishes while cadmium and lead levels correlated negatively to the condition factor in the local fishes (Figure 2a-h).

<table>
<thead>
<tr>
<th>Heavy metals</th>
<th>Imported fishes (mg kg⁻¹)</th>
<th>Local fishes (mg kg⁻¹)</th>
<th>FAO/WHO maximum permissible limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lead</td>
<td>0.15</td>
<td>0.21</td>
<td>0.5</td>
</tr>
<tr>
<td>Copper</td>
<td>0.07</td>
<td>1.04</td>
<td>30</td>
</tr>
<tr>
<td>Nickel</td>
<td>0.28</td>
<td>0.26</td>
<td>0.2</td>
</tr>
<tr>
<td>Arsenic</td>
<td>0.17</td>
<td>0.19</td>
<td>1.4</td>
</tr>
<tr>
<td>Zinc</td>
<td>0.54</td>
<td>0.21</td>
<td>30</td>
</tr>
<tr>
<td>Mercury</td>
<td>0.14</td>
<td>0.31</td>
<td>0.5</td>
</tr>
<tr>
<td>Iron</td>
<td>1.73</td>
<td>6.18</td>
<td>0.8</td>
</tr>
<tr>
<td>Cadmium</td>
<td>0.03</td>
<td>0.03</td>
<td>0.1</td>
</tr>
</tbody>
</table>

Table 1. Heavy metal levels in fish samples.

http://jurnal.unsyiah.ac.id/AJAS
Figure 1. Correlation between heavy metal and condition factor in imported fishes (a) cadmium level and condition factor; (b) iron level and condition factor; (c) mercury level and condition factor; (d) Correlation between zinc level and condition factor; (e) arsenic level and condition factor; (f) nickel level and condition factor; (g) copper level and condition factor; (h) lead level and condition factor in imported fishes.
Figure 2. Correlation between heavy metal and condition factor in local fishes (a) cadmium level and condition factor; (b) iron level and condition factor; (c) mercury level and condition factor; (d) Correlation between zinc level and condition factor; (e) arsenic level and condition factor; (f) nickel level and condition factor; (g) copper level and condition factor; (h) lead level and condition factor in imported fishes
DISCUSSION

The accumulation of heavy metals in organisms can be influenced by gender, size, species and seasons (Nussey et al., 2000; Sarong et al., 2013; Bawuro et al., 2018). This infers that bioaccumulation of metals can affect the condition factor of fish species. The accumulation of heavy metals in fishes can happen particularly when the rate of uptake far outweighs the rate of expulsion. The levels of nickel and iron were higher than the FAO/WHO maximum permissible limits in both the local and imported fishes. This is an indication that both the local and imported fish species were more affected by nickel and iron compared to the other heavy metals analysed in the study. The industrial and anthropogenic activities taking place around the Epe Lagoon may largely develop into a source of natural aquatic systems’ pollution of heavy metals in local fishes. The imported fishes are possibly exposed to anthropogenic activities (Afshan et al., 2014). Fish can adjust the metal burden in their bodies; however, this is only up to a limit, afterward, a build-up of the metals in the body begins.

The condition factor is commonly used to compare the stoutness or the healthy of fish (Ahmed et al., 2011). The theory in which the condition factor is based explains that weightier fishes of a length are in a well physiological condition. The condition factor of the fish species caught locally in Nigeria, in this study, was like what was obtained in earlier studies reported in different parts of the country. According to Nwadiaro and Okorie (1985) reported a condition factor of between 0.49-1.48 for fish species from Oguta Lake. Kumolu-Johnson and Ndimele (2011) also reported condition factor of 0.91-8.46 from Ologe Lagoon in Lagos. The condition factor of less than 1 could be due to the heavy metal build-up in the fishes (Bakhoun, 1999; Afshan et al., 2014; Bawuro et al., 2018). The condition factor assessed the physiologic and general wellbeing of the fishes with respect to contamination by heavy metals. The results from this study show that there were positive relationships between condition factor of the fish and metal levels in most cases. There were positive relationships between condition factor and the levels of iron, mercury, zinc, arsenic, nickel, and copper in the local fishes while positive correlation existed between the condition factor and cadmium, iron, zinc, nickel, copper, and lead levels in the imported fishes. A negative correlation existed between the condition factor and cadmium, as well as lead in local fishes while negative correlation existed between mercury and arsenic in the imported fishes. Other studies have also shown a positive correlation between condition factor and zinc, copper, mercury as reported in the local fishes in this study as well as cadmium in imported fishes in this study (Yi and Zhang, 2012).

Heavy metals can result in stressful conditions in the fish (Bat and Arici, 2016), they also reduce oestrogenic and androgenic secretions as well as cause pathological changes (Walczak and Reichert, 2016). Cadmium toxicity includes alteration of fish antioxidant defence, glucose levels (Celik and Oehlenschlager, 2004), as well as pathological alterations in the liver (Kumar and Singh, 2010; Sarong et al., 2013). Copper decreases the resistance of fish to diseases by causing oxidative injury, disrupting osmoregulation, disrupting migration as well as altering swimming. (Jiang et al., 2014). Although iron is vital for physiological processes, it may be detrimental to living creatures at higher concentrations especially fishes (Debnath et al., 2012). Nickel toxicity in fishes can result in respiratory dysfunction and can cause oxidative stress (Al-Attar, 2007). The mercury concentrations have been found to increase with the age as well as with the condition factor of the fish. Mercury can bioaccumulate in fish, and high concentrations can be expected to be accumulated in top predators such as a carnivorous fish (Sackett et al., 2013). Although polychlorinated biphenyls (PCBs)
can bioaccumulate in fishes just like heavy metals, their levels were not detectable in both local and imported fishes analysed in this study.

**CONCLUSIONS**

The lead, copper, arsenic, zinc, mercury and cadmium in both the imported and local fishes were within permissible limits compared with FAO/WHO maximum permissible limits. Also, a positive correlation in some heavy metals to the fishes’ condition factor infers that these metals might be altering physiologic activities in the fishes. The non-detectable levels of PCB in the fish muscles will serve as useful information for fishery scientists and policymakers on the local fishes caught as well as fishes imported into Lagos Nigeria.

**REFERENCES**


