International Journal of Research in Engineering and Applied Sciences(IJREAS)
Available online at http://euroasiapub.org/journals.php
Vol. 8 Issue 2, Februry-2018
ISSN (O): 2249-3905, ISSN(P): 2349-6525 | Impact Factor: 7.196

Quantification and Risk Assessment of Trace Metal Levels in Street Roasted Chickens Sold in Uyo Metropolis, Akwa Ibom State, Nigeria

Udosen, E. D.[1]
Department of Chemistry,
Faculty of Science,
University of Uyo, P. M. B. 1017, Uyo ,Akwa Ibom State, Nigeria

(Corresponding Author)***Uwah, E. I.**[2]
Department of Chemistry,
Faculty of Science,
University of Uyo, P. M. B. 1017, Uyo ,Akwa Ibom State, Nigeria

Nelson, I. A.[3]
Department of Chemistry,
Faculty of Science,
University of Uyo, P. M. B. 1017, Uyo , Akwa Ibom State, Nigeria

Udosen, I. E.[4]
Department of Biological Sciences,
Akwa Ibom State University, Akwa Ibom State, Nigeria

Abstract

Levels of Zn, Pb, Cd, Fe and Mn in public/street-roasted chicken (PRC) and un-roasted chicken (URC) samples sold in Uyo were quantified using AAS. Levels of the trace metals were equally quantified in self-roasted chicken (SRC) samples to serve as the controls. Samples were obtained from five sampling points along five major roads linking Uyo Metropolis. The results (mg/kg) gave the levels of the trace metals in the samples as follows: Zn levels ranged from 1.81±0.01 in PRC to 4.34±0.02 also in PRC and were below detection limit in the SRC from one of the sampling points. Pb levels ranged from 0.01±0.00 in the URC to 0.20±0.01 in the PRC and were below detection limit in both PRC and SRC samples from one of the sampling points. Cd was only detected in the URC and SRC samples obtained from two of the sampling points. Fe levels ranged from 0.12±0.01 in PRC to 1.91±0.01 in URC and Mn ranged from 0.54±0.01 in PRC to 2.19±0.01 in URC. Except Pb whose level exceeded the FAO/WHO maximum permissible limit of 0.1 mg/kg (in foods) in some of the PRC samples, the levels of all the other trace metals in all the samples were low compared with the FAO/WHO maximum permissible limits of such metals in foods. Accordingly, the levels of some of the trace metals in the samples were comparable with those reported in literature. Human health risk assessment through consumption of roasted chickens in Uyo Metropolis using the risk assessment models [target hazard quotients (THQs) and hazard indices (HIs)] indicated that the THQ values were higher in children than in adults. The combined non-carcinogenic effect of all the trace metals expressed as hazard index (HI) was less than unity (HI<1), indicating a negligible risk on consumption of street roasted chickens in the area. The study gives a representative data on levels of Zn, Pb, Cd, Fe and Mn in street roasted chickens consumed in Uyo Metropolis. The data will serve as base line references for future studies of such metals in street roasted chickens and related food samples in the area and its environ.

Key words: Trace metals, Street Roasted Chickens, Health Risk Assessment, Uyo

Introduction

Quantification of levels of trace metals in foods and food products such as street-roasted chickens sold in urban areas has been a great concern to scientists due to the fact that foods ingestion is a major route through which human being may be exposed to toxic amount of trace metals (Okafor *et al,* 2012). In recent days, street-food vendings have been on the increase in urban areas especially in cities of developing countries of the world as it is the case in Uyo metropolis, Nigeria. These foods are prone to chemical pollutants such as trace metals from numerous sources (Bamuwamye *et al,* 2015), ranging from methods, materials for processing, handling, environmental factors and human activities including traffic and traffic related materials.

Trace metal contamination poses a serious threat to human health due to its bioaccumulation, biomagnification and toxicity. It has caused widespread concern about human health, and therefore, scientists are focusing their studies on the levels of these metals in food consumed by humans, so as to evaluate the risk associated with exposure to trace metals (Hussain *et al*, 2012; Khan *et al,* 2015). Anthropogenic activities and urbanisation have adversely influenced the release of trace metals into the urban environment, and the potential health risks associated with them is high. Pollutants enter the urban atmosphere in the form of gases, particles, or as aerosols, by evaporation of liquids, by evaporation of dissolved solvents from water and by wind erosion of soil. These pose detrimental effects to humans and other animals in different ways, ranging from cancer, infertility, sexual underdevelopment, altered or reduced sexual behaviour and birth defects amongst others (Perlroth and Branco, 2017). Although the road side roasted chickens vending is one of the contributors to the economy of cities, the question of safety of these products has not been fully addressed in many African countries (Oguttu, 2015).

The general handling of street roasted meats in particular, possess a safety threat because the meats are prepared and sold in open and dusty environments with high levels of trace metals contamination (Bamuwamye *et al,* 2015). However, studies evaluating street roasted chickens of urban settings in developing countries are limited especially in Nigeria.

Due to the influx of population into Uyo, (Capital of Akwa Ibom state) and the emergence of new entrepreneurs in the state, Uyo has witnessed an alarming increase in street roasted foods vending and the safety stand of this particular set of foods is in doubt and there appears to be no information on trace metal contamination of street roasted chickens in Uyo Metropolis before or as at the time of this research. This study is therefore set to quantify the levels of trace metals and human health risk associated with the consumption of street roasted chickens sold in Uyo Metropolis.

MATERIALS AND METHODS

Study Area/Sampling points

Figure 1 shows the map of Uyo showing study areas/sampling points (SP) along five major roads linking the centre of Uyo Metropolis. The sampling points considered in this study were: Aka Road by Udo Udoma Roundabout/Aka Etinan Road Junction (SP1), IBB/Atiku Abubakar Way by Abak Road Roundabout (SP2), Ikot Ekpene Road by Oku Street Junction and the University of Uyo Roundabout (SP3), Calabar/Itu Road by Itam Junction Roundabout (SP4) and Oron Road by Nwaniba Junction Roundabout (SP5).

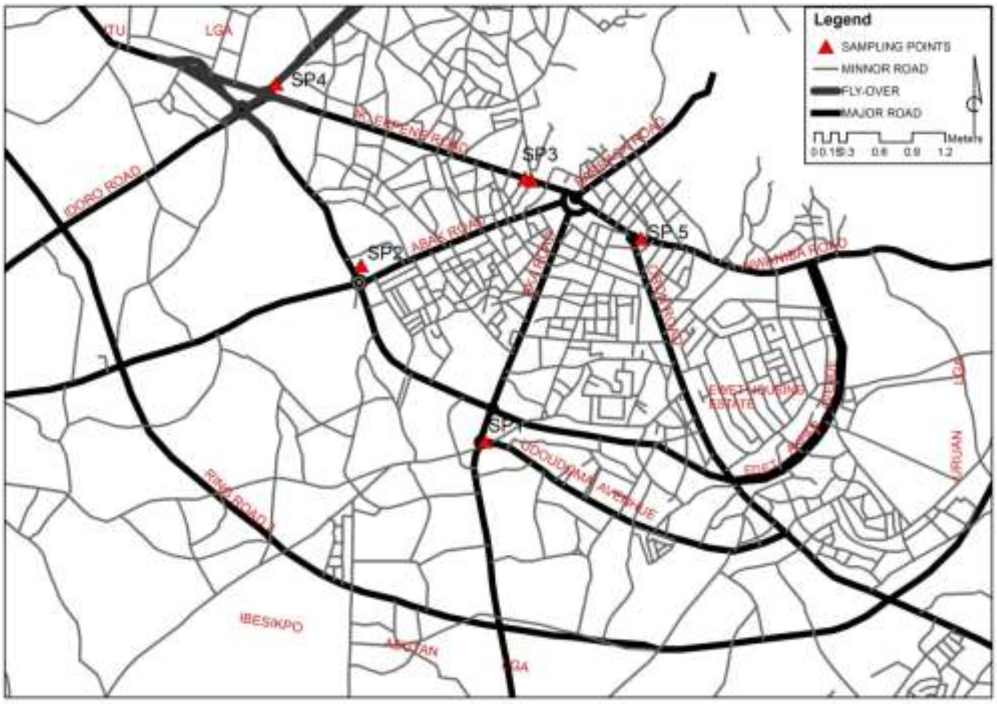

Figure 1: Map of Uyo Showing the Study Area/Sampling points

Samples and Sampling

A total of 15 chicken samples of three different sets: public/street-roasted chicken (PRC) and un-roasted chicken (URC) meat samples sold in Uyo Metropolis as well as self-roasted chicken (SRC) samples which serve as the controls, were randomly collected between the months of April and May, 2016, from different roadside roasted chickens vendors from the five sampling points (identified above as SP1, SP2, SP3, SP4 and SP5 along the five major roads linking the centre of

Uyo Metropolis). The collected samples were properly labeled, kept in polythene bags and taken to the laboratory for subsequent preparations, treatments and analyses.

Preparations and Treatments of Samples

Sample preparations and treatments were done using standard procedures. Each of the three sets of samples were differently chopped into small pieces and dried in an oven at about 60°C until constant weights were obtained. The dried samples were then ground into fine powder, stored in labeled polyethylene bags and kept in a refrigerator until used for acid digestion.

Digestion of Samples

The dried ground samples (1.0 g each) were taken into differently properly labeled crucibles and ashed in a SXL muffle furnace at a temperature range of 750^{o}C - 850^{o}C for 4 hours. After the ashing, the crucibles with the ashes were allowed to cool overnight to room temperature. The crucibles were then removed from the furnace and the ashes leached with 5 cm^3 of 6M HCl and transferred into 50 cm^3 volumetric flasks. Distilled water was used to rinse crucibles into the volumetric flasks, and the volumes made up to 50 cm^3 marks with distilled water (Ogner *et al,* 1991). The solutions for the blank determinations were treated in a similar manner but without the samples (Whiteside, 1979). The samples and the blank solutions were then stored in labeled plastic reagent bottles for trace metals analyses using Atomic Absorption Spectrophotometer (AAS). The reagent bottles used were previously soaked in a 10% nitric acid for 48 hours and later rinsed with distilled water with 3ml of concentrated HNO_3 and 3 cm^3 of 50% H_2O_2.

Determination of Trace Metal Levels in the Samples

Levels of trace metals in the sample solutions of the PRC, URC and SRC samples were determined as stipulated by the AOAC (2010) using the AAS (UNICAM 939/959 model). The trace metals analysed for their levels in the sample solutions were Zn, Pb, Cd, Fe and Mn. The solutions of the samples were aspirated into the instrument and the absorbance obtained was used to determine the concentrations of the metals in the different samples from calibration curves. The instrument was operated in accordance with the instrument's handbook while calibration was done using a mixed calibration standard solution prepared from the pure British Drug House (BDH) Analar grade salt of each metal. As a control, a blank determination was also made using the same procedures.

Estimated Daily Intake (EDI) of Trace Metals

The health risks posed to consumers were determined by the specific dietary intake of each contaminant and compared with the toxicologically acceptable levels.
The estimated daily intake (EDI) of trace metals (Zn, Pb, Cd, Fe and Mn) depended on both the metal concentration in the PRC and the amount of consumption of the respective food. The EDI of

trace metals from consumption of PRC and vended chicken meats was estimated using the following equation adopted by Copat *et al* (2013):

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

Where: C is level of trace metal in chicken meat samples (mg/kg), IR represents ingestion rate of roasted chicken meats in the area (g/person/day), BW is the average body weight (kg).

The average daily chicken meats intakes were taken as 150 and 100 g/person/day for adults and children respectively, while the average body weights were taken as 60 and 30 kg for adults and children respectively (Ihedioha and Okoye, 2013; Iwegbue *et al*, 2008).

Hence, exposure to trace metal was worked out in terms of estimated daily intakes (EDI) based on IR of 150g and 100g respectively for adults and children. The metal intakes were compared with the tolerable daily intakes for metals recommended by the FAO/WHO (2010), WHO (2000) and FSA (2006).

The health risks for adult and children were considered separately since the contact pathwa y with each exposure changed with age.

Target Hazard Quotient (THQ)

The health risks from consumption of public roasted chicken by the local inhabitants were assessed based on the THQ. The THQ is a ratio of determined dose of a pollutant to a reference dose level. If the ratio is less than 1, the exposed population is unlikely to experience obvious adverse effects. The method for estimating risks using THQ was provided in the U.S. EPA Region III risk-based concentration table (USEPA IRIS, 2007) and as expressed in the equation from by Udosen, *et al,* 2014.

$$THQ = EDI / Rfd \quad \ldots (2)$$

Where: THQ is the target hazard quotient, EDI is the estimated daily intake of roasted chickens (kg person-1day -1) and Rfd represents oral reference dose (mg /kg/day). Oral reference doses were based on 3E-01, 4E-03, 1E-03, 7E-01 and 1.4E-01 mg/kg/d for Zn, Pb, Cd, Fe and Mn respectively (USEPA, 1997; USEPA IRIS, 2007).

Data and Statistical Analyses:

Three replicates of the digested samples were analysed under the same conditions and statistical analysis was performed to calculate means ± standard errors (SE) using Excel 2007 spreadsheet, while IBM SPSS 20.0 Statistical software (SPSS Inc., Illinois, USA) was used to perform ANOVA, followed by Tukey's test. ANOVA and Tukey analyses were used to compare levels of trace metals in the different chicken samples from the five sampling sites of the study and differences were considered statistically significant at $p < 0.05$. The geochemical results were interpreted using Estimation of Daily intake (EDI) and pollution indices such as Target hazard quotient (THQ) and Hazard index (HI).

RESULTS AND DISCUSSIONS

Levels of Some Trace Metals in the Chicken Samples

The levels of Zn, Pb, Cd, Fe and Mn in the roasted chicken samples investigated in this study are presented in Table 1. From the Table, the results (mg/kg) indicated that Zn ranged from 1.81±0.01 in PRC to 4.34±0.02 also in PRC samples from the different sampling points. Zn was however below detection limit in the SRC sample from one of the sampling points. Zn is emitted into the environment as a result of wear from tires of automobiles, combustion from motor vehicle exhausts as a result of zinc-containing compounds in lubricating oils (Adebiyi *et al.,* 2008). The increased levels of Zn in the PRC

Table 1: Levels (mg/kg) of Trace Metals in Roasted Chicken Samples Sold in Uyo Metropolis, Nigeria.

Samples	Metals	Sampling Sites				
		SP1	SP2	SP3	SP4	SP5
URC	Zn	2.11±0.01	1.20±0.01	2.71±0.01	2.24±0.01	3.10±0.01
PRC		3.92±0.01	3.11±0.01	3.40±0.01	1.81±0.01	4.34±0.02
SRC		3.32±0.01	BDL	2.40±0.01	3.76±0.01	3.81±0.01
URC	Pb	0.03±0.01	0.04±0.01	0.02±0.01	0.01±0.00	0.01±0.01
PRC		0.20±0.01	BDL	0.19±0.01	0.21±0.01	0.10±0.01
SRC		0.06±0.01	BDL	0.05±0.01	0.08±0.01	BDL
URC	Cd	BDL	BDL	0.01±0.01	BDL	0.02±0.01
PRC		BDL	BDL	BDL	BDL	BDL
SRC		BDL	BDL	BDL	BDL	0.03±0.01
URC	Fe	1.52±0.01	1.50±0.01	1.85±0.01	1.42±0.01	1.91±0.01
PRC		0.12±0.01	0.40±0.01	0.40±0.01	0.42±0.01	0.53±0.01
SRC		1.63±0.01	0.89±0.01	1.61±0.01	1.02±0.01	1.55±0.01
URC	Mn	1.79±0.01	1.85±0.01	2.01±0.01	0.92±0.01	2.19±0.01
PRC		0.54±0.01	0.61±0.01	0.62±0.01	0.94±0.01	1.08±0.01
SRC		1.59±0.01	1.22±0.00	1.61±0.01	1.20±0.01	1.70±0.01

URC = un-roasted chickens; PRC= public-roasted chickens; SRC= self-roasted chickens (Controls),

BDL = below detection limit. SP1, SP2, SP3, SP4 and SP5 are the sampling sites as defined under the study area/sampling points section. The above values are mean ± standard deviation of triplicate analyses.

samples in this study could be attributed to traffic emissions and road dusts (Shinggu *et al.,* 2010). Generally, Zn levels reported in this study were lower than those reported by Bamuwamye (2015) in a similar study in Kampala and those reported by Nesta *et al* (2015) in Ghana. Zn levels reported by Okafor (2012) and Makanjuola (2016) in Nigeria are comparable with those reported in this study.

Pb (mg/kg) ranged from 0.01±0.00 in the URC to 0.20±0.01 in the PRC samples and was below detection limit in both PRC and SRC samples from one of the sampling points. Pb is a highly toxic metal whose widespread use has caused extensive environmental contamination and health problems in many parts of the world. Pb levels in all the PRC samples increased markedly when compared with those obtained in the other samples. Levels of Pb in samples other than the PRC samples varied from 0.01±0.00 to 0.04±0.01 mg/kg in the trend SP4 and SP5 < SP3 < SP1 < SP2 for URC samples and 0.05±0.01 to 0.08±0.01 mg/kg in the SP3 < SP1 < SP4 in the SRC samples. The highest Pb level of 0.21±0.01 mg/kg in this study was obtained in the PRC samples collected from the SP4 sampling point. The sources of Pb are gasoline and paint, which have now been extended to lead bullets, plumbing pipes, pewter pitchers, storage batteries, toys and faucets (Thürmer *et al.*, 2002). Other reported sources of Pb in the environment include automotive gasoline piston engines, oil burners, lead pipes, incinerators, industrial effluents and smokestack fallout (Sharma and Street, 1980). Pb levels reported by Bamuwamye (2015) were lower than the ones recorded in this study and those reported by Nesta *et al* (2015), Okafor (2012) and Makanjuola (2016) were comparable with those reported in this study.

Little levels of Cd (0.01±0.01 and 0.02±0.01mg/kg) were detected only in URC samples collected from SP3 and SP5 sampling points, respectively, as well as 0.03±0.01mg/kg in SRC sample collected from SP5 sampling point. These results were in agreement with those reported by Frederick (2015), Makanjuola (2016), Nesta *et al* (2015) and Bamuwamye (2015).

Fe (mg/kg) ranged from 0.12±0.01 in PRC to 1.91±0.01 in URC samples. The Fe levels in terms of sampling points were in the trend SP5 > SP3 > SP1 > SP2 > SP4 for URC samples, SP5 > SP4 > SP3 and SP2 < SP1 for PRC samples and SP1 > SP3 > SP5 > SP4 > SP2 for SRC samples. Accordingly, the Mn levels (mg/kg) ranged from 0.54±0.01 in PRC to 2.19±0.01 in URC samples. The Mn levels in terms of sampling points were in the trend SP5 > SP3 > SP2 > SP1 > SP4 for URC samples, SP5 > SP4 > SP3 and SP2 < SP1 for PRC samples and SP5 > SP3 > SP1 > SP2 > SP4 for SRC samples. Fe levels reported in this study were generally lower than those reported by Bamuwamye (2015), Nesta *et al* (2015) and Makanjuola (2016) while Mn levels were comparable with those of Makanjuola (2016). As noted by Joyce *et al* (2016), the results generally indicated that levels of Fe and Mn were affected by action of heat used in roasting the chicken meats.

Except for Pb whose level exceeded the FAO/WHO maximum permissible limit of 0.1 mg/kg in foods, in some of the PRC samples, the levels of all the other trace metals in all the samples investigated, were low when compared with the FAO/WHO maximum permissible limits for such metals in foods.

Human Health Risks Assessment

The evaluation of human's exposure to trace metals in roasted chickens sold in Uyo Metropolis was obtained for adults and children. The estimated daily intake of trace metals in the URC, PRC and SRC samples are summarised in Tables 2 and 3. Considering the worst scenario, which in this case was the estimated daily intakes (EDIs) of the metals (Zn, Pb, Cd, Fe and Mn) by children through consumption of roasted chickens sold in Uyo Metropolis (Table 3), the computed values showed that Zn was below the detectable limit in SRC samples collected from SP2 sampling point, but highest (1.42E-02 mg/kgbw/day) in PRC samples collected from SP5 sampling point. It indicated that children consuming the PRC are likely to be exposed to high levels of zinc metal intakes. However, the EDI values of zinc computed in this study were below the provisional maximum tolerable dialy intakes (PMTDI) of 3E-01 to 1 mg/kgbw/day for Zn. Daily intake of Pb computed for children ranged from 3.3E-05 to 6.7E-04 mg/kgbw/day. Comparison with PMTDI showed that the computed values are lower than the PMTDI value (4E-03 mg/kgbw/day) for Pb. Similarly, EDIs values were obtained for Cd, Fe and Mn with highest values (1E-04, 5E-02 and 6E-02) mg/kgbw/day, which are lower than their corresponding PMTDI values of (1E-03, 8E-01 and 5) mg/kgbw/day respectively. The results revealed that the estimated daily intake values (EDIs) calculated for Zn, Pb, Cd, Fe and Mn via the consumption of the investigated samples collected from the five sampling sites of this study were low compared to FAO/WHO (2011) and FAO (2009) PMTDI. Pb showed major contributions through the consumption of PRC for both adults and children, while Cd contributed less or were below detectable level in almost all samples obtained from all sampling points. Children are especially vulnerable to acute, sub-acute and chronic effects of ingestion of chemical pollutants, since they (children) consume more (twice of the amount) food per unit of body weight as adults (ENHIS, 2007). Comparing Tables 2 and 3, this study revealed that the EDIs in children due to consumption of roasted chickens obtained from the different sampling points were higher than those of the adults. As a result, intakes of these toxic metals through food could be higher for children consuming the roasted chickens for seven days per week in Uyo Metropolis.

Table 2: Estimated Daily Intake of Trace Metals via Roasted Chickens Consumed in Uyo Metropolis by Adults

Sites	Samples	Zn	Pb	Cd	Fe	Mn	CDI
SP1	**URC**	5.3E-03	7.5E-05	BDL	3.8E-03	4.5E-03	1.4E-02
	PRC	9.8E-03	5E-04	BDL	3E-04	1.4E-03	1.2E-02
	SRC	8.1E-03	1.5E-04	BDL	4.1E-03	4E-03	1.6E-02
SP2	**URC**	3E-03	1E-04	BDL	3.8E-03	4.6E-03	1.2E-02
	PRC	7.8E-03	BDL	BDL	1E-03	1.5E-04	9.0E-03
	SRC	BDL	BDL	BDL	2.2E-03	3.1E-03	5.3E-03
SP3	**URC**	6.8E-03	5E-05	2.5E-05	4.6E-03	5E-03	1.6E-02
	PRC	8.5E-03	4.8E-04	BDL	1E-03	1.6E-03	1.2E-02
	SRC	6E-03	1.3E-04	BDL	4E-03	4E-03	1.4E-02
SP4	**URC**	5.6E-03	2.5E-05	BDL	3.6E-03	2.3E-03	1.2E-02
	PRC	4.5E-03	5.3E-04	BDL	1.1E-03	2.4E-03	8.5E-03
	SRC	9.4E-03	2E-04	BDL	2.6E-03	3E-03	1.5E-02
SP5	**URC**	7.8E-03	2.5E-05	5E-05	4.8E-03	5.5E-03	1.8 E-02
	PRC	1.1E-02	2.5E-04	BDL	1.3E-03	2.7E-03	1.5 E-02
	SRC	9.5E-03	BDL	7.5E-05	3.9E-03	4.3E-03	1.8 E-02

CDI =Cumulative daily intake; URC = un-roasted chickens; PRC= public-roasted chickens; SRC= self-roasted chickens (Controls); BDL = below detection limit. SP1, SP2, SP3, SP4 and SP5 are the sampling sites as defined under the study area/sampling points section.

Target Hazard Quotient (THQ) and Hazard Index (HI) via Consumption of Roasted Chickens Sold in Uyo Metropolis

The target hazard quotient (THQ) and hazard index (HI) in adults via the consumption of roasted chickens sold in Uyo Metropolis are presented in Table 4 while those in children are presented in Table 5. All the THQ values calculated for URC, PRC and SRC samples in both adults and children were less than unity in the five sampling points for Zn, Pb, Cd, Fe and Mn. These suggest that the risk associated with the consumption of roasted chickens could not be adverse on humans. However, caution must be taken since perennial intake of these contaminated food animals is likely to induce adverse health effects arising largely from exposure to Pb. The highest THQ values for Pb or other trace metals in this study were in PRC samples obtained from SP4, SP1 and SP3 sampling points. It is assumed that the toxic risk due to potentially hazardous chemicals in the same medium is cumulative; therefore, the summation of the THQs was done to obtain the overall toxic risk, which is the hazard index (HI). The HI values were computed from the THQ values. The HI values for children were significantly higher compared to those of adults. Generally, all the computed HI values for roasted chickens from the five sampling poits in URC, PRC and SRC samples were less than unity for both children and adults. Like the THQ, a HI < 1 represents a potential for no adverse health effect on the population via consumption of the roasted chickens. These findings were in agreement with those reported in Iraq by Salwa (2014) and in Nigeria by Okafor *et al* (2012) who concluded that the exposure to excessive metals (Cd, Pb, Mn, Zn and Ni) via chicken meats, livers, and gizzards consumption do not pose any imminent health risk.

Table 3: Estimated Daily Intake of Trace Metals via Roasted Chickens Consumed in Uyo Metropolis by Children

Sites	Samples	Zn	Pb	Cd	Fe	Mn	CDI
SP1	**URC**	7E-03	1E-04	BDL	5E-02	6E-02	1.2E-01
	PRC	1.3E-02	6.7E-04	BDL	4E-04	1.8E-03	1.6E-02
	SRC	1.1E-02	2E-04	BDL	5.4E-03	5.3E-03	2.2E-02
SP2	**URC**	4E-03	1.3E-04	BDL	5E-03	6.2E-03	1.5E-02
	PRC	1.0E-02	BDL	BDL	1.3E-03	2E-03	1.3E-02
	SRC	BDL	BDL	BDL	3E-03	4.1E-03	7.1E-02
SP3	**URC**	9E-03	6.7E-05	3.3E-05	6.2E-03	6.7E-03	2.2E-02
	PRC	1.1E-02	6.3E-04	BDL	1.3E-03	2.1E-03	1.5E-02
	SRC	8E-03	1.7E-04	BDL	5.4E-03	5.4E-03	8.2E-03
SP4	**URC**	7.5E-03	3.3E-05	BDL	4.7E-03	3.1E-03	1.5E-02
	PRC	6E-03	7E-04	BDL	1.4E-03	3.1E-03	1.1E-02
	SRC	1.3E-02	2.7E-04	BDL	3.4E-03	4E-03	2.1E-02
SP5	**URC**	1E-02	3.3E-05	6.7E-05	6.4E-03	7.3E-03	2.4E-02
	PRC	1.4E-02	3.3E-04	BDL	1.8E-03	3.6E-03	2E-02
	SRC	1.3E-02	BDL	1E-04	5.2E-03	5.7E-03	5.9E-01
PMTDI (mg/kg bw/day)		0.3-1	0.004	0.001	0.8	5	

URC = un-roasted chickens; PRC= public-roasted chickens; SRC= self-roasted chickens (Controls),

BDL = below detection limit. SP1, SP2, SP3, SP4 and SP5 are the sampling sites as defined under the study area/sampling points section, CDI = Cumulative daily intake; PMTDI = Provisional maximum tolerable dialy intakes.

Table 4: Target Hazard Quotient (THQ) and Hazard Index (HI) in Adults via Consumption of Roasted Chickens Sold in Uyo Metropolis

Sites	Samples	Zn	Pb	Cd	Fe	Mn	HI
SP1	**URC**	2E-02	2E-02	BDL	1E-02	3E-02	8E-02
	PRC	3E-02	1.3E-01	BDL	4E-04	1E-02	1.7E-01
	SRC	3E-02	4E-02	BDL	6E-03	3E-02	1.1E-01
SP2	**URC**	1E-02	3E-02	BDL	1E-02	3E-02	8E-02
	PRC	3E-02	BDL	BDL	1.4E-02	1E-03	8E-02
	SRC	BDL	BDL	BDL	3E-03	2E-02	2E-02
SP3	**URC**	2E-02	1E-02	3E-02	1E-02	4E-02	1.1E-01
	PRC	3E-02	1.2E-01	BDL	1.4E-03	1E-02	1.6E-01
	SRC	2E-02	3E-02	BDL	6E-03	3E-02	9E-02
SP4	**URC**	2E-02	1E-02	BDL	1E-02	2E-02	6E-02
	PRC	2E-02	1.3E-01	BDL	1.6E-03	2E-02	1.7E-01
	SRC	3E-02	5E-02	BDL	4E-03	2E-02	1E-01
SP5	**URC**	3E-02	1E-02	5E-02	1E-02	4E-02	1.4E-01
	PRC	4E-02	6E-02	BDL	1.9E-02	2E-02	1.2E-01
	SRC	3E-02	BDL	8E-02	6E-03	3E-02	1.5E-01
PMTDI: (mg/kg bw/day)		0.3-1	0.004	0.001	0.8	5	

URC = un-roasted chickens; PRC= public-roasted chickens; SRC= self-roasted chickens (Controls), BDL = below detection limit. SP1, SP2, SP3, SP4 and SP5 are the sampling sites as defined under the study area/sampling points section; HI = hazard index; PMTDI = Provisional maximum tolerable dialy intakes.

Conclusions

Based on the analyses and results, this study has been able to establish the levels of Zn, Pb, Fe, and Mn in all the chicken samples investigated. Cd was below detection limit, except in URC samples obtained from SP3 and SP5 sampling points and in SRC sample obtained from SP5 sampling point. The levels of Pb in the PRC samples obtained from three sampling points (SP1, SP3 and SP4) were higher than the FAO/WHO maximum permissible limit of 0.1 mg/kg in foods. The levels of all the other trace metals in all the samples were low compared with the FAO/WHO maximum permissible limits for such metals in foods. Accordingly, the levels of some of the trace metals in the samples were comparable with those reported in literature. The contamination of the street roasted chickens with trace metals could have been associated with vehicular emissions, street dusts and other aerial particulates as well as the methods of processing and handling of the street roasted chickens.

Table 5: Target Hazard Quotient (THQ) and Hazard Index (HI) in Children via Consumption of Roasted Chickens Sold in Uyo Metropolis

Sites	Samples	Zn	Pb	Cd	Fe	Mn	HI
SP1	**URC**	2E-02	3E-02	BDL	7E-02	4E-02	1.6E-01
	PRC	4E-02	1.7E-01	BDL	6E-04	1E-02	2.2E-01
	SRC	4E-02	5E-02	BDL	8E-03	4E-02	1.4E-01
SP2	**URC**	1E-02	3E-02	BDL	1E-02	4E-02	9E-02
	PRC	3E-02	BDL	BDL	1.9E-03	1E-02	4E-02
	SRC	BDL	BDL	BDL	4E-03	3E-02	3E-02
SP3	**URC**	3E-02	2E-02	0.03	1E-02	5E-02	1.4E-01
	PRC	4E-02	1.6E-01	BDL	1.9E-03	2E-02	2.2E-01
	SRC	3E-02	4E-02	BDL	8E-03	4E-02	1.2E-01
SP4	**URC**	3E-02	1E-02	BDL	1E-02	2E-02	7E-02
	PRC	2E-02	1.8E-01	BDL	2E-03	2E-02	2.2E-01
	SRC	4E-02	7E-02	BDL	5E-03	3E-02	1.5E-01
SP5	**URC**	3E-02	1E-02	7E-02	1E-02	5E-02	1.7E-01
	PRC	5E-02	8E-02	BDL	2.6E-03	3E-02	1.6E-01
	SRC	4E-02	BDL	1E-02	7E-03	4E-02	1.9E-01

URC = un-roasted chickens; PRC = public-roasted chickens; SRC = self-roasted chickens (Controls), BDL = below detection limit. SP1, SP2, SP3, SP4 and SP5 are the sampling sites as defined under the study area/sampling points section; HI = hazard index.

Human health risk assessment through consumption of roasted chickens in Uyo Metropolis using the risk assessment models [target hazard quotients (THQs) and hazard indices (HIs)] indicated that the THQ values were higher in children than in adults. The combined non-carcinogenic effect of all the metals as hazard index (HI) was less than unity (HI<1) indicating a negligible risk on consumption of street roasted chickens from the study area.

The high levels of Pb and Zn in the PRC samples suggest the need for regular and consistent monitoring of street foods of urban environment against chemical contaminations. The study gives a representative data on the levels of Zn, Pb, Cd, Fe and Mn in street roasted/vended chickens consumed in Uyo Metropolis. The data will serve as base line references for future studies of such metals in street roasted chickens and related food samples in the area and its environ.

References

Adebiyi, F. M., Sonibare, J. A., Adedosu, T. A., Daramola, A. A., Omode, P. E., and Obanijesu, E.O., 2008, Assessment of the Effects of Air Pollution Using Road-Side Roasted Meats (Suya) as Indicators. Environmental Bioindicators, 3(3), pp 172-179.

AOAC (Association of Analytical Chemists), 2010, Official Method of Analysis (18th Edition) Washington, D. C., pp 200 – 381.

Bamuwamye, M., Ogwok, P., and Vivian, T., 2015, Cancer and Non-cancer Risks Associated With Heavy Metal Exposures from Street Foods: Evaluation of Roasted Meats in an Urban Setting. Journal of Environment Pollution and Human Health, 3(2), pp 24 – 30.

Copat, C., Conti, G. O., Signorelli, C., Marmiroli, S., Sciacca, S., Vinceti, M., and Ferrante, M., 2013, Risk Assessment for Metals and PAHs by Mediterranean Seafood. Food and Nutrition Sciences, 4, pp 10 – 13.

ENHIS (European Environment and Health Information System), 2007, Exposure of Children to Chemical Hazards in Food. World Health Organization; Geneva, Switzerland, Fact Sheet No. 4.4, CODE: RPG4_Food_EX1.

FAO (Food and Agriculture Organisation), 2009, Poultry Meat and Eggs, viale delle terme di Caracalla, 00153 Rome, Italy.

FAO/WHO (Food and Agriculture Organisation/World Health Organization), 2011, Evaluations of certain contaminants in food. Seventy-Second Report of the Joint FAO/WHO Expert Committee on Food Additives. Series 959.

FAO/WHO (Food and Agriculture Organisation/World Health Organization), 2010, Summary Report of the Seventy-third Meeting of JECFA. Joint FAO/WHO Expert Committee on Food Additives, Geneva.

FSA (Food Standard Agency), 2006, Metals and other elements in Processed Fish and Fish Products: Food Survey Information Sheet 08/06, ⟨http://www.food.gov.uk/science/surveillance⟩.

Hussain, R. T., Ebraheem, M. K., and Moker, H. M., 2012, Assessment of Heavy Metals (Cd, Pb and Zn) Contents in Livers of Chicken available in the local markets of Basrah City, Iraq. Basrah

Journal of Veterinary Research, 11(1), pp 43–51.

Ihedioha, J. N., and Okoye, C. O. B., 2013, Dietary Intake and Health Risk Assessment of Lead and Cadmium via Consumption of Cow Meat for an Urban Population in Enugu State, Nigeria. Ecotoxicology and Environmental Safety, 93, pp 101–106.

Joyce, K., Emikpe, B. O., Asare, D. A, Asenso, T. N., and Richmond, Y., 2016, Effects of Different Cooking Methods on Heavy Metals Level in Fresh and Smoked Game Meat. Journal Food Process Technology 7, 617 – 627.

Khan, M. Z., Perween, S., Gabol, K., Khan,I. S., Baig, N., Kanwal, R., and Tanveer, J., 2015, Concentrations of Heavy Metals in Liver, Meat and Blood of Poultry Chicken Gallus Domesticus in Three Selected Cities of Pakistan. Canadian Journal of Pure and Applied Sciences, 9(1), pp 3313 – 3324.

Makanjuola, O. M., 2016, Assessment of Heavy Metal in Raw Meat Sold in Some Notable Garages in Ogun State, South West, Nigeria. International Journal of Research Studies in Biosciences (IJRSB), 4(9), pp 10 – 13.

Nesta, B. S., Shouta, M. M. N., Yoshinori, I., Osei, A., Elvis, B., Yared, B. Y., Hazuki M., and Mayumi, I., 2015, Human Health Risks from Metals and Metalloid via Consumption of Food Animals Near Gold Mines in Tarkwa, Ghana: Estimation of the Daily Intakes and Target Hazard Quotients (THQs). Ecotoxicology and Environmental Safety, 111, pp 160–167.

Okafor, N. C., Osuji, L. C., and Onwuachu, U. I., 2012, Estimation of Dietary intake of Cadmium, Lead, Manganese, Zinc and Nickel due to consumption of chicken meat by inhabitants of Port-Harcourt Metropolis, Nigeria. Scholars Research Library Archives of Applied Science Research, 4 (1), pp 675 – 684.

Ogner, G., Opem, M., Remedios, G., and Sjorlie, B., 1991, The Chemical analysis programme of the Norwegian Forest Research Institute, As, Norway, pp 224–330.

Oguttu, J. W., 2015, Participatory Risk Analysis of Street Vended Chicken Meats sold in the Informal Market of Pretoria, South Africa. Food Control, 45, pp 87 – 94.

Perlroth, N. H., and Branco, C. W., 2017, Current Knowledge of Environmental Exposure in Children during the Sensitive Developmental Periods. Journal of Pediatrics (Rio Journal), 93, pp 17 – 27.

Salwa, A. A., 2014, Bioaccumulatin of Trace Elements in Tissues of Chicken and Quail and Estimate Health Risks from the Consumption of Birds Viscera, Basrah Journal of Veterinary Research, 2(1), pp 1-17.

Sharma, R. P., and Street, J. C., 1980, Public Health Aspects of Toxic Heavy Metals in Animal Feeds. Journal of American Veterinary Medicine Association*,* 177, pp 149–153.

Shinggu, D. Y., Ogugbuaja, V. O., Toma, I., and Barminas, J. T., 2010, Determination of Heavy Metals in Street Dust in Yola, Nigeria. African journal of Pure and Applied Chemistry, 4 (1), pp 17-21.

Thürmer, K., Williams, E., and Reutt-Robey, J., 2002, Autocatalytic Oxidation of Lead Crystallite Surfaces. Science, 297(5589), pp 2033–2035.

Udosen, E. D., Offiong, N. O., and Alade, I. G., 2014, Human Health Risk Assessment of Trace Metals due to Dietary Intake of Some Edible Fish Species Collected from Enyong Creek, Itu, Nigeria. A paper presented at the 37th International Conference of Chemical Society of Nigeria held at Uyo Nigeria, 7-13 September, pp 224 – 231.

USEPA (United State Environmental Protection Agency), 2007, Integrated Risk Information System-Database (IRIS). Philadelphia PA.

USEPA (United State Environmental Protection Agency), 1997, Exposure factors handbook. National Center for Environmental Assessment, Washington, DC.

Whiteside, P. J., 1979, Introduction to Atomic Absorption Spectrophotometer (AAS) 1st Edition, Pye – Unican Ltd, pp 17 – 75.

WHO (World Health Organization), 2000, Evaluation of certain food additives and contaminants. Report of the Fifty-Third of the Joint FAO/WHO Expert Committee on Food Additives.Technical Report Series No. 896. Geneva.