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Heavy metal burden in smoked and dried samples of meat and fish sold at Abakpa market, Enugu State and their health risk potentials

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Abstract
Studies were carried out to evaluate the heavy metal burden in smoked and dried samples of meat and fish sold at Abakpa market, Enugu State and their health risk potentials using standard analytical procedures and instrumentation. The mean range for Pb in the samples (smoked fish, dried fish and stock fish) from the aquatic environment was 0.303-0.509 µg/g and was 0.212-0.274 µg/g in the samples (dried cow meat and cow ponmo) from the non-aquatic environment. Cd had a mean range of 0.117-0.227 µg/g in the fish samples and 0.039-0.079 µg/g in the meat samples. Zn had a mean range of 5.688-7.189 µg/g in the fish samples and 1.789-2.017 µg/g in the meat samples. The mean levels of the studied metals in the meat and fish samples were statistically significant. The estimated daily intakes of the studied metals by the adult population, who consumes the meat and fish samples, were within the recommended provisional tolerable daily intakes of the metals as established internationally. Constant monitoring and assessment of the food samples for possible heavy metal contamination is encouraged, considering the fact that the food samples are daily fixture in peoples' meals and, more especially the fact that the fish samples have shown higher burden with the metals as found; in order to ensure that the consumers are not at severe health risk from the metals.

Keywords: Fish samples, meat samples, heavy metals and estimated daily intakes

Introduction
The majority of the animal protein requirements of man are gotten from the consumption of fish and meat of animals [14]. Meat or fish either dried, fresh or smoked, improves human nutrition because of its richness in essential minerals, vitamins and amino acids. As a protein requirement for human growth, body's wellbeing and replenishment of worn out tissues, fish and meats are common fixture in the daily meal of people of all classes [13]. According to [3, 17], consuming fish and meat provides an important source of protein, poly unsaturated fatty acids, lipo-soluble vitamins and essential minerals required for healthy living and all-round human development. According to [6], fish and animal meat account for about 38% of global population's intake of animal protein and 15% of all the protein consumed by humans [8]. Concluded that daily consumption of meat and fish by people of all classes in whatever quantity provided, is a critical requirement for maintaining optimum health and vitality. Meat and fish can be dried, smoked or cooked half-done (In the case of ponmo) to serve the food preparation preference of people. Although, meats and fish are critical food requirement for growth and general body well-being, the nutritive qualities and essential mineral components that it supplies can seriously be over-shadowed if they are contaminated with environmental food toxicants of concern such as heavy metals. According to [1], metal contaminants in food include, Fe, Pb, Cd, Zn, Cu, Hg. Mn, Ni, As, Cr and Co, although some of them such as Fe, Zn, Cu, Mn and Co are trace elements required by the body for optimum biochemical function. However, these trace elements when present in the body above their permissible limits can cause harm to the body [16]. Stated that the main threat to human health from heavy metals is associated with exposure to lead, cadmium, mercury and arsenic [8, 10, 12]. Stated that the toxic effects of metals and metalloids are mainly due to direct inhibition of enzymatic systems and the indirect alteration of the metal-ion equilibrium. Depending on the type of metal exposed to, the health effects of metal poisoning include gastro-intestinal disorders, tremor, diarrhea, paralysis, vomiting, convulsion, anemia, encelopathy, neuropathy and liver and kidney disorders [1, 2, 11, 14].

Fish and meat either dried, smoked or half-cooked, are consumed by people of all ages in our society, but more especially the adult population, primarily on account of their superior economic power and class in the society, and in all human ceremony, these necessary food materials are a constant fixture. Considering the fact that heavy metals as food contaminants exerts a gradual health toxicity to man, which could result to irreplaceable and irreversible health damage, evaluating its levels in daily food materials such as meat and fish consumed daily by the people, are of a serious interest to the food scientists and environmentalists.

Therefore, the adult population, who consumes significant quantity of these food materials daily are at risk of increased exposure to heavy metals and could suffer more grievous health consequences on account of their age. Consequently, the study to evaluate the heavy metal burden in dried and smoked samples of fish and meat sold at Abakpa market, Enugu State and their health risk concerns to the adult population became very important.

Materials and Methods

Sample collection and Preparation

5 pieces each of the dried fish, smoked fish, stock fish, dried cow meat and cow ponmo were purchased at different points in Abakpa market, Enugu State. The samples were oven-dried to a constant weight at 80ºC. The samples were then pulverized using a ceramic mortar and pestle and stored separately into well-labeled polyethylene bags until laboratory analysis.

Sample Digestion

As described by [2], from the dried samples, 1g was weighed and added into a 250ml beaker containing 5ml of Conc. HNO_3 and $HClO_4$, mixed in the ratio of 3:2 respectively. The digestion procedure proceeded at 150 °C and took 4hrs and was deemed to have been completed at the evolution of white fumes. The cooled digest was diluted with de-ionized water and filtered into 50ml volumetric flask using Whatmann filter paper and was subsequently made up to mark with de-ionized water. Triplicate digestion procedure was conducted for each of the sample together with the reagent blank and stored in laboratory condition until analysis. Levels of Pb, Cd and Zn were determined in the samples using Hitachi Z-5000 flame atomic absorption spectrophotometer (AAS), fueled with acetylene gas.

To minimize the risk of possible metal contamination during reagent preparation, quality control measures were applied in order to ensure the reliability of the results.

Statistical analysis

The data obtained were expressed in mean ± standard deviation and subjected to one way analysis of variance (ANOVA) at 5% confidence level using IBM SPSS 23.0.

Human health risk assessment

The health risk assessment of the daily intake of the investigated heavy metals through consumption of the dried, smoked or ponmo meats and fish by the adult population within Abakpa was estimated using the equation;

$$EDI = \frac{C \times Ac}{bw}$$

Where, EDI represents estimated daily intake, C equals to concentration (µg/g) of the heavy metals in the fish and meat samples, Ac equals to the average dry weight (about 150g) of the fish and meat samples consumed daily by the population, which was obtained using questionnaire and bw equals to the average adult bodyweight (60kg).

Results and Discussion

Table 1: Mean heavy metal concentration in the dried fish, smoked fish, stock fish, cow ponmo and dried cow meat samples sold at Abakpa market, Enugu State.

Sample Metal (µg/g)	Dried fish	Smoked fish	Dried cow meat	Cow ponmo	Stock fish	F test P value	[16] STD
Pb	0.381±0.064	0.303±0.051	0.274±0.034	0.212±0.066	0.509±0.026	0.02	0.5
Cd	0.117±0.023	0.195±0.014	0.039±0.012	0.071±0.010	0.227±0.035	0.01	10
Zn	7.189±0.362	5.688±0.472	2.017±0.351	1.783±0.140	6.040±0.955	0.01	30

Lead: Result of Table 1 shows that the mean Pb levels in the dried fish, smoked fish, dried cow meat, cow ponmo and stock fish samples sold at Abakpa market,

Enugu State, were 0.381±0.064, 0.303±0.051, 0.174±0.034, 0.212±0.066 and 0.509±0.026 µg/g respectively. The samples had mean Pb levels in the following decreasing order; stock fish > dried fish > smoked fish > dried cow meat > cow ponmo as shown in Figure 1 of the five studied food samples, only the stock fish samples had mean Pb levels above the recommended threshold levels for consumable food products as stated by [16]. The mean Pb levels in the studied food samples were statistically significant, which could have being as a result of the varying sources of the harvest of the samples and their anthropogenic contamination with heavy metals. It was equally observed from the result of Table 1 that the samples (dried fish, smoked fish and stock fish) from the aquatic environment had higher mean Pb levels compared to the samples (dried cow meat and cow ponmo) from the non-aquatic environment. The indiscriminate dumping of industrial and non-industrial wastes in the aquatic environment, where the fish samples were harvested could have given rise to this finding. According to [17], the stock fish samples sold at Ogbete main market, Enugu, had 0.192±0.023 µg/g as mean Pb value, which was lower than was gotten for the metal in the studied stock fish samples from Abakpa market. Because these samples can be harvested from different aquatic environments, the significant variation of the compared findings is therefore very consistent. According to [1, 5, 10, 11, 15], exposure to high levels of Pb through food or water or industrial occupation, can cause irreversible brain damage, anemia, damage to the liver, kidney and reproductive system and low IQ in children.

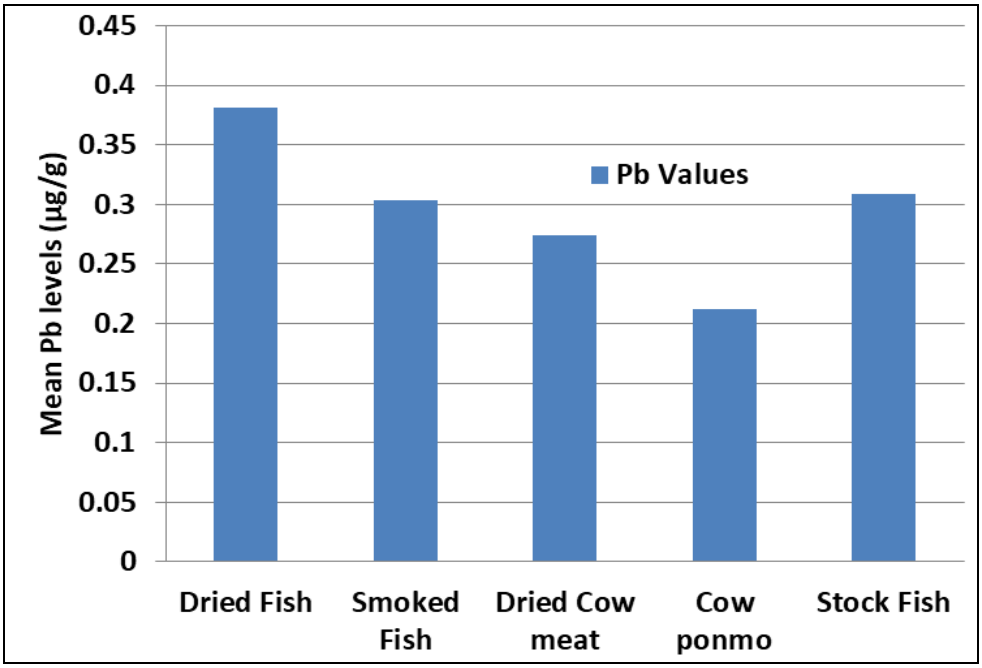

Fig 1: Bar chart description of the mean Pb levels in the studied fish and meat samples sold at Abakpa market, Enugu State.

Cadmium: 0.117±0.023, 0.195±0.014, 0.039±0.012, 0.071± 0.010 and 0.227±0.035 µg/g were the respective mean Cd levels in the dried fish, smoked fish, dried cow meat, cow ponmo and stock fish samples as shown in Table 1. The mean Cd levels in the samples decreased in the following order; stock fish > smoked fish > dried fish > cow ponmo > dried cow meat as shown in Figure 2.

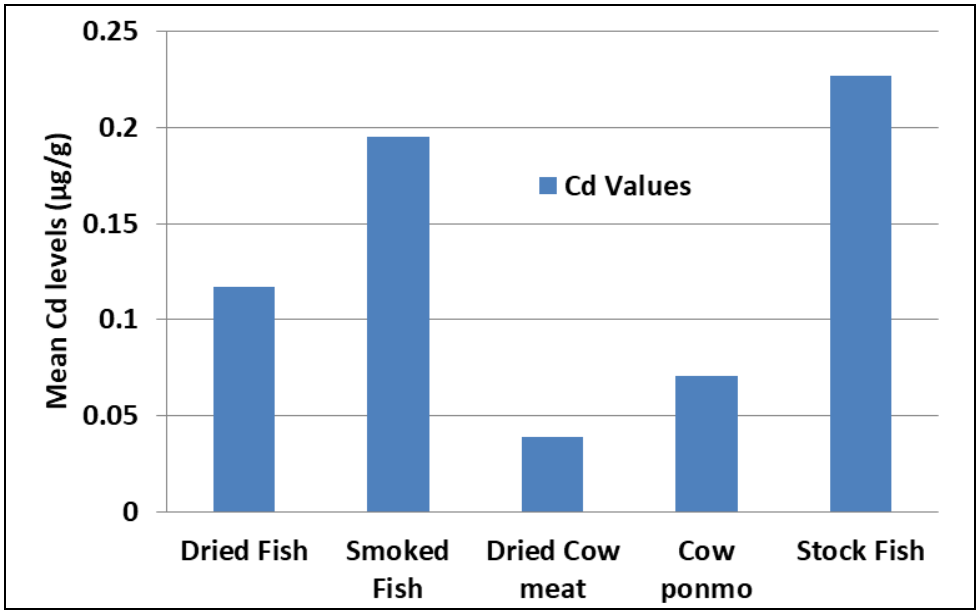

Fig 2: Bar chart description of the mean Cd levels in the studied fish and meat samples sold at Abakpa market, Enugu State.

The mean Cd levels in the studied samples differed statistically but were within the permissible limits set for it in consumable solid food substances. Just as observed for Pb in the samples, the mean Cd levels in the samples from the aquatic sources were higher than was found for the metal in the samples from the non-aquatic sources. According to [1, 7, 8. 13], food substances such as cereals, fruits, vegetables, fish and meat have been shown to contain Cd, even at the minutest levels, making this food substances the highest contributors to the dietary exposure to Cd, because they are the food materials consumed in the largest amounts [17]. Reported a comparable mean Cd value of 0.102±0.034 µg/g in the stock fish samples sold at Ogbete main market, Enugu State, with the dried and smoked fish samples of this study. According to [10], undue and consistent exposure to Cd even at low concentrations, adversely affects important organs of the body such as the liver, kidney, lungs, brain and bones.

Zinc: Result of Table 1 shows that the mean Zn levels in the dried fish, smoked fish, dried cow meat, cow ponmo and stock fish samples were 7.189±0.362, 5.688±0.472, 2.017± 0.351, 1.783±0.140 and 6.040±0.955 µg/g respectively.

The decreasing order of mean Zn levels in the samples were dried fish > stock fish > smoked fish > dried cow meat > cow ponmo as shown in Figure 3.

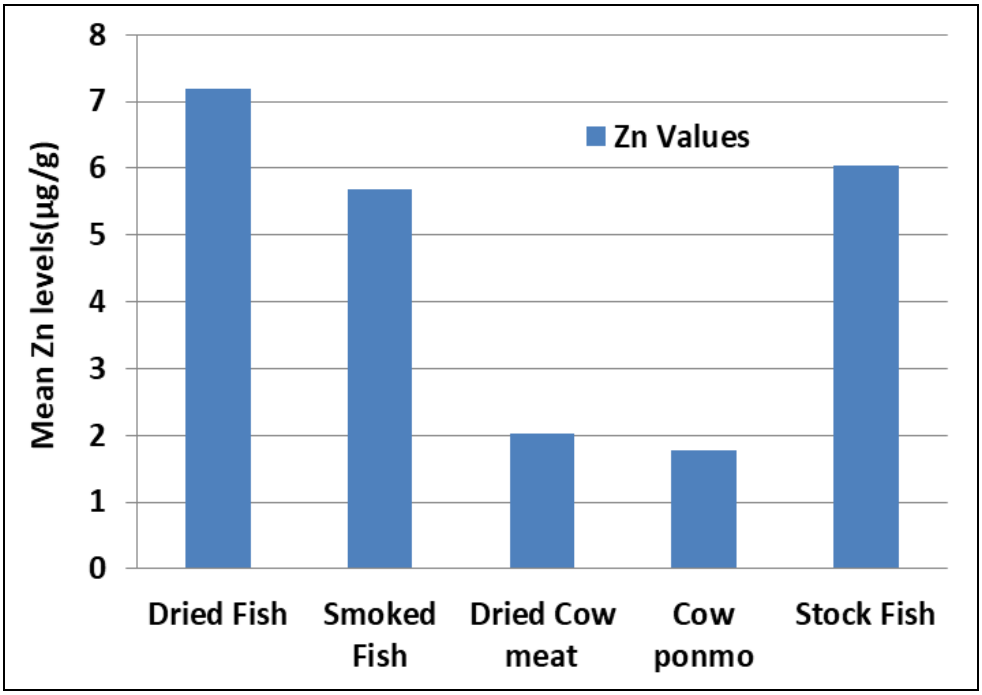

Fig 3: Bar chart description of the mean Zn levels in the studied fish and meat samples sold at Abakpa market, Enugu State.

Although the mean Zn levels in the samples were statistically significant, it was within the threshold levels as established by [16]. Similarly, the samples from the aquatic environment had higher mean Zn levels than the samples from the non-aquatic environment, therefore suggesting a higher nutritive potentials of the aquatic sourced samples. In as much as zinc is an essential element required for human nutrition, in which too little concentration of it can cause health problems, at undue dietary exposure, can cause harmful effects such as nausea, vomiting, epigastric pain, diarrhea, anemia and loss of hair [5, 10].

Human Health Risk

Table 2: Estimated daily intake (µg/kg/day) of the studied metals by the adult population, living within Abakpa, Enugu State, who feeds on the meat and fish samples.

Sample Metal	Pb	Zn	Cd
Dried fish	1.00	1.08	0.30
Smoked fish	0.80	0.86	0.50
Dried cow meat	0.44	0.30	0.10
Cow ponmo	0.60	0.26	0.20
Stock fish	1.24	0.90	0.56
[4, 16] PMTDI	3.60	1000	0.83

As stipulated by [4, 16], the estimated daily intake (EDI) of the studied heavy metals by the adult population (with 60kg body weight), who consumes an estimated (from questionnaire) 150g of the fish and meat samples daily, were within the recommended provisional tolerable daily intakes (PMTDI) as shown in Table 2. For the adult population, the burden and risk of increased dietary exposure to the heavy metals were more on the samples (fish) from the aquatic environment than the samples (meat) from the non-aquatic environment.

Conclusion

The evaluated metals (Pb, Cd and Zn) were present in the stock fish, dried fish, smoked fish, dried cow meat and cow ponmo samples at detectable levels. Of the five studied food samples for heavy metal contamination, the stock fish samples had mean Pb level at toxic levels. The samples (stock fish, dried fish and smoked fish) from the aquatic environment were more burdened with the investigated heavy metals than the samples (dried cow meat and cow ponmo) from the non-aquatic environment.

However, the dietary exposure to the heavy metals by the adult population, who consumes the meat and fish samples daily are not facing any health concern or food risk from the heavy metals.

Conflicts of Interests

The authors' declare that there are no conflict of interests in carrying out this research and its publication.

References

1. Aniobi CC, Ezeh E, Okeke O, Ikedinobi CS, Achu VV. Assessment of Cd, Pb and Cu contents in ready-to-eat foods (sharwama, chin-chin, chicken pie, fish pie and butter pie) sold in eateries within Enugu metropolis and their potential health risks to the consumers. Journal of Chemical, Biological and Physical Sciences. 2019;9(4):392-401.
2. Aniobi CC, Ndubuisi JO, Ezeagwu PC, Okeke OR, Igoche SA, Ejinaka NO. Heavy metal determination in selected local and foreign food seasonings sold in markets within Enugu metropolis and their health risk potentials. Discovery. 2023;59(e98d1302):1-7.
3. Bender DA. Nutritional biochemistry of the vitamins. Cambridge University Press, Cambridge, UK; c2003. p. 41-49.
4. European Food Safety Authority. Statement of torable intakes of metals from food additives application in foods. European Food Safety Authority Journal. 2012;10:2551-2559.
5. Ezeh E, Okeke O, Aburu CM, Anya OU. Comparative evaluation of the cyanide and heavy metal levels in traditionally processed cassava meal products sold

within Enugu metropolis. Journal of Environmental Science, Computer Science and Engineering & Technology. 2018;7(3):390-398.
6. Food and Agricultural Organization. Global forest resources assessment, FAO STAT statistics data base. Rome; c2010b. p. 331-334.
7. Food Safety Authority of Ireland. Mercury, lead, cadmium, tin and arsenic In: Toxicology Fact Sheet Series. 2009;1:1-13.
8. Okeke O, Okeke D. Assessment of selected heavy metal residues in the kidney, liver, muscle and gizzard of chickens raised within Enugu metropolis. International Journal of Environment and Pollution Research. 2015;3(4):62-66.
9. Khan MA, Amir RM, Ahmad A. Application of nanoparticles for the removal of heavy metals from wastewater. Int. J. Agric. Food Sci. 2022;4(2):109-113. DOI: 10.33545/2664844X.2022.v4.i2b.102
10. Okeke O, Aburu CM, Ozuah AC, Ezeh E. Effect of application of seasonings/spices and heating/processing methods on the levels of polycyclic aromatic hydrocarbons and heavy metals in cooked, fried and roasted meats sold within Enugu metropolis. Journal of Chemical, Biological and Physical Sciences. 2018;8(3):257-268.
11. Okeke O, Aniobi CC, Akagha CI, Ezeh E, Ezejiofor CC. Effect of distance of sanitary pits on the microbial and heavy metallevels in hand dug well water samples consumed by people living in Akwuke, Enugu South Local Government Area of Enugu State. Journal of Water Resource and Protection. 2021;13(05):325-339.
12. Okeke O, Ndubuisi JO, Ozuah AC, Aniobi CC, Okeke MU. Physicochemical characteristics, heavy metal levels and pollution index status in soil samples around Nnobi Abattoir in Anambra State. Journal of Environmental Science, Computer Science and Engineering &Technology. 2020;9(3):471-480.
13. Okeke OR, Okeke MU. Estimation of the dietary intakes of heavy metals by children, adolescents, adults and seniors consuming meats within Awka and Enugu metropolis and its environs. British Journal of Environmental Sciences. 2015;3(3):1-13.
14. Okeke OR, Aniobi CC, Ezejiofor CC, Ezeagwu PC, Ndubuisi JO, Ndubuisi KC, *et al*. Microbial and heavy metal assessment of meat samples from ranche and non-ranched domestic animals sold at Gariki market, Enugu State, Nigeria. Research in Health Sciences. 2023;8(2):22-33.
15. Okoye PAC, Ajiwe VIE, Okeke OR, Ujah II, Asalu UB, Okeke DO. Estimation of heavy metal levels in the muscle, gizzard, liver and kidney of broiler, layer and local (Cockerel) chickens raised within Awka metropolis and its environs, Anambra State, South Eastern, Nigeria. Journal of Environmental Protection. 2015;6:609-613.
16. World Health Organization. Heavy metal safety evaluation of certain food additives and contaminants. 55th Meeting of the joint FAO/WHO expert committee on food additives; WHO food additive series, Geneva; c2014. p. 46-81.
17. Okeke OR, Ejindu-Ejisi CO, Aburu CM, Odenigbo CD, Odenigbo JO. Assessment of heavy metal residues in stock fish, crayfish and consumable vegetables sold in selected markets in Enugu State, South Eastern part of Nigeria. Global Advanced Research Journal of Physical and Applied Sciences. 2016;5(2):018-021.