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Assessment of Toxic Metals Concentration and Health Risks in Some Fresh and Roasted Red Meat Consumed in Makurdi.

Agbendeh, Z.M., Wuana, R.A., Adimora, K.C. and Jibrin, S.
Department of Chemistry,
Federal University of Agriculture, Makurdi, Nigeria
Corresponding Email: zack.agbendeh@uam.edu.ng

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Abstract: This research was conducted to assess the levels of Cd, Cr, Cu, Pb, Zn and Ni and their human health risks in some fresh and roasted pork and beef from five major markets (five samples each were assessed). Metal assay in the samples was done using atomic absorption spectrophotometry after pretreatment and digestion of samples. Additionally, chronic daily intake, target hazard quotient, estimated daily intake and hazard ratio index values of the metals were calculated using their respective concentrations and other reference data. Mean concentration (mg/kg) of Cu and Zn in fresh beef were 3.00 ±2.00 and 41.80 ± 39.07 respectively, while those for steak (suya) were 4.40 ± 2.70 and 69.20 ± 49.59 respectively. Those concentrations (mg/kg) of cu and Zn in fresh pork were 19.80 ± 30.48 and 9.00 ± 0.707 respectively while for roasted pork were 5.40 ± 1.52 and 42.00 ± 1.52. The concentrations of Cu were below WHO permissible levels in fresh pork samples, fresh beef and steak (suya) from modern markets, whereas, most of the Zn concentration in meat except the steak (suya) samples from modern markets were above permissible limits. Meanwhile, THQ and HR values in adults were less than 1, meanwhile, THQ and HR values in children were greater than 1 for fresh and roasted pork. Similarly, CDI, THQ, EDI and HR values in children were greater than 1 for fresh and steak (suya) meat. This indicates the existence of potential health hazard from metal ingestion through the consumption of red meat both roasted and fresh.

Keywords: Spectrophometer, Concentration, Potential, health hazard, Ingestion, Mean,

Introduction

Potentially harmful metals contents in soil may come not only from the bedrocks itself, but also from anthropogenic sources like solid and liquid waste deposit, agricultural inputs, and fallout of industrial, and urban omission (Wilson and Pyatt, 2007) excessive accumulation in agricultural soil may result not only in soil contamination, but also has negative consequences on food quality and safety. So, it is essential to monitor food quality, given that plant uptake is one of the main pathways through which metals enter the food chain (Antonious and Kochher, 2009)

Heavy metals have been identified in effluents of textile industry, grasses, fishes, aquatic environment, surface and microbes (Jiraunget *et. al.,* 2007; Arabani*et al.,* 2010; Muhammad, 2014). Toxic metals including heavy metals are individual metals and metal compound that negatively affect people's health with increasing industrialization, more and more metals are entering into the environment. These metals stay permanent because they cannot be degraded in the environment. They enter into the food materials and from there they ultimately make their passage into the tissue.

Meat is an important source of protein in human nutrition and diet (Idahor, *et. al.,* 2009) however, meat from beef and pig are most commonly consumed by people in the Northern part of Nigeria and Benue state in particular in various forms. Therefore, they can potentially accumulate toxic minerals because of the open grazing system which they are subjected to for their own food and water. These could have been contaminated by toxic metals which constitute great risk to the human health because of their potential toxicity, bioaccumulation and biomagnifications in the food chains.

Consumption of heavy metals contaminated food can seriously deplete some essential nutrients in the body causing a decrease in immunological defenses, disabilities associated with malnutrition and a high prevalence of upper gastrointestinal cancer (Arora *et. al.,* 2008). As, consumption of these meat are injurious to health, it is important to access the accumulation of such heavy metals which are of public health importance in the blood and tissue of animals.

The aim of the study is to assess the heavy metal contamination in commonly consumed red meat both as fresh or in roasted forms in Makurdi. The specific objectives were to: (i) determine the concentrations of Cd, Cr, Cu, Ni, Pb and Zn of fresh and roasted pork and beef sold in major markets in Makurdi, and (ii) calculate the human health risk indices of toxic metals using their concentrations and other reference data.

Materials and Methods

Brief Description of the study area

The study was conducted in Makurdi and situated at latitude 7.73ºNlatitude and 8.52ºE longitude with an elevation of 104 meters above sea level. Makurdi, a town with the famous river Benue with two bridges the New and the old bridges respectively. Makurdi has a population of 500, 797 as of 2007 census making it the biggest city in Benue.

Samples were obtained from five major markets in Makurdi town; Wurukum, Wadata, North- Bank and High levels markets. The samples were prepared and pretreated in the Chemistry Laboratory of the Federal University of Agriculture, Makurdi.

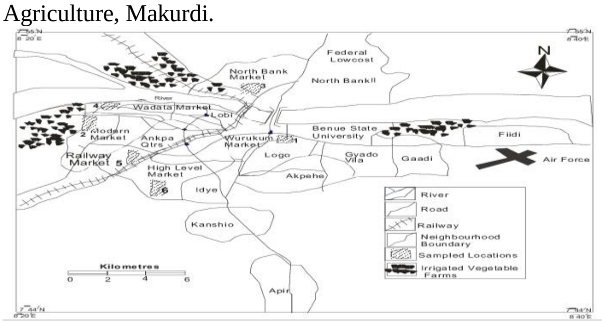

Fig 1: Map of Makurdi showing the study area (Wurukum**,** Wadata, High-level, Modern and North-bank markets)

Materials and Methods

The materials and methods used were according to standard procedures adopted in one of our research works published somewhere (Agbendeh, *et. al.,* 2022) and reagents used were of analytical grade.

Human Health Risk Indices for Toxic Metals

Human exposure to heavy metals occurs through several pathways including direct ingestion, dermal absorption through skin, inhalation through mouth and nose. Ingestion is the most common pathways for meat Wu, *et. al.,* (2016); Li, *et al.,* (2013). Heavy metals can be exposed to humans of polluted air as dermal absorption from contaminated bathing water and occupational exposure to metal contaminated air.

Chronic daily intake (CDI)

The USEPA points out that the human body absorbed pollutant dose is calculated from chronic daily intake (CDI), which means the pollutant dose per kilogram of body weight per day that is absorbed through direct ingestion, dermal absorption or inhalation USEPA, 2004. We used the direct ingestion as the main exposure pathway.

The CDI of the meat ingestion and dermal adsorption

$$CDI_{in} = \frac{C\ x\ FIR\ x\ ABSg\ X\ EF\ x\ ED}{BW\ x\ AT} \quad (1)$$

Where;

FIR is the metal ingestion rate,

ABSg is the gastrointestinal absorption factor,

EF is the exposure frequency,

ED is the exposure duration,

BW is the body weight of the consumer (70 kg average weight for an adult)

AT is the average time.

CDI_{in} is the exposure does from ingestion of meat ($mgkg^{-1}day^{-1}$), and C is the average concentration of heavy metals (mg/kg).

Estimated daily intake (EDI)

Heavy metals estimated daily intake (EDI) is dependent on the heavy metal levels the skin and viscera of cattle and the rate of consumption. EDI can be calculated using the formula below USEPA, (2004).

$$EDI = \frac{C\ x\ FIR}{BW} \quad (2)$$

Where;

C = concentration of heavy metal in the sample (mg/kg wet weight),

FIR = Skin and viscera ingestion rate (g/day),

BW = body weight of the consumer (70 kg average weight of adult)

The EDI can then be compared with the total daily intakes FAO and WHO 2019

Target hazard quotient (THQ)

THQ is used to evaluate health risk accompanied with non-carcinogenic and carcinogenic effect of any toxic metal. Skin and viscera consumption risk of cattle can be evaluated according to THQ. THQ is a relation between the determined pollutant dose and the level of the RFD (reference dose. The reference dose is the daily exposure of a contaminant estimated which the population exposed along a lifetime continually with no significant dose Okoro, *et. al.*, 2010. If this relation is less than one (1), the population has improbable no noticeable bad effects. The equation below is used to determine the risk assessment;

$$THQ = \frac{EF\ X\ ED\ X\ FIR\ X\ C}{RFD\ X\ BW\ X\ AT} X10^{-3} \quad (3)$$

where;

EF = the frequency of exposure (365 days/ year),

ED = the duration of exposure (70 years, average exposure),

FIR = ingestion rate of meat (g/day)

RFD = oral reference dose (mg/kg/day)

At = exposure time average (365 days/ year x exposure years number)

BW = body weight of consumer (70 kg average weight for an adult).

The oral reference dose of Pb, Cd, Zn and Cu is 0.004, 0.001, 0.3 and 0.04 (mg/kg/bw/day) respectively USEPA, 2004

Hazard Ratio index (HR)

The equation used for this study is

$$\text{Hazard Ratio (HR)} = \frac{EDI}{RFD} X10^{-3} \quad (4)$$

The hazard ratios (HRs) can be summed to generate a hard (HI) to estimate the risk of mixed contaminants so HI can be generated using the following equations;

$$HI = \sum HRi \quad (5)$$

Where; I represent each metal, EDI is estimated daily intake, RfD is Reference Dose, A HR and/ or HI of > 1 indicates that there is potential risk to human health, whereas a result of ≤ 1 indicates no risk of adverse health effects.

Results and Discussion

Heavy metal concentrations in Beef and pork both in their fresh and roasted forms from five major Markets in Makurdi.

Table 1: Concentration of toxic metals (mg/Kg) in fresh beef and steak (suya) from five major markets

Samples	Cd	Cr	Cu	Pb	Zn	Ni
NB fresh	ND	ND	1.00	ND	56.00	ND
HL Fresh	ND	ND	0.00	ND	0.00	ND
WK Fresh	ND	ND	3.00	ND	0.00	ND
MM Fresh	ND	ND	5.00	ND	76.00	ND
WD fresh	ND	ND	5.00	ND	77.00	ND
NB Steak	ND	ND	2.00	ND	80.00	ND
HL steak	ND	ND	3.00	ND	146.00	ND
WK steak	ND	ND	4.00	ND	55.00	ND
MM steak	ND	ND	4.00	ND	11.00	ND
WD steak	ND	ND	9.00	ND	54.00	ND

Table 2: Concentration of toxic metals (mg/Kg) in pork samples from five major markets

Samples	Cd	Cr	Cu	Pb	Zn	Ni
NB fresh	ND	ND	4.00	ND	65.00	ND
HL Fresh	ND	ND	2.00	ND	54.00	ND
WK Fresh	ND	ND	74.00	ND	90.00	ND
MM Fresh	ND	ND	9.00	ND	49.00	ND
WD Fresh	ND	ND	10.00	ND	40.00	ND
NB Steak	ND	ND	5.00	ND	41.00	ND
HL Steak	ND	ND	6.00	ND	33.00	ND
WK Steak	ND	ND	3.00	ND	43.00	ND
MM Steak	ND	ND	6.00	ND	87.00	ND
WD Steak	ND	ND	7.00	ND	6.00	ND

Note: ND means Not Detected; NB means North bank;HL means High- level; MM means Modern markets; WK means Wurukum and WD means Wadata markets.

The study shows the presence of Zn and Cu in the fresh beef and steak (suya) samples. Cd, Cr, Pb and Ni were not detected in all the meat samples collected from the five major markets of Makurdi as shown in table 1. Zn in fresh samples examined in High-level and Wurukum samples were very low beyond detectable limit.

Copper

Copper concentration of the beef samples ranged between 1.00 mg/kg and 5.00 mg/kg and 9.00 mg/kg. Although copper is essential for good health, very high intakes can cause health problems such as liver and kidney damage. Determination of Cu content in food is also an important subject with respect to human consumption. In this study all sample contained lower amount of Cu than their limits, and there was no significant difference between the paired samples studied. The concentration of Cu in both meat samples were below USDA permissible level for Cu in meat (20 mg/kg). Similarly, copper was detected in most of the sample (table 2). The levels of Cu in this study ranged between 74.00 mg/kg and 2.00 mg/kg with the highest level observed in the fresh pork samples from modern market which is higher than the WHO permissible limit for Cu in meat of 40 mg/kg (Merian, 1991). Meanwhile, other pork samples had copper concentrations lower than the WHO permissible level of 40 mg/kg. The results agreed with Gonzalez *et. al.,* (2014) who found the level of Cu in beef as 12.37 mg/kg.

Zinc

Zinc is an essential trace metal for all organisms and has an important role in metabolism, growth, development and general well- being. The provisional tolerable weekly intakes (PTWI) of Zn in meat is 700 mg/week/ person. The highest Zn concentration for beef was 77.00 mg/kg fresh beef from Wadata market and the least was 56.00 mg/kg fresh from North-bank market. In steak (suya) meat, the highest concentration was 146.00 mg/kg in High level market and the least was 11.00mg/kg in modern market. Table 1.

From table 2, Zinc was detected in all samples with concentrations ranging from 90.00 mg/kg to 6.00 mg/kg. The permissible limit of Zinc in meat according to WHO standards is 50 mg/kg (Merian, 1991). Fresh pork samples from (North-bank, High-level and Modern markets) and roasted pork samples from North-bank) were above the WHO permissible limits whereas, fresh pork samples from (Wurukum and Wadata) and roasted pork samples from (High-level, Wurukum, Wadata and Modern markets) were below the WHO permissible limits. This result agrees with Amani and Lamia (2012) who reported the zinc in beef as 41.72 mg/kg. Also, it disagreed with Bendedouche *et al.,* (2014) who found, the concentration of Zinc in beef meat as 36.99 mg/kg. However, the result also disagreed with Akan *et. al.,* (2010) who found, Zinc concentrations in the meat of beef as ranged from (0.10 to 2.04) mg/kg.

From table 1, none of the samples exceeded the permissible limit. The Zn and Cu content found in the fresh beef can be caused by pollution, the environment itself, agricultural practices and livestock feed. Contamination is transferred to animals through direct sewage water and industrial effluent. Contamination of meat can also be caused by vehicle emission and from dirty slaughter places while that of steak (suya) can also be caused by the knives, metal stripes used in roasting and engine oil used to fuel the wood.

From table 2, chromium concentration in all the samples was also below detection limit so they were not detected. The concentration of chromium in the samples was less than WHO permissible limit (Merian, 1991) for chromium which is 2.6 mg/kg. Cadmium in the present study was less than the detectable limits (0.01) which conforms to the regulatory standards (USDA, 2006; European commission, EC 1881, 2006; gulf standard, 2015; JEFCA, 2004; Food standards Australia New Zealand, FSANZ, 2003 and China 2006). This result similarly agrees with Makanjuola, and Olakunle (2016) who found concentration of Cadmium in some meat samples was lower than detection limits (0.002). However, the result disagrees with Chafik (2014) who reported the concentration of cadmium in beef (0.00) mg/kg, also disagrees with Amani and Lamia (2012) who reported, the cadmium in beef as (1.68), ppm respectively of cadmium in beef as (1.65) mg/kg.

Nickel in the present study was below detectable limits (0.003) mg/kg. The result agrees with Hozan and Hemin (2013) who found the concentration of Ni in exposed corned beef and chicken lucheon that are sold in Sulaymaniah as 0.00 mg/gm. However, the result disagrees with Akan *et. al.,* (2010) who found Nickel concentrations inmeat of beef, mutton, caprine and chicken as ranged from (0.01 to 0.22) mg/kg. Also, it disagreed with Makanjuola and Olakunle (2016) who found concentration of Nickel in meat as 0.01 – 0.56 mg/kg.

Lead was also detected in all samples due to the fact that its concentration in the samples was less than (0.001) which conforms to the regulatory standards (USDA, 2006; European Commission, EC 1881, 2006; gulf standard, 2015; JEFCA, 2004; Food standards Australia New Zealand, FSANZ, 2003 and China 2006). However, this result disagrees with Gonzales- Waller *et. al.,* (2006) who reported the mean concentration of lead in the pork products 6.72 ppb and in the beef products 9.12 ppb. Also, disagrees with Demirezen and Uruc (2006) who found the average lead concentrations obtained from Pastirma, meat and sausage as 0.126, 0.115, 0.135 mg/kg respectively. And disagrees with Abedi (2011) who reported the lead content in sausages from Iran as 53.5 mg/kg and Gonzalez *et. al.,* (2006) who found concentrations of lead in chicken products samples as (3.16) mg/kg, pork product (4.89) mg/kg and (4.76) mg/kg in beef product. Also, disagrees with Santhi*et. al.,* (2008) who reported relatively higher lead content in baconas (1.64) mg/kg, ham (1.966) mg/kg, sausage (1.352) mg/kg, Salami (3.250) mg/kg and luncheon meat (2.231) mg/kg obtained from retail outlets of Chennai city, and disagrees with Dora *et. al.,* (2014) who found lead in sausages as 9.0 mg/kg.

Table 3: Mean concentration of Heavy Metals in Beef and Steak (suya) sample.

Samples	Zn	Ni
Fresh Beef	3.00 ± 2.00	41.80±39.07
Roasted Beef	4.40 ± 2.70	69.20± 49.59

Table 4: below shows mean and standard deviation of metal concentrations in fresh and roasted pork samples.

Samples	Cu	Zn
Fresh Pork	19.80 ± 30.48	59.60±19.24
Roasted pork	5.40 ± 1.52	42.00 ± 29.17

The result from this study showed that beef and (Suya) sold in Makurdi market accumulated varying levels of heavy metals. The mean concentration of Cu and Zn in fresh beef were 3.00 ± 2.00 and 41.80 ± 39.07 mg/kg respectively while for steak (suya) were 4.40 ±2.70 mg/kg respectively.

The high concentration of heavy metals recorded in steak (suya) may be attributed to the presence of heavy metals from the environment, the metal stripes used in roasting or it occurs naturally in plant consumed by animals. In fresh beef, the mean concentration of Cu and Zn from the present study was found to be lower than those obtained from previous studies. The differences in the concentration of heavy metals in the various studies could be due to the different environmental factors, rearing and slaughtering and butchering techniques.

Cu was below the maximum permissible level set by WHO (2010) and European regulation in 2006.

The increase in the concentration of Cu and Zn of meat after roasting may be attributed to the fact that the meat was placed directly on metal and rods or the type of substance used to fuel such as kerosene, petrol and engine oil. Heavy metals were detected in samples analysed. The mean concentrations of heavy metals determined in the meat samples are indicated as shown in fig 3.

Human Health Risk Indices for Toxic Metals in Beef and Steak (Suya) from the five major Markets in Makurdi, Nigeria

Human health risk indices were calculated for adults and children using the concentrations of all the heavy metals that were detected in the course of this analysis and other reference standard data provided by some international bodies and other researchers. The following human health risk indices were calculated using equation 1-5 above and the results are shown below;

Chronic Daily Intake (CDI)

CDI values of copper and Zinc were calculated for both adults and children in beef and pork samples in tables 5 and 6 below.

Table 5: Chronic Daily Intake (CDI) values of Toxic Metals in Beef for both Adults and Children Concentration in Copper and Zinc.

Samples	Cu	Zn	Cu	Zn
NB Fresh	0.4110	23.0137	3.8356	214.7945
HL Fresh	0.0000	0.0000	0.0000	0.0000
WK Fresh	1.2329	0.0000	11.5068	0.0000
MM Fresh	2.0548	31.2329	19.1781	291.5068
WD Fresh	2.0548	31.6438	19.1781	295.3425
NB Roasted	0.8219	32.8767	7.6712	560.000
HL Roasted	1.2329	60.0000	11.5068	210.9589
WK Roasted	1.6438	22.6027	15.3425	210.9589
MM Roasted	1.6438	4.5205	15.3425	42.1918
WD Roasted	3.6986	22.1918	34.5205	207.1233

Table 6: Chronic Daily Intake (CDI) values of Toxic Metals in pork for both Adults and Children Concentration in Copper and Zinc.

Samples	Cu	Zn	Cu	Zn
NB Fresh	1.6438	17.8082	15.3425	166.2100
HL Fresh	0.8219	14.7945	7.6712	138.0822
WK Fresh	30.4110	24.6575	283.8356	230.1310
MM Fresh	3.6986	13.4247	34.5205	125.2968
WD Fresh	4.1096	10.9589	38.35205	102.2831
NB Roasted	2.054	11.2329	38.3562	104.8402
HL Roasted	2.4658	9.0411	19.1781	84.3836
WK Roasted	1.2329	11.7808	23.0137	109.9543
MM Roasted	2.4658	23.8356	11.5068	222.4658
WD Roasted	2.8757	1.6438	23.0137	15.3425

Table 5. Shows calculated chronic daily intake (CDI) values for consumption of fresh beef and steak (suya) in Makurdi. The results indicated that heavy metals were not or below detectable limit in High-level fresh beef samples. Zn and Cu was present in considerable amount. The CDI values for Cu and Zn ranged from 0.4110- 2.0548, 3.8356 – 19.1781 respectively and 23.0137 – 31.6438, 214.7945- 295.3425 respectively for Cu and Zn in fresh beef. For both adult and children 0.8219- 3.6986, 7.6912 – 34.5202 respectively and 4.5205 – 60.000, 42.1918- 560.0000 respectively for Cu and Zn in steak (suya) for both children and adult. The result shows Zn has the highest intake for both adult and children. Therefore, CDI indices for heavy metal in the study were found in the order of Zn> Cu. Cu in the study was found to be below 20 mg/kg European Commission, 2006. Zinc toxicity can occur in both acute and chronic forms. Acute adverse effects of high zinc intake include nausea, vomiting, loss of appetite, abdominal cramps, diarrhea and headaches (IMFNB, 2001).

Table 6 Shows the chronic daily intake (CDI) values of toxic metals in fresh and roasted pork samples. The CDI values for children were generally higher than those in adults.

Copper: The highest CDI value for copper was gotten in fresh pork sample from modern market (30.4110), while the lowest value was observed in fresh pork sample from high-level (0.8219). in children, the highest CDI value was also observed in fresh pork sample from modern market (283.8356) and the lowest value in fresh pork sample from high-level (7.6712).

Zinc: The highest CDI value for Zinc in adults was gotten in fresh pork sample from modern markets (24.6575), while the lowest value was observed in roasted pork sample from modern market (1.6438). In children, the highest CDI value was also observed in fresh pork sample from Modern market (230.1310) and the lowest value in roasted pork sample from Modern market (15.3425).

Estimated Daily Intake (EDI)

EDI were also calculated for adults and children and are shown in tables 7 and 8 below for beef and pork samples respectively.

Table 7: Estimated Daily Intake (EDI) values of metals for both Adults and Children concentration in Copper and Zinc (beef)

Samples	Cu	Zn	Cu	Zn
NB Fresh	1.4286	80.0000	13.3333	746.6667
HL Fresh	0.0000	0.0000	0.0000	0.0000
WK Fresh	4.2857	0.0000	40.0000	0.0000
MM Fresh	7.1429	108.5714	66.6667	1013.3333
WD Fresh	7.1429	110.0000	66.6667	1026.6667
NB Roasted	2.8571	114.2857	26.6667	1066.6667
HL Roasted	4.2857	208.5714	40.0000	1946.6667
WK Roasted	5.7142	78.5714	53.3333	733.3333
MM Roasted	5.7142	15.7143	53.3333	146.6667
WD Roasted	12.8571	77.1429	120.0000	720.0000

Table 8: Estimated Daily Intake (EDI) values of toxic metals in pork samples for both Adults and Children concentration in Copper and Zinc

Samples	Cu	Zn	Cu	Zn
NB Fresh	5.7143	92.8571	53.3333	866.6667
HL Fresh	2.8571	77.1429	26.6667	720.0000
WK Fresh	105.7143	128.5714	988.6667	1200.0000
MM Fresh	12.8571	70.000	120.000	653.3333
WD Fresh	14.2857	57.1429	133.3333	533.3333
NB Roasted	7.1429	58.5714	66.6667	546.6667
HL Roasted	8.5714	47.1429	80.0000	440.0000
WK Roasted	4.2857	61.4286	40.0000	573.3333
MM Roasted	8.5714	124.2857	80.0000	1160.0000
WD Roasted	10.0000	8.5714	93.3333	80.0000

As revealed from the tables above, Zn has the highest intake among the samples. It should be noted that the DIM estimation is a risk assessment designed to avoid underestimation of risk. Therefore, the EDI values of Cu as revealed in the result shows that fresh beef and steak (suya) are above 1.4 mg/day recommended limit for Cu in UK (Ysart *et. al.,* 2009). Similarly, for Zn all samples were above 11.0 mg/day recommended for Zn daily dietary intake (Ysart *et. al.,* 2009).

Generally, the results revealed that fresh beef and steak (suya) samples for Cu and Zn in both adult and children have levels of metals above the daily dietary recommended limit for studied metals in the samples. Thus, frequent intake of these contaminated products is likely to induce health effects arising largely from Cu and Zn.

Target Hazard Quotient (THQ)

The values for the THQ are calculated for beef and pork samples as below;

Table 9: Target Hazard Quotient (THQ) values of Toxic metals for both adults and children concentration in Cu and Zn for beef samples.

Samples	Cu	Zn	Cu	Zn
NB Fresh	0.0342	0.2557	0.3196	2.3866
HL Fresh	0.0000	0.0000	0.0000	0.0000
WK Fresh	0.1027	0.0000	0.9589	0.0000
MM Fresh	0.1712	0.3470	1.5982	3.2390
WD Fresh	0.1712	0.3516	1.5982	3.2816
NB Roasted	0.0685	0.3653	0.6393	3.4094
HL Roasted	0.1027	0.6667	0.9589	6.2222
WK Roasted	0.1370	0.2511	1.2785	2.3440
MM Roasted	0.1370	0.0502	1.2785	0.4689
WD Roasted	0.2460	0.2460	2.8767	2.3014

Table 10; Target Hazard Quotient (THQ) values of Toxic metals in pork samples for both adults and children concentration in Cu and Zn.

Samples	Cu	Zn	Cu	Zn
NB Fresh	0.1370	0.2968	1.2785	2.7702
HL Fresh	0.0685	0.2466	0.6393	2.3014
WK Fresh	0.3082	0.2237	2.8767	2.0883
MM Fresh	2.5342	0.4110	23.6530	3.8356
WD Fresh	0.3425	0.1826	3.1963	1.7047
NB Roasted	0.2055	0.3973	1.9178	3.7078
HL Roasted	0.1712	0.1872	1.5982	1.7473
WK Roasted	0.2055	0.1507	1.9178	1.4064
MM Roasted	0.2397	0.3973	1.9178	3.7078
WD Roasted	0.1027	0.1963	0.9589	1.8326

Tables 9 and 10 above, the Target hazard quotients (THQ) for heavy metals consumed in fresh beef and steak (suya) studied. All THQs for adult were less than 1, suggesting that adult would not experience significant health risks from the intake of individual's metals through an average amount of fresh beef and steak consumption. The THQ for Zn in this study was higher than the 0.089 reported in fish in Taiwan. The highest THQ for Zn in this study was recorded for children, except for beef and steak for Cu in North-bank and steak (suya) for Zn in modern market. Which were below 1 for children. Since the THQ for children were above 1, children are especially vulnerable to acute and chronic effects of ingestion of chemical compounds since they consume more food per kilogram of body weight than adults. The result shows more exposed to chemical hazard in food than adult.

The target hazard quotients of copper for adults and were within the range of 0.0685 to 2.5342 for fresh pork samples and 0.1027 to 0.2397 for roasted pork samples (table). Those for Zinc, adults were within the range of 0.2466 to 0.4110 for fresh pork samples and 0.1507 to 0.3973 for roasted pork samples

For children, THQ values for Cu were within the range of 0.6393 to 23.6530 for fresh pork and 0.9589 to 2.2374, whereas THQ for Zn in children ranged from 1.7047 to 3.8356 for fresh pork and 0.2557 to 3.7078 for roasted pork samples.

Target hazard quotient was > 1 for Cu for fresh pork samples from modern market, whereas all other samples had both Cu and Zn < 1 for adults. Meanwhile, most of the THQ values for Cu and Zn were > 1, except for Cu in (fresh pork from High-level market and roasted pork from Wadata market) and Zinc in roasted pork from Modern market in children. Similar observations have been reported previously by Wang *et.al.,* (2012). Children are more susceptible to the impact f toxic metal pollution than adults (Sadovsk, 2012). The THQ values which are > 1 for Cu and Zn suggests that the consumption of pork sold in these markets might be unsafe for consumption. The communities at high risk of toxic metal poisoning from the consumption of pork sold in these markets.

Hazard Ratio Index (HR)

The values of HR were also calculated and are shown in table below, the values are also shown for adults and children.

Table 11; **Hazard Ratio Index (HR) values of Toxic metals for both adults and children concentration in Cu and Zn for beef samples.**

Samples	Cu	Zn	Cu	Zn
NB Fresh	0.0357	0.2557	0.3333	2.4889
HL Fresh	0.0000	0.0000	0.0000	0.0000
WK Fresh	0.1071	0.0000	1.0000	0.0000
MM Fresh	0.1785	0.3619	1.6667	3.3778
WD Fresh	0.1785	0.3667	1.6667	3.4222
NB Roasted	0.0714	0.3810	0.6667	3.5556
HL Roasted	0.1071	0.6952	1.0000	6.4889
WK Roasted	0.1429	0.2619	1.3333	2.4444
MM Roasted	0.1429	0.0524	1.3333	0.4889
WD Roasted	0.3214	0.2571	3.0000	2.4000

Table 12: Hazard Ratio Index (HR) values of Toxic metals for both adults and children concentration in Cu and Zn for Pork samples.

Samples	Cu	Zn	Cu	Zn
NB Fresh	0.1429	0.3095	1.3333	2.8889
HL Fresh	0.0714	0.2571	0.6667	2.4000
WK Fresh	0.3214	0.4286	24.6667	4.0000
MM Fresh	2.6429	0.2333	3.0000	2.1778
WD Fresh	0.3571	0.1095	3.3333	1.7778
NB Roasted	0.2143	0.4143	2.0000	3.8667
HL Roasted	0.1786	0.1952	1.6667	1.8222
WK Roasted	0.2143	0.1571	2.0000	1.4667
MM Roasted	0.2500	0.0286	2.3333	0.2667
WD Roasted	0.1071	0.2048	1.0000	1.9111

Table 11 shows the hazard ratio (HR) for Cu and Zn in fresh beef and Steak (suya) samples studied. All HR values for adult were less than 1, which suggests a smaller risk, making the consumption of fresh beef and steak (suya) in Makurdi market is safe for adult consumption because it doesn not exceed the estimated hazard ratio of consumption of fresh beef which is 1.15 with 95% confidence interval. The highest HR in the study was recorded for Zn of steak (suya) meat in high- level, although some of the meat samples in some markets (North bank fresh beef, Wurukum fresh beef, North-bank Steak and high-level steak) of Cu recorded a value of 1 and < making beef of children in those area a little safe but the rest market recorded HR > 1 making the consumption of meat in these market very unsafe for the children health, cause it might result to cancer for young children and it can cause premature death for children. The result above shows children are more exposed to chemical hazard in food than adults.

The result of HR values through the consumption of fresh and roasted pork is shown in table 12, the hazard ratio of copper for adults was within the range of 0.0714 to 2.6429 for fresh pork samples and 0.1071 to 0.2500 for roasted pork samples and 0.0286 to 0.4143 for roasted pork samples.

For children, HR values for Cu were within the range of 0.6667 to 24.6667 for fresh pork and 1.0000 to 2.3333, whereas Zn in children ranged from 1.7778 to 4.0000 for fresh pork and 0.2667 to 3.8667 for roasted pork samples.

Hazard ratio was > 1 for Cu in fresh pork samples from Modern markets, whereas all other samples had both Cu and Zn, 1 for adults. Meanwhile, most of the values for Cu and Zn were > 1, except for Cu in (fresh pork from high-level market and roasted pork from Wadata market) and Zn in roasted pork from Makurdi in children. Similar observations have been reported previously by Wang *et. al.,* (2017). Children are more susceptible to the impact of toxic metal pollution than adults.

Generally, THQ and HR values <1 means that the exposed population is safe from toxic metal risks while, THQ and HR values>1 means the reverse (Khan *et.al.*, 2008). The population is therefore at greater risk of Zn and Cu poisoning bas reported by Tsafe *et. al.*, (2012), communities around these markets might be at high risk of toxic metal poisoning from contaminated pork. On the other hand, THQ and HR values of < 1 are suggestive that the exposed population is assumed to be safe.

Conclusion.

Heavy metals are considered particularly dangerous to human health because, in the preparation or processing of food, they do not decompose. On the contrary, their concentration tends to bioaccumulate. Copper and Zin were present in fresh beef and steak samples sold in five major markets (high-level, Wurukum, North-bank and modern market) in Makurdi. Cadmium, Chromium, Lead and Nickel were not detected in the samples. THQ values for adults were below 1, meaning the intake of heavy metals by adults consuming these meats is not likely to cause any appreciable health effect on the adult's body. While the THQ for Children were above 1, in some market samples of fresh beef and steak indicating a potential hazard. It can therefore be concluded that metals bioaccumulation in meat samples did not exceed the permissible limits for heavy metals intake by world health organization (WHO). Therefore, the monitoring of these products is important with respect to toxic elements affecting human health.

For the pork samples, most of the HR and THQ values of these metals were above 1 which implies that the consumers of pork in Makurdi are at risk of potential toxicity as a result of metal poisoning especially children.

Conflict of Interest

The Authors declare no conflict of interest

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