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HEALTH RISK ASSESSMENT OF SELECTED TRACE ELEMENTS IN CANNED FISH SOLD IN BENIN CITY, EDO STATE, NIGERIA

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ABSTRACT

In this study, the level of heavy metals in selected readily consumed canned fish obtained from Benin metropolis, Edo State, Nigeria were determined using BUCK 210 VGP Atomic Absorption Spectrophotometer, while human health risk was estimated using standard risk assessment indices. The level of Nickel (Ni) ranged from 2.25±0.41to 4.03±0.11mg/kg, while Manganese (Mn) ranged from 3.25 ± 0.10 to 7.75 ±0.30 mg/kg, Cadmium (Cd) and Lead (Pb) ranged from 0.00±0.00 to 0.82±0.06 mg/kg and 0.34±0.12 to 1.87±0.47mg/kg respectively. Copper (Cu) ranged from 0.25±0.15 to 7.75±0.51 mg/kg, Iron (Fe) ranged from 6.21±0.31 to 16.21±0.50 mg/kg and Zinc (Zn) ranged from 2.02±0.91to 9.46±0.42 mg/kg. Fe, Zn, Cu and Pb were found to be significant (P<0.05) while Mn and Cd were found to be non-significant. Recoveries of the trace elements were in the range of 89.5 ± 1.45 to 98.7 ± 3.12%. Risk estimates show that the estimated daily intakes in the examined samples were below the FAO/WHO 2006 Guidelines limits while Target Hazard Quotients (THQ) and Hazard Index (HI) were less than one for all metals considered. The results of this study indicate that no considerable health risk could arise from the consumption of selected canned fish readily available in Benin Metropolis.

1. INTRODUCTION

There is increasing concern about the quality of canned foods in several parts of the world. The presence of toxic elements in food has prompted studies on their toxicological effects (Iwuoha *et al.,* 2013). The determination of metals in human foods is of significant concern due to their double-edged roles which range from the nutritional requirement of essential elements to the toxicity associated with the excessive intake of both the essential and toxic metals (Bassey *et al.,* 2014). Canned fish is widely consumed in many parts of the world because of its low saturated fat and omega fatty acids that support good health (Ikem and Egiebor, 2005). High levels of metals may be found in canned foods due to corrosion and leaching of the metals from unlacquered cans, or from tin foils used in packaging. These canned containers have a high potential of releasing metals into the foods (Dallatu *et al.,* 2013).

Onianwa *et al.* (2000) investigated the Cadmium and Nickel composition of 78 different classes of Nigerian foods. The canned processed foods revealed concentrations of heavy metals (mg/kg) in sardine to be 0.25 (Cd) and 1.8 (Ni), baked beans 0.12 (Cd) and 0.53 (Ni), canned geisha 0.17 (Cd) and 1.00 (Ni) and corned beef 0.007 (Cd) and 3.63 (Ni). The average values across canned category were 0.15±0.08 and 1.7±1.4 for Cd and Ni respectively. Khansari *et al.* (2005) assessed the heavy metals content of canned tuna fish. A total of 21 canned tuna were used for the study and results revealed that the metal contents, (expressed in µg/g wet weight), varied from 0.043 to 0.253 with an average value of 0.117 for mercury, from 0.0369 to 0.2618 with an average value of 0.128 for arsenic, from 0.0046 to 0.0720 with an average value of 0.0223 for cadmium, from 0.0126 to. 0726 with an average value of 0.0366 for lead and non-detectable for tin. They concluded that the tuna fish from the Persian Gulf area of Iran had concentrations well below the permissible FAO/WHO levels for the toxic metals and the fish were safe for human consumption. Shiber (2010) assessed the level of Arsenic, Cadmium, Lead and Mercury in commercially available canned sardines in eastern Kentucky, USA and the result ranged from As 0.49–1.87 (mean: 1.06), Cd < 0.01–0.07 (0.03), Pb < 0.06–0.27 (0.11) µg/g. The concentrations of Pb, Zn, Fe, Cd, Mn and Hg in 46 canned fish samples of nine different brands purchased within Kumasi in the Ashanti Region of Ghana were determined using the Flame Atomic Absorption Spectrophotometer. The ranges of the metals were (wet weight) were: Pb (0.058 - 0.168), Zn (0.010 - 0.370), Hg (0.088 - 0.410), Mn (0.001 - 0.057), Fe(0.990 - 32.607) µg/g. The result showed no significant variations (P>0.05) in the concentrations of the metals in the same brands of canned fishes (Boadi *et al.,* 2011). This study was therefore carried out to assess the levels of heavy metals in some selected canned fish products in Nigeria.

2. MATERIALS AND METHODS

2.1. Materials

A total of seventy samples of seven different brands of canned fish were purchased from local supermarkets in Benin City. Each brand of can was assigned a sample code (Alphabet) and the details on the packaging were recorded. The content of each can was then analyzed in the Laboratory for Ecotoxicology and Environmental Forensics, University of Benin. All glass wares were soaked over-night in aquaregia (a solution of nitric and hydrochloric acid in ratio 1:3) and rinsed with deionised water and dried before its use. All reagents used were of analytical reagent grade (Loba Chemie, India). Standard solutions of cadmium, lead, Copper, zinc, Manganese, Iron, and nickel were prepared from a stock standard solution containing 1000 ppm in deionised water. Calibration and measurement of elements were carried out using Atomic Absorption Spectrophotometer.

2.2. Methods

Prior to digestion, the samples were homogenized (AOAC 1984). Wet digestion of food was performed with Nitric acid – Perchloric acid – Sulphuric acid (HNO_3–$HClO_4$–H_2SO_4) (Radojevic and Bashkin, 1999). One-fifth of the sample material (0.2 g) was weighed into a beaker and 10 ml of Nitric acid was added, followed by 5 ml of Perchloric acid and 10 ml of Sulphuric acid. A small glass funnel was inserted to act as a reflux condenser and the mixture was heated with a bunsen burner for 15-30 mins at 150^oC until a dense white fume was noticed and a colourless solution obtained. It was removed from the block and cooled to 100 ^oC. The solution was filtered with a filter paper into a 100 mL volumetric flask and diluted to the mark with water. The blank was prepared with same procedure but without samples. The trace elements content was read off using AAS Buck Scientific (Model 210 VGP) (Radojevic and Bashkin, 1999).

2.2.1 Health risk assessment

2.2.1.1. *Average estimated daily intake (EDI)*

EDI was calculated using Equation (1), which is recommended by the US EPA (USEPA, 1997).

$$EDI = \frac{C \times IR \times EF \times ED}{BW \times AT} \quad (1)$$

Where C is the heavy metal concentration in the exposure medium (mg/L or mg/kg), IR is the ingestion rate (L/day, or kg/day), EF is the exposure frequency (365 days/year), ED is the exposure duration (60 years, equivalent to the average lifespan), BW is the body weight (kg) and AT is the time period over which the dose is averaged (365 days/year × number of exposure years, assumed to be 60 years in this study).

2.2.1.2. *Target hazard quotient (THQ)*

The human health risk posed by contaminant exposure are usually characterized by the target hazard quotient (THQ) (USEPA 1997), which is the ratio of the average estimated daily intake (EDI) resulting from exposure to the reference dose (RfD) for an individual pathway and chemical. Oral reference dose obtained from the Integrated Risk Information System (USEPA 2007) is an estimation of maximum permissible risk to a human population through daily exposure when taking into consideration a sensitive group during a lifetime. The applied RfD for Cd, Pb, Cu, and Zn are; 1.0, 4.0, 40, 300 mg/kg/d, respectively. The THQ based on non-cancer toxic risk was determined using Equation (2).

$$EDI = \frac{EDI}{RFD} \quad (2)$$

If the value of THQ is less than 1, the risk of non-carcinogenic toxic effects is assumed to be low. When it exceeds 1, there may be concerns about potential health risks associated with overexposure.

2.2.1.3. *Hazard index*

To assess the overall potential risk of adverse health effects posed by more than one metal, the THQs can be summed across contaminants to generate a hazard index (HI) to estimate the risk of a mixture of contaminants. The HI was determined using Equation (3).

$$HI = \sum THQ_i \quad (3)$$

In the present study, the HI was used as a screening value to identify whether there is significant risk caused by heavy metals through average dietary consumption of canned foods.

2.3. Statistical Analysis

All data were subjected to one-way analysis of variance (ANOVA) using XL Stat program for windows. The level of significance was chosen at $p<0.05$ and the results are presented as the mean ±standard error.

3. RESULTS AND DISCUSSION

The mean and standard error for canned fish showed variation across the different canned fish products as shown in Figure 1. The Ni values ranged from to 2.25±0.41 to 4.03±0.11, Mn ranged from 3.25 ± 0.10 to 7.75 ±0.30 mg/kg, Cd and Pb ranged from 0.02±0.47 to 0.12±0.34mg/kg and 0.12±0.34 to 1.87±0.47mg/kg respectively. Cu ranged from 0.25±0.15 to 7.75±0.51 mg/kg, Fe ranged from 6.21±0.31 to 16.21±0.50 mg/kg and Zn from 2.02±0.91 to 9.46±0.42 mg/kg. The levels of Fe, Zn, Cu, and Pb were found to be significant ($p<0.05$). On the other hand, Mn and Cd were found to be non-significant ($p>0.05$). The Ni in the analysed samples was higher than the values obtained by Ikem and Egiebor, (2004). The upper tolerable intake level (UL) of nickel for children (1–3 years old) and males/females (19–70 years old) is 7 and 40 mg/day, respectively (Institute of Medicine, 2003).

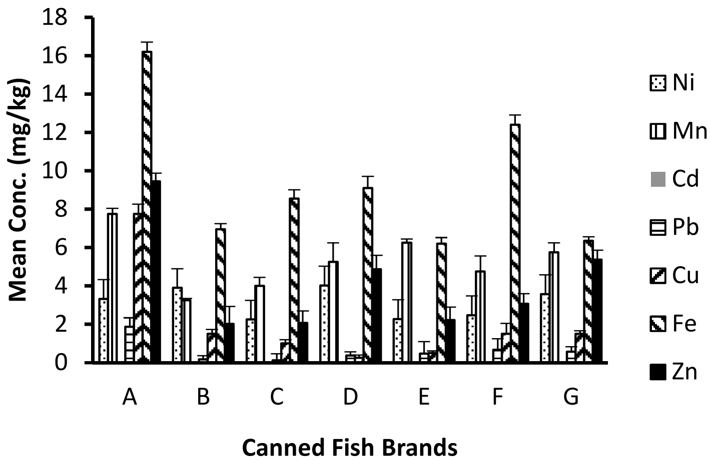

Figure 1: Mean concentration of heavy metals in selected canned fish brands

The Fe concentration in this study was higher than that reported by (Zarei *et al*., 2010). It was also higher than the result obtained by Iwuoha *et al.,* (2013) were the Fe level in canned Geisha and Founty Mackerel in Choba market ranged from 0 – 0.0379 mg/kg. However, a considerable amount of Fe was detected by Korfali and Hamdan (2013) when they analysed toxic metals in Lebanese marketed canned foods. Their result showed that Fe in canned fish (including Tuna and sardine) ranged from 3-21µg/g. Levels of Mn obtained in this study was found to be far higher than the findings of Boadi *et al.* (2011). The Zn values for all sampled canned fish in this study was below the recommended statutory limit of 50mg Zn/kg (MAFF, 1995). However, Bordajandi *et al.* (2004) reported similar values for Zn in sea fish including canned tuna and sardines, and meat and meat product when they assessed the heavy metals of food samples from Spain.

The levels of Cd in this present study was below the Codex Committee on Food Additives and Contaminants (CEC, 2001) draft guideline of 0.5 mg Cd/kg. This finding corroborates with that of Dallatu *et al.* (2013) who reported the levels of Cd in fresh and canned foods were lower than WHO standards and the values ranged from 0.0073 – 0.1919 mg/kg. However, results from this study did not agree with the findings of Bordajandi *et al.* (2004) who reported a much higher value for Cd which ranged from 0.0730 – 159µg/g. The accumulation of Cd in the human body may induce kidney dysfunction, skeletal damage and reproductive deficiencies (CEC 2001). Copper is essential for good health but a very high intake can result in adverse health problems, such as liver and kidney damage. The Cu levels in all canned fish samples were below the permissible limit of 30 Cumg/kg (MAFF, 1995; FAO, 1983). Lead compounds may also exert carcinogenic effects (Silbergeld, 2003). In this study, there is a potential of Pb poisoning from consuming the same canned fish products because certain brands had Pb concentrations way above the Commission of the European Communities, (2001). (Figure 1). As much as 1.87 mg/kg was recorded in brand A in can fish which is greater than 0.3 mg/kg set by EU for fish.

Table 1: Health Risk Indices in Canned fish

Samples	Ni		Mn		Cd		Pb		Cu		Fe		Zn		HI
	EDI	HQ	EDI	HQ	EDI	HQ	EDI	HQ	EDI	HQ	EDI	HQ	EDI	HQ	
A	0.0014	0.0694	0.0032	0.2307	0.00002	0.0208	0.0008	0.1948	0.0032	0.0807	0.0068	0.0096	0.0039	0.0131	0.6192
B	0.0016	0.0813	0.0014	0.0967	0.00003	0.0250	0.0001	0.0177	0.0006	0.0156	0.0029	0.0041	0.0008	0.0028	0.2433
C	0.0009	0.0469	0.0017	0.1190	0.00002	0.0167	0.0001	0.0125	0.0004	0.0104	0.0036	0.0051	0.0009	0.0029	0.2135
D	0.0017	0.0840	0.0022	0.1563	0.00001	0.0083	0.0002	0.0385	0.0001	0.0026	0.0038	0.0054	0.0020	0.0068	0.3019
E	0.0010	0.0475	0.0026	0.1860	0.00000	0.0000	0.0002	0.0490	0.0002	0.0052	0.0026	0.0037	0.0009	0.0031	0.2945
F	0.0010	0.0517	0.0020	0.1414	0.00002	0.0208	0.0003	0.0698	0.0006	0.0156	0.0052	0.0074	0.0013	0.0043	0.3109
G	0.0015	0.0746	0.0024	0.1711	0.00000	0.0000	0.0002	0.0594	0.0006	0.0156	0.0027	0.0038	0.0022	0.0075	0.3320

EDI of Fe in this study was found to be less than the 0.09 mg/kg bw/day reported by Korfali and Hamdan, (2013) in their study of canned foods in Lebanon. Most diets are fortified with metals such as Fe and Zn but they are required in diet within a dietary intake level certified not to cause any form of toxicity. The risk associated with the exposure to contaminants present in food products had aroused widespread concern in human health. Improvements in the food production and processing technology had increased the chances of contamination of food with various environmental pollutants, especially heavy metals (Santhi *et al.*, 2008). EDI values in mg/kg bw/day for Ni ranged from 0.0017 – 0.0009, Mn (0.0032-0.0014), Cd (0.00003-0.0000), Pb (0.0008-0.0001), Cu (0.0032-0.0001) and Fe (0.0068-0.0026) and were mostly found to be within provisional tolerable weekly intake (PTDI) of 0.8 mg/kg bw/day set by JECFA (1983). In a similar way, the EDI for Zn were found to be below 1 mg/kg bw/day set by JECFA (1982) and the range from this study was 0.0039-0.0008 mg/kg bw/day. The EDI for Cd in this study was found to be lower than 0.11 µg/kg bw/day reported by Bordajandi *et al.* (2004) and 0.14 µg/kg bw/day reported by Urieta *et al.,* (1996). The EDI for Pb in this study was lower than 0.38µg/kg bw/day reported by Bordajandi *et al.,* (2004) and 0.55 µg/kg bw/day reported by Urieta *et al.* (1996). If the value of THQ is less than 1, the risk of non-carcinogenic toxic effects is assumed to be low. When it exceeds 1, there may be concerns about potential health risks associated with overexposure. In this study, the THQ values for all canned foods categories were less than 1.

4. CONCLUSION

Metals analyzed where all within recommended standards and THQ and HI were less than one suggesting a low non-cancer toxic effect when this food is consumed, hence a no risk of food poisoning for consumers.

5. ACKNOWLEDGMENT

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6. CONFLICT OF INTEREST

There is no conflict of interest associated with this work.

REFERENCES

AOAC (1984). *Official methods of analysis of the Association of Official Analytical Chemists.* 14th ed. Washington, DC.

Bassey, F. I., Oguntunde, F. C., Iwegbue, C. M. (2014). Effects of processing on the proximate and metal contents in three fish species from Nigerian coastal waters. *Food Science & Nutrition, 2*(3), pp. 272–281.

Boadi, N. O., Twumasi, S. K., Badu, M. and Osei, I. (2011). Heavy Metal Contamination in Canned Fish Marketed in Ghana. *American Journal of Scientific and Industrial Research,* 2(6), pp. 877-882.

Bordajandi, L.R., Gomez, G., Abad, E., Rivera, J., Fernandez-Baston, M.D.L. and Blasco, J. (2004). Survey of persistent organochlorine contaminants (PCBs, PCDD/Fs, and PAHs), heavy metals (Cu, Cd, Zn, Pb, and Hg), and arsenic in food samples from Huelva (Spain): levels and health implications. *Journal of Agricultural and Food Chemistry,* 52, pp. 992–1001.

Commission of the European Communities (CEC) (2001). Commission Regulation (EC) No. 221/2002 of 6 February 2002 amending regulation (EC) NO. 466/2002 setting maximum levels for certain contaminants in foodstuffs. Official Journal of European Commucities, Brussels, 6 February, 2002.

Dallatu, Y. A., Abechi, E. S., Abba, H., Muhammed, S. U. and Ona, C. E. (2013). levels of Heavy metals in Fresh and Canned Foods Consumed in Northern Central Nigeria. *Scholarly Journal of Agricultural Science,* 3(6): pp 210-213.

Food and Agriculture Organization (1983). Compilation of legal limits for hazardous substances in fish and fishery products, FAO fishery circular No. 464, pp. 5–100.

Food and Agriculture Organization of the United Nations/World Health Organization (2006). Food Safety Risk Analysis; a Guide for National Food Safety Authorities. FAO food and Nutrition Paper 87, 102pp.

Ikem, A. and Egiebor, N.O. (2005). Assessment of trace elements in canned fishes (mackerel, tuna, salmon, sardines and herrings) marketed in Georgia and Alabama (United States of America). *Journal of Food Composition and Analysis,* 18(8), pp. 771–787.

Institute of Medicine (2003). Dietary Reference Intakes: Applications in Dietary Planning. Subcommittee on Interpretation and Uses of Dietary Reference Intakes and the Standing Committee on the Scientific Evaluation of Dietary Reference Intakes. Institute of Medicine of the National Academies, The National Academies Press, Washington, DC, p. 248.

Iwuoha, G. N., Uporo, V. B. and Onwuachi, U. I. (2013). Variation of Heavy Metals in Canned Geisha and Funty Mackerel fish Brands Obtained from Choba Market Port Harcourt, Nigeria. *Journal of Applied Science and Environmental Management*, 17 (4), pp. 577-580.

Joint FAO/WHO Expert Committee on Food Additives; JECFA. (1982). Evaluation of certain food additives and contaminants. Twenty-six report of joint FAO/WHO Expert committee on food additives WHO Technical Report Series, p. 683.

Khansari, F. E., Ghazi-Khansari, M. and Abdollahi, M. (2005). Heavy Metals Content of Canned Tuna Fish. *Food Chemistry,* 93, pp. 293-296.

Korfali, S.I. and Hamdan, W. A. (2013). Essentials and Toxic Metals in Lebanese Marketed Canned food: Impact of Metals Cans. *Journal of Food Research,* 2(1), pp. 19-30.

MAFF (1995). Monitoring and surveillance of non-radioactive contaminants in the aquatic environment and activities regulating the disposal of wastes at sea, 1993. Aquatic Environment Monitoring Report No. 44. Directorate of Fisheries Research, Lowestoft.

Onianwa, P. C., Lawal, J. A., Ogunkeye, A. A. and Orejimi, B. M. (2000). Cadmium and Nickel Composition of Nigeria Foods. *Journal of Food Consumption and Analysis,* 13, pp. 961-969.

Radojevic, M. and Bashkin, V. N. (1999). *Practical Environmental Analysis*. 2nd edition, RSC Publishing UK, p. 457.

Shiber, J.G. (2010). Arsenic, Cadmium, Lead and Mercury in Canned Sardines Commercially available in Eastern Kentucky, USA. *Marine Pollution Bulletin*, 62, pp. 66-72.

Silbergeld, E.K. (2003). Review. Facilitative mechanisms of lead as a carcinogen. *Mutation Res*earch, 533, pp. 121–133.

Urieta, I., Jalon, M. and Eguileor, I. (1996). Food surveillance in the Basque Country (Spain). II. Estimation of the dietary intake of organochlorine pesticides, heavy metals, arsenic, aflatoxin M1, iron, zinc through the total diet study. *Food Additive and Contamination*., 13, pp. 29-52.

USEPA, (1997). Exposure Factors Handbook. Office of Research and Development, National Center for Environmental Assessment, Cincinnati, Ohio.

Zarei, M., Mollaie, A. and Eskandari, M. H. (2010). Histamine and Heavy Metals Content of Canned Tuna Fish. *Global Veterinaria,* 5(5), pp. 259-263.