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Analysis of Heavy Metals in Roasted Meat (*Suya)* in Anyigba, Kogi State, Nigeria and their Health Risk Assessment.

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Abstract *The aim of this work is to assess the concentration of some heavy metals in roasted meat that are sold along the road sides in Anyigba with the view of estimating their potential health risk using contamination indices. Roasted meat samples were collected from four different sample locations in Anyigba and were screened for the presence of Fe, Mg, Zn, Pb and Cd. The filtrates were analyzed for the presence of some heavy metals analysis using Atomic Absorption Spectrophotometer (AAS). The results obtained indicated that the mean concentrations of the analysed heavy metals were: 40.4 ± 0.26 -74.8 ± 0.84 mg/kg (Fe), BDL - 9.00 ± 1.20 mg/kg (Mg), 0.60 ± 0.14 - 6.80 ± 0.23 mg/kg (Zn), BDL - 2.60 ±0.65 mg/kg (Pb), BDL - 0.20 ± 0.16 mg/kg (Cd). Concentrations of Pb (1.03 ± 0.02) and Cd (0.20 ± 0.01) were above some recommended limits (EC, 2001; FAO/WHO, 2010). Also, mean concentration of Fe (46.5 ± 0.64) mg/kg was slightly above NASEM (2001) recommended limit while calculated EDI, ILCR and THI were within the permissive limit (except for the THI for Pb in adult).*

Key Words: *Roasted meat, heavy metals, tolerance limits, health risk assessment*

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1.0 Introduction

Heavy metals are those metals whose density is greater than 5 g/cm3 (Eddy et al., 2004; Yahaya *et al.,* 2012). They are generally known for their toxicity when the observed concentration is above critical value (Ekop and Eddy, 2009). The present of heavy metals in the environment has generally been reported in various forms and in all the components of the ecosystem including aquatic, soil, plants and animals (Essien and Eddy, 2015). Their impacts on the health of man and other components of the environment have also been documented Eddy and Udoh, 2006). Few of the challenges facing the control of heavy metal distribution in the environment is their tendency to be transfer from lower organism (such as plant) to higher organism (such as animal that feed on contaminated plant) and even to man through the food chain (i.e consumption of contaminated plants or animals)(Even and Ghaffari, 2011; Yahaya *et al.,* 2012). Also, some organism has the tendency to bioaccumulate some heavy metals in their system through inhalation (Ekhator *et al.,* 2017). Unfortunately, bioaccumulation of heavy metals. Several anthropogenic activities including power transmission and advancement in food technology could probably lead to contamination of food with different toxic heavy metals including Hg, Cd and As caused by environmental pollution (Tukura et al., 2005). Some heavy metals such as iron and magnesium have biochemical functions in the human system are needed for body grow while metal like zinc are metallogenic enzyme because trace concentration of this metal is required to speed up the activities of enzyme in the body system (Yahaya *et al.,* 2020). Some heavy metals like (including Cd, Pd, As and Hg) are toxic at very low concentration and have no unique biological functions but will rather bioaccumulate to toxic concentration and subsequent impact (Taiwo *et al.,* 2020; WHO, 2000; Yahaya *et al.,* 2012). The surplus heavy metals could lessen some essential nutrients in the body system resulting into diminished psycho- social behaviours, reduction in immunological resistances and probably upper gastrointestinal disorder (Arora et al., 2008). For example, cadmium has the capacity to replace calcium or act freely on bone tissue, leading to bone diseases (Kjellstrom, 1992; D'Haese *et al.,* 1999; Järup, 2002). It has been reported by Kjellstrom, (1992) that cadmium-induced osteomalacia caused itai-itai (ouch-ouch) disease in Japan.

Meat is cut into sheets, fix in a stick arranged round the fire or placed on the wire gauze and roasted on open charcoal fire with addition of salt, ground nut oil, dried pepper and monosodium glutamate as spice (Garba *et al*., 2017).

Processing methods for meats are barbequing, boiling, grilling, pan frying, stir frying and roasting which is done to increase its flavor, taste, palatability and to make it tender (Joyce et al., 2016). Roasting of meats is a common and one of the most patronize forms of meat processing in Nigeria. Consequently, some studies have reported the presence of heavy metals in fresh and roasted meats. For example, Ndu and ThankGod (2018) reported significant concentrations of Fe, Ni, Cd, Pb and chromium in some roasted meat samples sold in Port Harcourt by hawkers. Similar reports were also reported for roasted meats samples in Enugu (Okeke *et al.,* 2018). However, in spite of some of the reported cases of heavy metals concentrations in roasted meat, literature cited heavy metals concentrations in meats roasted within Kogi State has not been reported. Therefore, the present study is aimed at investigating levels of concentrations of heavy metals in roasted meats (sold within Ayigba) and assess their potential public heat risk.

2.0 Materials and Method

2.1. Materials

Polyethene bags, refrigerator, analytical balance, crucibles, drying oven, spatula, mortar and pestle, beakers, filter paper, volumetric flasks, deionised water, concentrated nitric acid and Atomic Absorption Spectrophotometer (AAS).

2.1.1 Sample collection

Samples of roadside roasted meats (*suya)* were randomly collected from four different selling points (Beside Ogohi Hotel (A), Opposite Jayus Plaza (B), Stadium Road Junction (C) and Anyigba Garage (D) and raw meat samples from each sampling point in Anyigba town. In order to prevent contamination during sampling, transportation and storage, polyethylene bags were used in the collection and labeled for easy identification of various location of collection. They were stored in refrigerator at temperature of −4 ºC before analysis.

2.1.2 Sample preparation and analysis

The samples were pulverized and homogenized to aid digestion using agate mortar. The ground and homogenized samples were transferred into labeled crucibles (which were washed with a 10% nitric acid, rinsed with deionized water and dried in an oven at 450 ºC for 1 hour. 5g of each sample were digested with 10 ml of 1 M solution of nitric acid in 100 ml volumetric flask at 100 º C for 2 hours. The digested sample was allowed to cool before filtration into a 50 mL conical flask using a Whatman filter paper No. 42. The filtrate was made to the mark with distilled water and was used for heavy metal ion determination using Atomic Absorption Spectrophotometer (AAS) (Perkin Elmer Analyst 200 model).

2.2 Statistical analysis

The software application used for the analysis of data was Statistical Programs for Social Sciences (SPSS). The data were analyzed for analysis of variance (ANOVA), mean, standard deviation and regression analysis were done using statistical significance was proven when $p < 0.05$.

2.3 Risk Assessment

Internationally recommended method was used for the risk assessment (UNEP, 1996; US EPA,1989; 1997 and 2000a). For the estimation of daily intake (EDI), equation 1 was adopted (Copat *et al.,* 2012, 2013),

$$EDI = \frac{IR \times C}{\mathrm{BW}} \quad (1)$$

Where: C is the concentration of the heavy metal; IR is the ingestion rate = 227g or 0.227 kg (meal size) for adult with body weight (BW) of 70 kg; IR in 6years old child= 0.114kg and BW = 16 Kg (US-EPA, 2000a and 2000b)

Target Hazard Quotient (THQ), shows the ratio of exposure rate to the reference dose and can be expressed equation 2.

$$THQ = \frac{EF \times ED \times IR \times C}{RfDo \times \mathrm{BW} \times AT} \quad (2)$$

where: EF is the exposure frequency = 350 days/year for people taking Suya times in a week; ED is exposure duration = 70 years for adult and 6 years (Child); IR is the food ingestion rate 0.227 kg in adult 0.114 kg in children. C is the concentration of metal in Suya (μg /g, wet weight);

RfDo oral reference dose (μg/g/day), Pb = 0.0035 and Cd. 0.001 (Song *et al.,* 2015); body weight (BW), AT is the averaging time = EF (350) × ED (70). If THQ risk is greater than 1, it is assumed that there is potential health risk (US-EPA, 2000a and 2000b; Yahaya *et al.,* 2017; Antoine *et al.,* 2017**).**

For the evaluation of incremental lifetime cancer risk (ILCR) equation 3 was applied for the estimation of potential carcinogenic risk.

$$ILCR = \frac{EF \times ED \times IR \times C}{CFS \times \mathrm{BW} \times AT} \quad (3)$$

where: CSF is the cancer Slope Factor (μg/g/day) for Pb = 0.0085 and Cd = 15 mg/kg (US EPA, 200a; Zeng *et al.,* 2015; Hossian *et al.,* 2018). If incremental lifetime cancer risk (ILCR) risk is great than 10^{-5} value as recommended by US-EPA, it is presumed as an acceptable risk for cancer (US-EPA, 1997 and 2000a)

3.0 Results and Discussion

Mean concentrations of heavy metal ions (Table 1) in the samples were 40.4 ± 0.26 -74.8 ± 0.84 mg/kg (Fe), BDL - 9.00 ± 1.20 mg/kg (Mg), 0.60 ± 0.14 - 6.80 ± 0.23 mg/kg (Zn), BDL - 2.60 ±0.65 mg/kg (Pb), BDL - 0.20 ± 0.16 mg/kg (Cd) (Table 1).

Table 1: Mean concentrations of some elements (mg/kg) of studied meat samples

Metals	Roasted meat (Suya			Raw Meat	
	A	B	C	D	E
Fe	74.8 ± 0.84	36.9± 0.01	51.5 ± 0.05	43.6 ± 0.01	40.4 ± 0.26
Mg	9.00 ± 1.20	9.00± 1.00	BDL	7.40 ± 1.06	6.40 ± 0.18
Zn	6.50 ± 0.08	6.80 ± 0.23	2.60± 0.16	6.70± 0.12	0.60 ± 0.14
Pb	2.60 ±0.65	1.60 ± 0.14	0.90 ± 0.12	0.60 ± 0.14	BDL
Cd	0.20 ± 0.01	0.20 ± 0.00	0.20 ± 0.10	0.20 ± 0.16	BDL

**** Mean ± standard deviation of triplicate analysis, BDL = blow detection limit**

Also, there is no significant difference in Suya samples because the values obtained were closely related irrespective their sampling points or locations ($p>0.05$) In raw meat (unprocessed) all metals were found at low concentrations with Pb and Cd not detectable. The level of Fe, Mg and Zn were within the NASEM, recommended value (Table 2) in the sampling points B, C, D except in A where Fe (46.5 ± 0.64) mg/k g was slightly above NASEM value 45 mg/kg. Mean concentrations of Fe and Zn were higher than those reported by Dibofori-Orji and ThankGod (2018) and Olajide *et al.,* (2019). for some roasted meat.

The observed concentrations of Fe, Mg and Zn are not in the toxic zone since they are essential minerals required for body metabolism such as proper functioning of muscle and nerve, maintenance of healthy immune system and a steady heartbeat, facilitates blood formation (Fe), effective cell growth enzymes (Zn) among others (Lieu *et al.,* 2001; Haug *et al.,* 2007; FAO, 201; Vormann, 2016).

Table 2: Comparison concentrations of analyzed metal in Suya with EC, NASEM, FAO/WHO

Metals	Mean concentration (mg/kg)	MCL (mg/kg) (EC, 2001)	DRI-TUILE (mg/d) (NASEM, 2001)	TIVTMA (mg/kg) (FAO/ WHO 2010)
Fe	46.5 ± 0.64	----	45	----
Mg	6.47 ± 0.14	-----	350	-----
Zn	4.22 ± 0.15	-----	40	-----
Pb	1.03 ± 0.02	0.5	0.2 FAO/WHO	0.025
Cd	0.20 ± 0.01	0.005	0.05 FAO/WHO	0.007

European Commission Regulation (EC, 2001); maximum contaminant levels (MCL); Dietary Reference Intakes Tolerable Upper Intake Levels, Elements (DRI-TUILE). *A Tolerable Upper Intake Level (TUL) is the highest level of daily nutrient intake.* National Academies of Sciences, Engineering, and Medicine (NASEM), Tolerable intake values of selected toxic metals for adults per week (TIVTMA) (Olajide Et al., 2019; www.nap.edu)

The observed mean concentration of lead in the meat samples was less than those reported by Garba *et al.* (2017), Olajide *et al.* (2019) and Ojebah and Ewhr, (2015) for meats obtained from various locations while mean concentration of cadmium ion was closely comparable to those reported by Ojebah and Ewhr, (2015). The concentration of Cd detected agrees with the values reported by Ojebah and Ewhr, (2015) and Dibofori-Orji and ThankGod (2018) respectively. However, mean concentration of lead and cadmium in our samples reported were above the EC maximum contaminant limits of 0.5 mg/kg and 0.005 mg/kg (EC, 2001) and FAO / WHO (2010) limits of 0.025 mg/kg and 0.007 mg/kg respectively. Since these meats are normally kept on the road side, some studies have suspected that vehicular emission and industrial chimney can significantly contributes to the level of lead and cadmium in the exposed meat (Ibeto and Okoye, 2010; Dan'azumi and Bichi, 2010; Garba *et al.,* 2017). The target organ for lead is the blood and the brain. High concentration of Pb in blood system may cause infertility, heart diseases and cancer in adult as well as low intelligence and antisocial behaviour in children (Tuormaa, 1995; Ojebah *et al.,* 2015). Spices may contain Cd (200 ng g-1) depending on the soil that they were grown, Therefore, interaction of the spices with the meat may also increase concentration of this and other heavy metals in the meat. Epidemiological studies revealed that the half-life of Cd in human kidney range from 10 to 30 years (Fox Spivey,1987). Hence, longtime exposure to Cd may result to nephrotoxicity in humans (Nordberg, 1999).

Calculated pollution indices for lead and cadmium are presented in Table 3. Calculated EDI values for lead and cadmium were lower than FAO/WHO recommended limits.

The observed EDI (Table 3) values are 3.296×10^{-3} and 7.313×10^{-3} for Pb and 6.4×10^{-4} and 1.42×10^{-3} for Cd in adult and children respectively. Since, the tolerable upper intake level is the maximum concentration of daily nutrient intake that could probably pose no risk of adverse health effects both adult and child on consumption Suya (FAO/WHO, 1972; 2010),

Calculated THQ values are less than unity (except for lead in adult profile) indicating that the observed concentrations may not have potential health risk except for adult less than 1 except in adult where the concentration of Pb is higher than 1 (US EPA,1989, 2000a and 2000b) Furthermore, all the ILCR values are less than the expected limit indicating that there is no imminent potential risk to cancer.

Table 3. EDI, THQ and ILCR (mg/kg/day) of Pb and Cd in adult and children

	Pb		Cd	
	Adult	Children	Adult	Children
EDI	3.296×10^{-3}	7.313×10^{-3}	6.4×10^{-4}	1.42×10^{-3}
THQ	1.164	0.479	0.793	0.093
ILCR (mg/kg/day)	0.497	0.895	5.276×10^{-5}	9.5×10^{-5}

Estimated daily intake (EDI) is the initial investigation of food contaminant potential risk based on its consumption rate. For instance, It could seven times in a week.

Target Hazard Quotient (THQ), is defined as the ratio of exposure to the reference dose and evaluated using an integrate US-EPA risk analysis.

Incremental lifetime cancer risk (ILCR) is used to estimate the probable carcinogen risk base on the exposure at dignified dose of pollutant or contaminants using the Cancer Slope Factor (CSF).

4.0 Conclusion

Suya samples at the different locations were analyzed for heavy metal and their potential health risk was assessed. The results revealed than Pb and Cd were above the WHO maximum permissible limits. The EDI, ILCR and THI were within the US EPA recommended limits except the THI for Pb in adult which signifies the potential health. Pb and Cd have no biological importance in human body. Since roadside dust, pollutants released from vehicle exhausts and pyrolysis of spices are the potential sources of these toxic metals, therefore, there is need for adequate monitoring the processing of *Suya* as to prevent the adverse health effect of these metal.

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Conflict of Interest

The Authors declare no conflict of interest