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Health Risk Assessment of Heavy Metal in Smoked Trachurus Trachurus Sold in Yenagoa, Bayelsa state, Nigeria

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Abstract: This study investigated the health risk of heavy metal in smoked Trachurus trachurus sold in Yenagoa, Bayelsa state, Nigeria. The fish samples were purchased from Tombia Junction market in Yenagoa metropolis, Nigeria. The samples were dry-ashed, digested and analyzed using atomic adsorption spectrometry. The daily intake and target hazard quotients were computed following standard procedure. Results showed mean manganese, copper, chromium, zinc and iron 0.865mg/kg, 0.085 mg/kg, <0.001mg/kg, 12.98mg/kg and 37.20 respectively. Manganese, iron and zinc concentration were above recommended level for fish food as specified by Food and Agricultural Organization/ World Health Organization and Median international standard. Target hazard quotient were <1 for both children and adult apart from iron and zinc that were high in only adults. This is an indication of potential health concern of iron and zinc in adult that consumes the smoked Trachurus trachurus sold in the study area.

Keywords: Fish food; Health risk assessment; *Trachurus trachurus*; Yenagoa metropolis.

1. Introduction

Protein is one of the essential substances needed for normal growth and healthy life [1-5]. Protein is obtained from both plant and animals sources. Livestock, poultry, beef, fish, bush-meat are the major source of animal protein in developing country like Nigeria. According to Oladejo [6], Angaye, *et al.* [5], about 20% animal protein sources are provided by fish. The choice of fish as major source of animal protein is as a result of its readily availability and affordability [7].

Fish is also rich in nutrient such as vitamins, calcium, phosphorus and unsaturated fat [3, 8-11] and other health benefits [12]. For instance, [1] reported that fish contain low fat compared to any other source of animal protein. According to [13], the nutrient from fish is essential for growth and development.

Fish consumed in Nigeria is processed into several forms including fresh fish peppersoup, frying and roasting/smoke dried. The type of preparation majorly depends on the users. Furthermore, the preparation of roasted fish especially marine fish is mainly to avoid post-harvest handling processes. Most sea fish-food such as mackerel is imported into Nigeria. In areas of epileptic electricity supply, mean of preservation is a major threat. So most sea fish vendors roast the fish to avoid deterioration [14]. This could be one of the reasons why several fish are smoked prior to consumption. [15], [2] estimated that about 70 – 80% fish species (fresh and marine) available in Nigeria are smoke dried before consumption. Roasting is carried out using firewood or coal. Furthermore, they can also be fried or cooked fresh prior to consumption. The acceptability in most parts of the country due to its unique taste, flavor and good texture [16].

Fish has the potential to bioaccumulate and biomagnify toxicant from their environment as such they are used as bio-indicator [3, 17]. According to Abubakar, *et al.* [18], fish bioaccumulate heavy metals much more than the concentration in its ecosystem. The aquatic ecosystem are frequently contaminated by several factors including anthropogenic activities viz: activities of abattoir [19, 20], market [21, 22], wastes such as municipal solid waste, sewage [23, 24], activities of oil and gas [24-28], dredging, boating, swimming/navigation and runoff after rainfall. As such the aquatic ecosystem is a major recipient of pollutants resulting from natural and human activities [29].

These activities could contaminate the water and affect the water sediment [30, 31]. Most of the toxic substances in such water bioaccumulate in the tissue/body of the fish found in such environments. Notable fish parts that toxicant can accumulate in include the liver, kidneys, bone, muscle, blood, and fin [3, 32-34].

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The major toxicants commonly found in fish parts are heavy metals. Authors have reported that heavy metals have density that is about 5 times greater than the density of water [3, 32-34]. These heavy metals are highly toxic especially the non-essential metals (arsenic, cadmium, mercury, lead) which are not required in the human body. While the essential metals such as chromium, iron, zinc, copper, manganese become toxic when their concentration exceed the recommended limits according to Median international standard (MIS), Food and Agricultural Organization/ World Health Organization (FAO/WHO); United State Environmental Protection Agency (USEPA); Water Pollution Control Legislation (WPCL) and World Health Organization (WHO).

Heavy metals can cause different disease conditions in the body including impairment of the various organs and tissues. For instance non-essential heavy metals such as cadmium, lead, mercury and arsenic and essential metals such as chromium, iron, manganese, zinc copper could cause disease condition and their individual pathological effects have been comprehensively documented by Izah, *et al*. [32], Izah and Angaye [3], Izah, *et al.* [33].

There is an increasing concern about food quality in several regions of the world [38]. Therefore the need to assess heavy metal concentration in fish-food frequently consumed. Health risk assessment has been used to assess the potential health effect associated with heavy metals. This present study aimed at evaluating the health risk assessment from smoke dried *Trachurus trachurus* sold in Yenagoa, Bayelsa state, Nigeria

2. Materials and methods

2.1. Study Area

This study was conducted in Yenagoa metropolis, the capital of Bayelsa state, Nigeria. Typically, Bayelsa State is located at the coastal region of the Niger Delta. The region is characterized by high water table/ level and multiple flooding events. Yenagoa is a fast developing city with few industries and several business activities. *Trachurus trachurus* is often smoked alongside with other fishes species and sold in several locations including roadside, streets, markets and even homes. The climate of the area is similar to other areas of the Niger Delta that have been comprehensively documented [20, 23, 30, 35-37]. Furthermore, the area is characterized by high rain fall.

2.2. Sample Collection

Replicate samples of *Trachurus trachurus* were obtained from Tombia Junction market and packaged in sterile Ziploc bag and transported to the laboratory for analysis.

2.3. Sample Preparation and Heavy Metal Analysis

The samples were oven dried at 105^{o}C to constant minimum moisture content for 6 hours and blended into powered. Then it was dry-ashed in a muffle furnace at 450^{o}C until sample was completely ashed. The ashed sample was digested using nitric and hydrochloric acid. The solution was analyzed using Atomic Absorption Spectrometry (Model: GBC Avanta PM A6600) at varying wave length of: 213.9nm, 324.70nm, 248.3nm, 279.5nm and 357.90nm for zinc, copper, iron, manganese and chromium respectively

2.4. Health Risk Assessment

Risk assessment has been widely applied in health and environment assessments. On health, risk assessment has been applied in several food materials consumed. The common indices frequently assessed include Heath Quotient (HQ) and Daily Intake Metal (DIM) [18, 38-46].

2.4.1. Estimated Daily Intake

Based on the values of heavy metal obtained the dietary intakes were determined based on the method previously described by Ihedioha, *et al.* [45]

$$\text{Estimated daily intake (EID)} = \sum \text{MC} \times \text{MI}$$

Where MC = mean concentration of individual heavy metal in the fish (mg/kg), MI = estimated quantity of yeast biomass consumed (g/person/day). In this study it was estimated that adult (≥ 19years with body weight of 70kg) and children (7 - 18 years with body weight of 48kg) consumes 100g and 80g of fish per day respectively [18]

2.4.2. Target Hazard Quotients

Target Hazard Quotients (THQ) is one method of assessing lifelong exposure to heavy metals through diets [44, 45]. The health risks from consumption of the yeast biomass were assessed using the target hazard quotients, which is typically the ratio of determined dose of a pollutant to a reference dose level [45]. As such it has been identified as useful parameter for evaluation of risk associated with the consumption of metal contaminated food [45, 47, 48]. When the target hazard quotients is <1, it suggest no potential adverse effects [38, 39, 45, 49]. Typically, THQ was developed by the United State Environmental Protection Agency (EPA) for estimation of potential health risk associated with long term exposure to chemical pollutants [50]. The Target Hazard Quotients were calculated based on the formula previously described by US EPA [51], [42, 43], [44], [45], [38], [39].

$$\text{Target Hazard Quotients} = \frac{\text{EFr x ED}_{\text{total}}\text{x EID}}{\text{RFD x BWa x ATn}}\ x0.001$$

Where

- EFr=the exposure frequency (350days/year) [45].
- EDtot=the exposure duration (48.4 years based on life expectancy rate in Nigeria from 2 years of age) [44]

- EID=Estimated dietary intake
- RfD=oral reference dose for the heavy metals under study were Copper (0.04), iron (0.7), Zinc (0.3), Manganese (0.14), Chromium (1.5) [44]
- BWa=average adult body weight (kg) (adult and children weight body of 70kg and 48kg respectively (Abubakar et al., 2014)
- ATn=average time for non-carcinogen (days) (EDtot x 365days/year) [45]
- 0.001= conversion factor.

2.5. Statistical Analysis

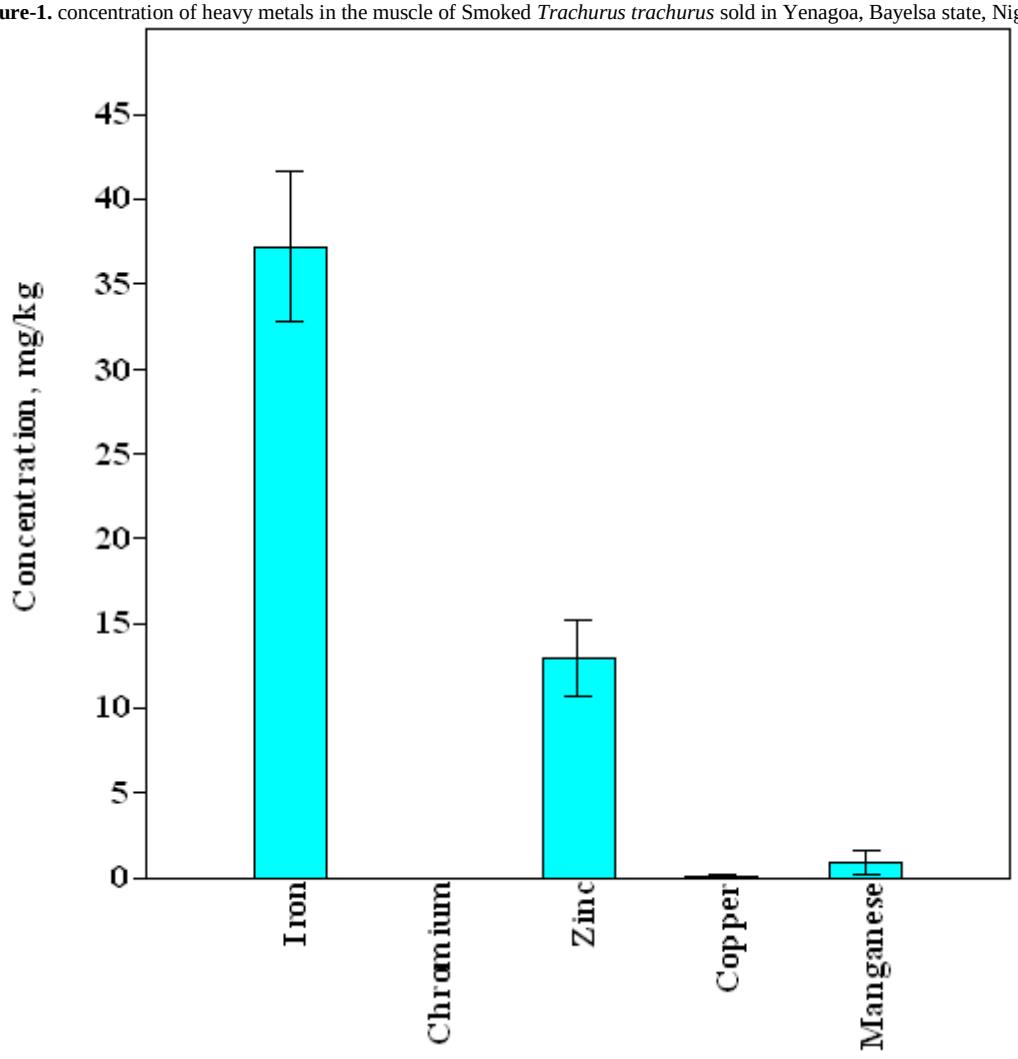
Paleontological statistics software package by Hammer, *et al.* [52] was used for the statistical analysis. The mean and standard error was computed. The chart for heavy metal concentration was plotted using Paleontological statistics software package and the standard error bar was determined at 95% interval level. The chart for the risk assessment was plotted using Microsoft excel.

3. Results and Discussion

The concentration of heavy metals in the muscle of smoked *Trachurus trachurus* sold in Yenagoa, Bayelsa state, Nigeria is presented in Figure 1. The concentration of manganese ranged from 0.16 – 1.57 (mean ± standard error 0.865 ±0.705) mg/kg. The concentration of manganese in this study is for food fish is higher than the concentration of 0.02mg/kg recommended by [53, 54], 0.50mg/kg specified by WHO [54, 55] and 0.02mg/kg recommended by WPCL [54, 56].

Copper concentration ranged from <0.001 – 0.17 (mean ± standard error 0.085 ±0.085) mg/kg. the copper level found in this study were close to the concentration of 20.0 µg/g specified by Median International Standard for fish food [57-59], and lower than the values of 30.0 mg/kg specified by FAO/WHO [60, 61], 2.25 mg/kg specified by [53, 54], 2.25 mg/kg specified by WHO [54, 55] and 2.0 mg/kg specified by WPCL [54, 56].

Figure-1. concentration of heavy metals in the muscle of Smoked *Trachurus trachurus* sold in Yenagoa, Bayelsa state, Nigeria



Chromium were not detected viz <0.001mg/kg in the muscle of *Trachurus trachurus.* As such the concentration was below Median International Standard of 1.0 µg/g for fish food [57-59]. Furthermore, chromium is this study is contrary to the value of previous study by Nnaji and Ngele [62] that reported chromium in the range of 0.01 –

0.08mg/kg in smoked *Trachurus trachurus* in some market in Umuahia, Nigeria. The non-detection of chromium in this present study is an indication of no health risk of chromium associated with the consumption of smoked *Trachurus trachurus* in the study area. Typically, chromium is an essential metal required by the human body for enhancement of insulin activity, but concentration above the specified limit it could be deleterious to the body [62].

The zinc concentration in the muscle of smoked *Trachurus trachurus* ranged from 10.74 – 15.21 (mean ± standard error 12.98 ± 2.24) mg/kg. The values were higher than the levels of 45.0 µg/g specified by Median International Standard [57-59], 40.0 mg/kg by FAO/WHO) [60, 61], 5.0 mg/kg by [53, 54] 5.0 mg/kg by WHO [54, 55] and 4.25 mg/kg by WPCL [54, 56].

Iron concentration in the muscles ranged was from 32.76 – 41.64 (mean± Standard error 37.20 ±4.40) mg/kg. The concentration were higher than the concentration recommended for food fish by USEPA (0.5 mg/kg) [53, 54] WHO (0.30 mg/kg) [54, 55] and WPCL (0.45 mg/kg) [54, 56]. The concentration of iron in this study is lower than the values by Abubakar, *et al.* [18] reported iron concentrations in tissues/organs (skin, muscles, gills, liver, intestine, kidneys, brain and bones) of *Trachurus Murphyi* sold in Zaira market in the range of 48.417mgkg-1 to 818.05mgkg-1. But higher than the values of 10.02 – 15.40 mg/kg in smoked *Trachurus trachurus* sold in some market in Umuahia, Abia state as reported by Nnaji and Ngele [62].

The high concentration of metals such as iron, manganese and zinc in this study could be from the surface water that the fishes were harvested from [18] since they have the potential to bioaccumulate and biomagnify heavy metals [3, 36, 63, 64]. Typically, all the heavy metals accessed in this study are essential metals that are required by the body at trace concentrations and above the recommended levels they are probably toxic to the body and or interfere with other metals [65] and interferes with metabolites in the human body. Okunola, *et al.* [65] attributed the poisoning and toxicity of heavy metals to their interference with normal body biochemistry in the normal metabolic processes. The disease condition associated with high heavy metals has been comprehensively reported by [32, 33], [66], [3].

The estimated daily intake of muscles of Smoked *Trachurus trachurus* sold in Yenagoa, Bayelsa state, Nigeria is presented in Figure 2. The estimated daily intake of iron, zinc, copper and manganese was 3720.00, 1297.50, 8.50 and 86.50 respectively for adult and 2976.00, 1038.00, 6.80 and 69.20 respectively for children. Figure 3 presents the target hazard quotient in the muscles of Smoked *Trachurus trachurus* sold in Yenagoa, Bayelsa state, Nigeria. The target hazard quotient of iron, zinc, copper and manganese was 3.523, 2.868, 0.141 and 0.410 respectively for adult and 0.001, 0.003, 0.024 and 0.007 respectively for children. In the assessment of health risk it is important to determine the exposure level by quantifying the routes of exposure of a pollutant to the target organism [40]. In this study, the heavy metals are ingested through the consumption of the fish food. Hence, in the study area, the Smoked *Trachurus trachurus* are usually sold in several area including streets, homes, markets. The targets hazard quotients revealed no health concern (since THQ = <1) except for iron and zinc that indicate potential health concern in adults. Therefore the study found that adults that consumed smoked *Trachurus trachurus* is the study area are at a risk of diseases associated with iron and zinc.

Figure-2. Estimated daily intake of muscles of Smoked *Trachurus trachurus* sold in Yenagoa, Bayelsa state, Nigeria

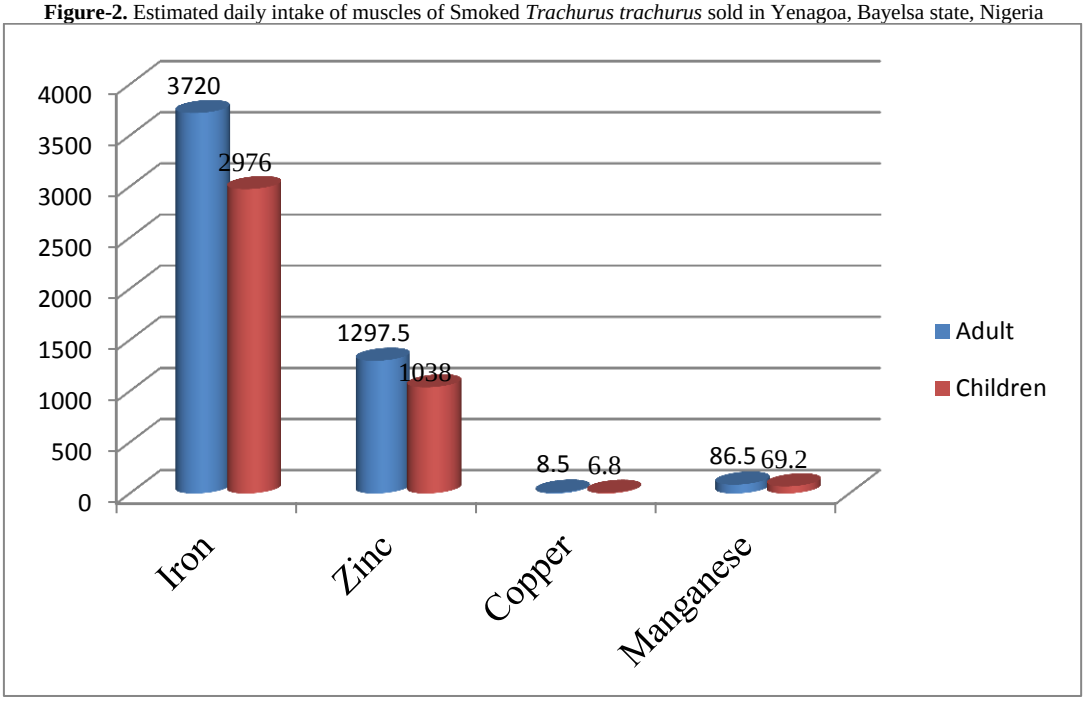
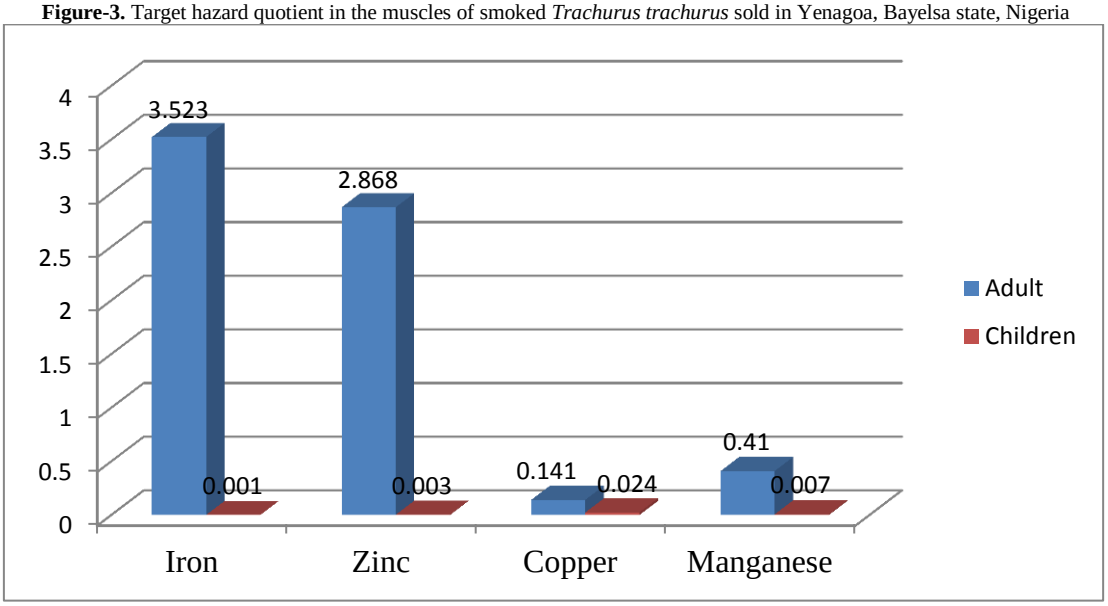


Figure-3. Target hazard quotient in the muscles of smoked *Trachurus trachurus* sold in Yenagoa, Bayelsa state, Nigeria



4. Conclusion

Fish is a major source of animal protein to several families in Nigeria. This study evaluated the health risk assessment of heavy metal in smoked *Trachurus trachurus* sold in Yenagoa, Bayelsa state, Nigeria. The study found that heavy metals such as manganese, iron and zinc were above recommended level for fish food as specified by Food and Agricultural Organization/ World Health Organization and Median international standard. Health risk assessment showed that iron and copper in adult were >1 suggesting potential health concern for both heavy metal, while the five heavy metal under study showed no potential health effect based on target hazard quotients.

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