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LEAD AND CADMIUM TOXICITY IN TWO FISH SPECIES COMMONLY CONSUMED IN SOUTH WEST NIGERIA AND HEALTH RISK ASSESSMENT

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ABSTRACT

Lead and Cadmium are two toxic heavy metals that have the ability to bioaccumulate in human body system even at low concentrations when ingested. This present study is aimed at assessing the concentrations of Cadmium (Cd) and Lead (Pb) in the tissues of raw and smoked fishes of *Clupea harengus* (Herring fish) and *Gadus morhu*a (Cod fish) collected from food vendors in selected local government areas in Ibadan, Oyo state. The tissues were digested using standard procedure and analysed with Atomic Absorption Spectroscopy (AAS). The result revealed the mean concentration of Cadmium in the tissue of *Gadus morhu*a (Cod fish) was 91% higher than that of Lead. The mean concentration of Lead and Cadmium in the Cod fish sample was observed to be lower in the smoked sample (0.02mg/kg and 0.42mg/kg) than in the raw sample (0.04mg/kg and 0.49mg/kg). Higher level of Lead (33.3%) and Cadmium (46.5%) were observed in the Cod fish than Herring fish. All the fish samples showed concentrations lower than the permissible limits of World Health Organization (WHO) and Food and Agriculture Organization (FAO) (0.3 mg/kg for Lead and 0.5 mg/kg for Cadmium). The health risk assessment (THQ < 1) on consumption of both fish tissues obtained suggest that there is no obvious health risk to human populace on ingestion over a period of a year.

Key words: *Cadmium, Lead, bio accumulate, health risk assessment*

INTRODUCTION

The consumption of fish as a source of protein is increasing globally because of their nutritional benefits and tolerable cholesterol level when compared to meat. Fish are known to contain essential minerals, unsaturated fatty acids and vitamins (Medeiros *et al*., 2012). They have been highly recommended as being more heart friendly and healthier especially for the adult. Quite a number of studies have revealed that fish and fish oil contain high amount of polyunsaturated fatty acids which are valuable in decreasing the serum cholesterol and can prevent a number of coronary heart diseases and increase neurological development (Turkmen *et al*., 2005). Eating of fish can reduce the risk of heart diseases and lower the risk of developing dementia, including Alzheimer's diseases (Kelly and Knopman, 2008). The American Heart Association recommended eating fish at least twice per week in order to reach the daily intake of omega-3 fatty acids. In Nigeria, especially in the South West region, fish is an important component in the diets for humans and animals (Holma and Maalekuu, 2013). Fish is consumed in different forms, they can be cooked, fried or smoked before consumption. Fish also served as a ready source of protein in processing food for other animals. In Nigeria Its acceptance cuts across socio-economic, age, religions and educational barriers (Adebayo *et al*., 2008). In addition to its nutritional benefits fishes are generally considered to be the most relevant organisms for pollution monitoring in aquatic ecosystems (Vander Oost *et al*., 2003).

Inspite of nutritional value of fish mentioned above, consumption of fish could have a potential hazard to the consumers. The presence of toxic heavy metals in fish can invalidate their beneficial effects. Heavy metals are trace metals which have high atomic weight and density greater than water (Tchounwou *et al*., 2012). They include both essential and non-essential metals. The essential metals are important for the normal metabolism of fish and while the non-essential metals may accumulate in the tissues and organs of aquatic organisms where they have been reported to cause genetic, physiological, biochemical changes (Canli and Atli 2003; Mahboob *et al*., 2016) and also biomagnified in the food chain with potential health hazard to human health when ingested even at low concentrations (Adesuyi *et al*., 2016; Castro-Gonz´alez *et al*., 2008; Storelli *et al*., 2005.).

Essential metals include iron (Fe), copper (Cu), zinc (Zn) and manganese (Mn), whereas non-essential metals are mercury (Hg), lead (Pb), nickel (Ni) and Cadmium (Cd) (Türkmen *et al*. 2005). Cadmium and Lead are highly toxic to human health; they are known carcinogen, and have been reported to cause serious damage to body organs. Heavy metals in the ecosystem have both natural and anthropogenic sources with large variations in concentrations. Anthropogenic sources of heavy metals in the aquatic environment are majorly from untreated effluents from industries, agricultural and urban run-offs contaminated with heavy metals. Heavy metal concentrations in organic samples such as fish products are mostly determined using atomic absorption spectroscopy (AAS) (Tüzen 2003, Henry *et al.,* 2004, Mendil *et al*., 2005, Türkmen *et al*., 2005).

Gardus morhua (Cod fish) and *Clupea harengus* (Herring fish) are categorized as marine fishes; they are more affordable and available than other seafoods. According to the study of Adekoya and Miller (2004), marine fish is generally cheaper and more abundant when compared with fresh water fishes, which are relatively more expensive in Nigeria. *Clupea harengus* (Herring) is numerically one of the most important pelagic species in several North Atlantic ecosystems and has been a staple food source since at least 3000 BC. Herring are very high in the long chain omega-3 fatty acids EPA and DHA. It is a good source of Vitamin D (Tarjal *et al.,* 2005). The most abundant and commercially important specie belong to the genus *Clupea,* found particularly in shallow, temperate water of the North pacific and North atlantic oceans, Including the Baltic sea, as well as off the west coast of South America.

Gardus morhua is a benthopelagic fish of the family *Gadidae,* widely consumed by humans. It is also commercially known as cod or codling. Dry cod may be prepared as unsalted stock fish as cured salt cod or clipfish. Its habitat ranges from the shoreline down to the continental shelf. The Atlantic cod is labeled vulnerable on the IUCN Red list of threatened species. Cod has a distribution North of cape Hatteras, North Carolina, and around both coasts of greenland and the Labrador sea, in the Eastern, Atlantic it is found from the Bay of Biscay North to the Arctic ocean, Including the Batlic sea, the North sea, Sea of the Hebrides, areas around Ice-land and the Barents sea. This study is aimed at determining the level of Cadmium and Lead which are toxic heavy metals in the tissue of two widely consumed fish species in South West Nigeria and also carry out their human health risk assessment.

Figure 1: Smoked *Clupea harengus* (Herring Fish)

Figure 2*:* Smoked *Gadus morhua* (Cod fish)

Materials and methods

Sample Collection

Total of eighty fish samples were collected in ice pack from fish vendors in the selected local Government area. The raw fish samples were thoroughly washed with water to remove any adhering contaminants. The raw and smoked fish samples were then dissected and the fish tissues were separated from other parts of the fish. Afterwards the fish samples were kept in a clean and sterilized in a well labelled polythene bag and stored in deep freezer prior to digestion.

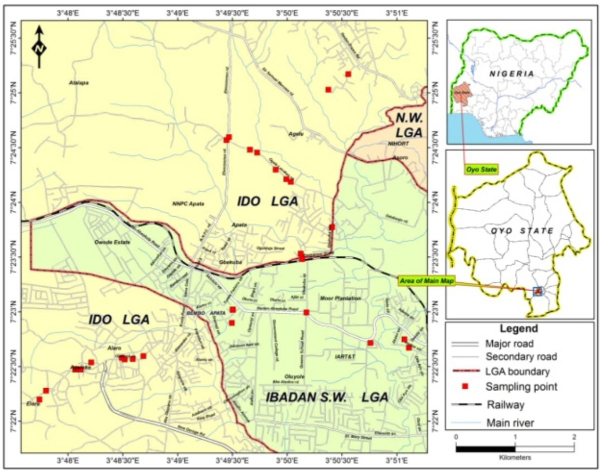

Fig 3: A map showing the sample site locations

Sample Digestion

The fish tissue samples were oven dried at 70°C until constant weight was obtained. The dried fish was grinded into fine powder and stored in desiccators to avoid moisture accumulation before digestion. 5.0g each of the samples were weighed into digestion tube. One tablet of selenium catalyst was added into the tube along with 10mls each of perchloric acid (10%) and nitric acid (10%). The tubes were placed inside a digestion block and slowly digested. The digest was washed into 100mls volumetric flask and make up with distilled water.

Sample Analysis

The fish samples were analysed using atomic absorption spectrophotometer (A.A.S) of model A ANALYSE 200 at university of Ibadan central laboratory.

HUMAN HEALTH RISK ASSESSMENT

Estimated Daily Intake of Heavy Metals From Fish

Estimated Daily Intake (EDI) in (mg/kg body weight (bw)/day) of heavy metals from consumption of fish was obtained from the equation below according to USEPA (2000) = where,
C = Concentration of heavy metals in fish (mg/kg)
F_{IR} = Average daily fish consumption/ingestion rate (40 g/person/day)
B_{WA}= Body weight average of (70 k

Target Hazard Quotients Determination

The methodology for the determination of THQ was described in the United States Environmental Protection Agency (USEPA) Region III risk-based concentration table (2000). The equation for estimating THQ is stated below

$$THQ = \frac{E_{FR} \times ED_{A} \times F_{IR} \times C}{RfDo \times B_{WA} \times A_{TN}} \times 10^{-3}$$

E_{FR}= Exposed frequency (365 days/year);
E_{DA} = Exposure duration (70 years, average lifetime);
F_{IR} = Food ingestion rate (g/person/day);
C = Mean heavy metal concentration in fish (mg/kg);
RfDo = Oral reference dose (mg/kg/day);
B_{WA} = Average adult body weight (70 kg) and A_{TN}=

Averaging exposure time for non-carcinogens (365 days/year x number of exposure years, assuming 70 years in this study).

Results and Discussions

Table 1: Mean concentration (mg/kg) of Lead and Cadmium in raw and smoked tissues of *Gadus morhua* (Cod Fish)

	Lead	Cadmium
Raw	0.04 ± 0.01	0.49 ± 0.11
Smoked	0.02 ± 0.01	0.42±0. 13
WHO/FAO standard	0.3	0.5

Table 2: Mean concentration (mg/kg) of Lead and Cadmium in raw and smoked tissues of *Clupea harengus* (Herring Fish)..

	Lead	Cadmium
Raw	0.020± 0.001	0.26± 0.12
Smoked	0.170± 0.021	0.28± 0.16
WHO/FAO standard	0.3	0.5±

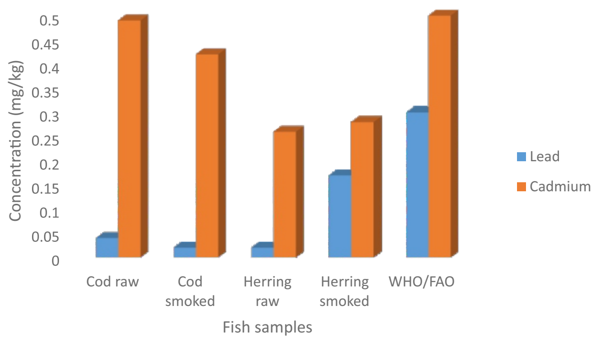

Figure 4: Comparison of the level of Lead and Cadmium in the two species of fish.

Table 3: Estimated daily intake (EDI) of Lead and Cadmium in the consumption of raw and

	Gadus morhua	*Clupea harengus*
Pb	Raw: 0.19	Raw: 0.13
	Smoked: 0.11	Smoked: 0.19
Cd	Raw: 0.28	Raw: 0.14
	Smoked: 0.24	Smoked: 0.16

Table 4: Total hazard quotient (THQ) for lead and cadmium in the consumption of raw and smoked fish tissues of *Gadus morhua* (Cod Fish)

Heavy metals	THQ
Pb	Raw: 0.054
	Smoked: 0.032
Cd	Raw: 0.56
	Smoked: 0.48

Raw Total THQ = 0.614 Smoked Total THQ =0.512

Table 5: Total hazard quotient (THQ) for Lead and Cadmium in the consumption of raw and smoked fish tissues of Herring fish (*Clupea harengus*)

CONTAMINANTS	THQ Herring (*Clupea harengus)*
Pb	Raw: 0.038
	Smoked: 0.054
Cd	Raw: 0.30
	Smoked: 0.32

Raw Total THQ = 0.338 Smoked Total THQ = 0.374

Discussion

The description of the sampling sites is shown in Figure 3. Table 1 shows the mean concentration (mg/kg) of Lead and Cadmium in raw and smoked fish of cod fish. The result revealed that the mean concentration of Cadmium in the tissue of the fish sample was 91% higher than that of Lead. The concentration of Lead and Cadmium was observed to be lower in the smoked sample than in the raw sample. This could be attributed to the removal of soluble metal contaminants in the sample, part of which would have been removed during smoking. Cod contains a high percentage of water compared to Herring fish which is very oily. The concentration of Lead and Cadmium in Herring fish is shown in Table 2. Higher level of Cadmium compared to Lead was also observed in both the raw and smoked tissue of the fish. However, unlike Cod the level of the metal contaminants were more in the smoked sample than the raw sample. This could still be attributed to the fact that water soluble metals have less sites to bind in the tissue of the oily fish. The level of bio accumulation is highly affected by the higher concentration of oil than water in the body of the fish. Figure 3 further revealed 46.9% higher concentrations of Cadmium in raw sample and 33.3% in smoked sample in the tissue of cod fish than herring fish. This makes cod fish a more tolerant specie to the heavy metals. The higher level of Cadmium than Lead observed in all the fish sample further showed that most Cadmium contamination comes from food sources mostly aquatic and consumption of marine food as reported by some studies (Luevano *et al.,*2014; Templeton *et al*., 2010; Amiard ,1999). The concentrations of both Lead and Cadmium where however found to be below the permissible limits as set forth by standard organizations (WHO and FAO). The estimated daily intake of the two metal contaminants calculated with average consumption of 40g/person/day with average body weight of 70kg shows a daily intake below the permissible limits. However, children and adolescents may be at greater risk considering their average body weight compared to the average weight of adults. Total Hazard Quotient value (THQ < 1) revealed that the consumption of this fish over a period of one year poses no risk to the consumer. Table 4 and 5 shows the THQ value for Cadmium and Lead present in the raw and smoked tissue of *Gadus morhua* (Cod Fish) and herring fish consumed by the population in the studied local government areas of Ibadan Nigeria. The assessment revealed that the population may not experience any obvious health risk due to consumption of raw and smoked fish tissues obtained for a period of one year as the values of all the THQ calculated is less than 1. But after a long period of time they may bioaccumulate in the body, which can cause obvious health risk to humans. Higher THQ values were also observed in Cadmium than Lead.

Conclusion

The level of Cadmium and Lead in the tissue of *Gadus morhua* and *Clupea harengus* in the area under study shows higher concentration of Cadmium than Lead in the raw and smoked fish samples. *Gadus morhua* shows more tolerant to the toxic heavy metals as the mean concentration shows higher value than that of *Clupea harengus.* However, the consumption of the two fishes poses no risk to the populace as revealed by the WHO/FAO standard and Total Hazard Quotient (THQ) values obtained.

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