FUAM Journal of Pure and Applied Science

Available online at
www.fuamjpas.org.ng

An official Publication of
College of Science
Joseph Sarwuan Tarka University,
Makurdi.

FUAM Journal of Pure and Applied Science

https://fuamjpas.org.ng/
Vol.4 No. 1 June, 2024

Health Risk Assessment of Heavy Metals in Selected Offals and Skin of Cattle and Pigs Slaughtered in some Abattoirs in Makurdi Metropolis, Nigeria

S. M*. Tongu, S. Ande and J.G. Odoh

Department of Chemistry, Joseph Sarwuan Tarka University, Makurdi, Nigeria

*Correspondence Email: tongusyl@gmail.com

Received: 24/11/2023 **Accepted**: 15/01/2024 **Published online**: 17/01/2024

Abstract
The health risks of some heavy metals in selected offals and skins of cattle and pigs slaughtered at Modern Market and Wurukum Abattoirs in Makurdi Metropolis was investigated. A total of twenty four (24) samples were purchased from the abattoirs. The samples were digested and analyzed for Cd, Cr, Cu, Pb and Zn using Atomic Absorption Spectrometer (AAS). The results showed that Cd, Cr and Pb were not detected in any of the samples while copper and zinc were detected in all the samples except in skin of cattle at Modern Market Abattoir where copper was not detected. The concentrations (mg/kg) of zinc ranged from 47.14±1.01 - 81.42±0.76, 37.69±0.89 - 81.05±1.40, 79.34±0.57 - 135.13±2.20 and 10.15±0.13 - 37.96±0.69 for heart, kidney, liver and skin samples of both animals respectively. The levels of copper (mg/kg) in both animals ranged from 0.35±0.18 - 9.48±0.20, 0.68±0.06 - 2.24±0.23, 0.85±0.05 - 11.07±0.33 and ND - 0.73±0.16 for heart, kidney, liver and skin samples respectively. The values of copper and zinc in this research were below the 10 mg/kg and 100 mg/kg respective maximum limits set by Food and Agriculture Organization (FAO) for all foodstuffs except in livers of cattle and pig at Modern Market Abattoir where Cu was 11.07 mg/kg and Zn was 135.13 mg/kg. There was no risk posed to human health based on the hazard index values which were all less than one (1).
Keywords: Offals, Health risk, AAS, Heavy Metals, Abattoir

Introduction

Meat is of immense benefit to humanity because it is a source of their large amount of bioavailable micronutrients [1]. The consumption of meat is very essential in maintaining a healthy and balanced diet which is crucial in realizing optimum human growth and development [2]. As one of the best sources of protein, meat serves to improve the overall health and well-being of the body through the repair and building of body tissues, production of antibodies as well as a vital source of vitamins [1]. Despite reports of possible relationship between consumption of meat and elevated risks of cardiovascular diseases, some forms of cancers and metabolic disorders its role in human brain, intellectual development and human health cannot be overlooked [2-3]. Some meat products contain high amounts of healthy unsaturated omega-3 fatty acids that have a positive impact on cardiovascular health and help in lowering cholesterol, blood pressure and triglyceride levels [1].

Despite the underscored nutritional values of meat and meat products, its quality in some cases may be compromised by chemical contaminants. There are increasing concerns about heavy metals in animal derived foods [4]. Heavy metals are among the chemical contaminants that are prevalent in our environment and have been reported in various food samples and environmental matrices [4-11]. They are ubiquitous in the environment due to both natural and anthropogenic activities [12]. Metals such as Cu and Zn are classified as essential metals but can be harmful at concentrations above specified limits while metals such as Cd, Cr and Pb which can cause toxic effects even at low concentrations are classified as toxic metals [5,7]. In high concentrations, they are a very important group of environmental toxicants since they are potent metabolic poison to humans, animals, fish and plants [1].

Reports on heavy metal contamination of meat and other edible tissues including blood is a matter of great concern for food safety and can be a threat to human health [1, 13 - 16]. It is worth of note that toxic metals tend to bioaccumulate in different parts of the body but particularly in vital organs and tissues such as heart, liver, kidneys, blood, stomach and intestines. These same organs are preferred to the flesh by consumers due to the concentration of essential nutrients in them [1]. These parts commonly enjoy high patronage both at drinking joints and in restaurants within Makurdi city. However, there is little information on the level of toxic metals in these parts of pigs and cattle which are mostly consumed in the study area. It is against this background that the present study was carried out to assess the levels and the potential health risks of these toxicants in the heart, liver, kidneys and skin of cattle and pigs slaughtered at Modern Market and Wurukum abattoirs in Makurdi metropolis. Health risk assessment (HRA) is used to estimate the risk of potential adverse health effects to humans through their exposure to contaminants [17-18].

Materials and methods

Materials

All reagents and chemicals used were of analytical grade; glassware used during the laboratory analysis were thoroughly washed with HNO_3 solution and properly rinsed several times using deionized water.

Study area

The study area and the sampling sites are shown in Figure 1. Makurdi is a fast growing city in Benue State, North Central Nigeria. It doubles as the State Capital and as the headquarters of Makurdi Local Government Area. The town is divided into North and South Banks by River Benue, the second largest River in Nigeria. Modern and Wurukum markets are parts of Makurdi metropolis with daily high commercial activities and human presence. While the abattoir at Modern market is located inside the market, the one at Wurukum is situated outside the market, close to the bank of River Benue, along Makurdi - Lafia high way.

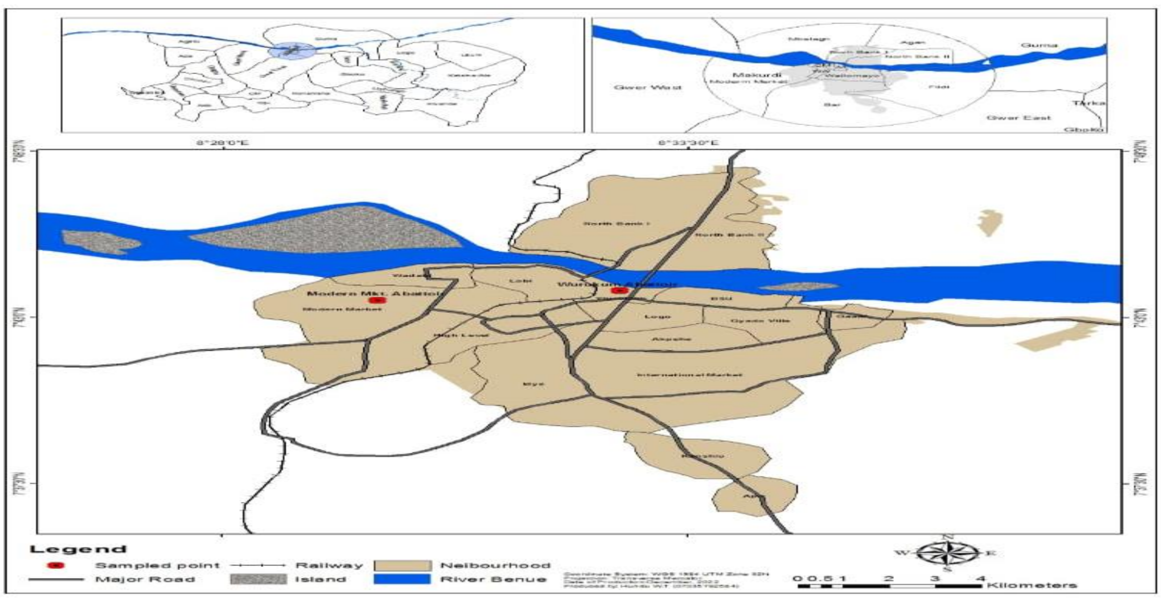

Figure 1: Map of Makurdi Metropolis showing the Sampled Area

Sample collection

Sample of offals and skins of cattle and pigs were purchased from Modern Market and Wurukum abattoirs in Makurdi metropolis. Particularly heart, liver, kidney and skin samples of each animal were considered and a total of twenty-four (24) samples (12 from cattle and 12 from pigs) were purchased immediately after slaughtering. The samples were collected in dark labeled polythene bags which were sealed with a rubber band and stored in ice chest at 4°C and immediately transported to the laboratory. The samples were kept frozen at 4°C until the time for extraction and analysis. In the laboratory, the samples were washed with distilled water to remove any contaminant.

Determination of moisture content

Each meat sample was cut into small pieces using clean stainless steel knife and placed in pre-weighed clean and dry porcelain dish. The dish together with the content was weighed again and then oven dried at 105 ^{0}C. They were re-weighed at different time intervals until a constant weight was obtained. The loss in weight was noted as the moisture content which was calculated in percentage (%) according to equation

$$\text{Moisture content (\%)} = \frac{\text{weight loss}}{\text{sample weight}} \times \frac{100}{1}$$

$$\text{Dry matter (\%)} = 100 - \text{\% moisture content}$$

Digestion of samples and heavy metal analysis

The wet digestion procedure was employed. After drying to constant weight, 1.0 g of each sample was placed in a digestion tube and predigested with 10 mL concentrated (1:1) HNO_3 and $HClO_4$ acids. The digestion tube with content was placed on a hot plate at 105 °C until oxidation of the liquor was completed. Thereafter, 5 mL H_2O_2 and 50 mL de-ionized water were added and boiled for 1.5 hours. The temperature was maintained at 105 °C and the product of the digestion was allowed to slowly evaporate to near dryness. At the end of the digestion, the digest was cooled and 20 mL of distilled water was added to bring the metals into solution. Samples were allowed to cool to room temperature and subsequently filtered through Whatman filter paper into 50 mL volumetric flask and made up to mark with distilled water. Determination of Cd, Cr, Cu, Pb and Zn were done using Atomic Absorption Spectrophotometer.

Statistical analysis

The data obtained were statistically analyzed using Microsoft Excel 2016 and Statistical Package for Social Science (SPSS) version 22.

Risk assessment

Human health risk assessment was done by calculating the average daily dose via inhalation, dermal contact and ingestion. The average daily dose obtained was divided specific reference dose to get the hazard quotient (HQ The summation of the hazard quotient via ingestion, dermal contact and inhalation gave the hazard index which was used to determine whether there is adverse health effect pose to human beings or animals.

The equations for average daily dose (ADD) (mg/kg/day) of toxic metals via ingestion, dermal contact and inhalation were adapted from USEPA [19].

$$ADD_{ingest} = \frac{C \times IngR \times EF \times ED \times CF}{BW \times AT} \quad (1)$$

$$ADD_{dermal} = \frac{C \times SA \times AF \times ABS \times EF \times ED \times CF}{BW \times AT} \quad (2)$$

$$\mathrm{ADD_{inhale}} = \frac{\mathrm{C \times InhR \times EF \times ED}}{PEF \times BW \times AT} \quad (3)$$

where C is the concentration of toxic metals (mg/kg); IngR, the ingestion rate (mg/day); SA, the surface area of the skin exposed to toxic metals (cm^2); AF, the skin adherence factor ($mg/cm^2/day$); ABS, the dermal absorption factor (mg/cm^2); InhR, the inhalation rate (m^3/day); PEF, the particle emission factor (m^3/kg); EF, the exposure frequency (days/year); ED, the exposure duration (year); BW, the body weight (kg); AT, the average time (days); and CF, the conversion factor. The parameters of average daily dose (ADD) and reference dose (RfD), which were obtained from the Exposure Factors Handbook [19] and Integrated Risk Information System [20] were used. The hazard quotient (HQ), which is used to determine the non-carcinogenic risk to children during a lifetime, was calculated by dividing the ADD from each exposure pathway by a specific reference dose (RfD), as shown in equation 4. RfD is the estimated maximum permissible risk posed to humans through daily exposure. Hazard index (HI), (Eqn 5), is the sum of the HQs for all the three exposure pathways (ingestion, dermal contact, and inhalation), which indicates the cumulative non-carcinogenic risk. HI value of more than one indicates that there is a significant non-carcinogenic risk posed to human health.

$$HQ = \frac{ADD}{RfD} \quad (4)$$

$$HI = HQ_{ingest} + HQ_{dermal} + HQ_{inhale} \quad (5)$$

Results and Discussion

Moisture and dry matter contents

The moisture and dry matter contents of the meat samples from Modern Market Abattoir are presented in Table 2. The results showed the offals from cattle having the highest moisture content (72.83 – 76.61 %) in the order of LCM < HCM < KCM) but with lower moisture content in skin of cattle (63.51 %) than in skin of pigs (65.94 %). The moisture content of offals from pigs ranged from 62.9 – 70.46 % and varied in the order of LPM < KPM < HPM.

Conversely, offals from pigs have highest dry matter in the range of 29.54 – 37.1 % as compared to offals in cattle and varied in the order of HPM < KPM < LPM. The dry matter in the offals from cattle ranged from 23.39 -27.17 % and varied in the order of KCM < HCM < LCM. The skin of cattle showed more dry matter content (36.49 %) than the skin of pig (34.06 %) at Modern Market Abattoir. The moisture content of a meat sample inversely affects the shelf life of the meat while the dry matter content increases its shelf life.

Table 1: Moisture and Dry Matter Content of Cattle and Pigs Samples in Modern Market Abattoir

Parameters	Moisture Content (%)	Dry Matter Content (%)
HCM	74.76	25.24
KCM	76.61	23.39
LCM	72.83	27.17
SCM	63.51	36.49
HPM	70.46	29.54
KPM	66.21	33.79
LPM	62.90	37.10
SPM	65.94	34.06

HCM: Heart of cattle in Modern Market Abattoir, **KCM:** Kidney of cattle in Modern Market Abattoir**, LCM:** Liver of cattle in Modern Market Abattoir, **SCM:** Skin of cattle in Modern Market Abattoir, **HPM:** Heart of pig in Modern Market Abattoir, **KPM:** Kidney of pig in Modern Market Abattoir, **LPM:** Liver of pig in Modern Market Abattoir and **SPM:** Skin of pig in Modern Market Abattoir. Results of the moisture and dry matter contents of the meat samples from Wurukum Abattoir are presented in Table 2. The results show the moisture content in the offals of cattle ranged from 66.65 - 79 % in the order of LCW < HCW < KCW) but with higher moisture content in skin of cattle (60.66 %) than in skin of pigs (55.92 %). The moisture content of offals from pigs ranged from 62.49 – 71.74 % and vary in the order of LPW < KPW < HPW. The results showed that the moisture content of offals from pigs in both abattoirs varied in the order of heart > kidney > liver (Tables 1 and 2). However, the order on moisture content in the offals of cattle from both abattoirs was in the order of kidney > heart > liver. The dry matter content of offals from pigs at Wurukum Abattoir ranged from 28.26 – 37.51 % and varied in the order of HPW < KPW < LPW. The dry matter in the offals from cattle ranged from 21 – 33.35 % and varied in the order of KCW < HCW < LCW.

Table 2: Moisture and Dry Matter Content of Cattle and Pig Samples in Wurukum Abattoir

Parameters	Moisture Content (%)	Dry Matter Content (%)
HCW	78.00	22.00
KCW	79.00	21.00
LCW	66.65	33.35
SCW	60.66	39.34
HPW	71.74	28.26
KPW	64.30	35.00
LPW	62.49	37.51
SPW	55.92	44.08

HCW: Heart of cattle in Wurukum Abattoir, **KCW:** Kidney of cattle in Wurukum Abattoir, **LCW:** Liver of cattle in Wurukum Abattoir, **SCW:** Skin of cattle in Wurukum Abattoir, **HPW:** Heart of pig in Wurukum Abattoir, **KPW:** Kidney of pig in Wurukum Abattoir, **LPW:** Liver of pig in Wurukum Abattoir and **SPW:** Skin of pig in Wurukum Abattoir

Heavy metals in the meat samples

The concentrations of heavy metals in the hearts of cattle and pigs are presented in Table 3. The results showed the concentrations of zinc in the hearts of both animals ranged from 47.14±1.01 - 81.42±0.76 mg/kg and copper ranging from 0.35±0.18 - 9.48±0.20 mg/kg in the study area. The concentrations of cadmium, chromium and lead were not detected in the heart samples. The result on Pb, Cd and Cr agreed with another study [1] which reported lead below detection limit in entrails of Cows, Goat and Pigs but differed in terms of Cd and Cr. Although zinc and copper are among essential elements needed by both humans and plants, they are poisonous at high concentrations. Higher values of copper (9.48±0.20 mg/kg) and zinc (81.42±0.76 mg/kg) were obtained for the heart pig in Modern Market Abattoir as compared to the heart of pig at Wurukum Abattoir with 0.85±0.23 mg/kg and 47.14±1.01 mg/kg respectively. Meanwhile, Higher values of copper (1.82±0.18 mg/kg) and zinc (70.66±0.54 mg/kg) were obtained for the heart cattle in Wurukum Abattoir as compared to the heart of cattle at Modern Market Abattoir with 0.35±0.18 mg/kg and 56.21±0.88 mg/kg respectively. These variations in concentrations and the non-detection of Cd, Cr and Pb may be due to the diet of the animals as well as the possible difference in ages of the animals. Younger animals have less tendency of bioacummulating the metals while the elemental composition of the diet of the animals will determine the metals that can be obtained from their samples.

Table 3: Concentrations of Heavy Metals in Heart of Cattle and Pig

Sample/Metals (mg/kg)	Cd	Cr	Cu	Pb	Zn
HCM	ND	ND	0.35±0.18	ND	56.21±0.88
HPM	ND	ND	9.48±0.20	ND	81.42±0.76
HCW	ND	ND	1.82±0.18	ND	70.66±0.54
HPW	ND	ND	0.85±0.23	ND	47.14±1.01

ND = Not detected

The concentrations of heavy metals in the kidneys and livers of cattle and pig are presented in Tables 4 and 5 respectively. The values of Zn in the kidney samples ranged from 37.69±0.89 mg/kg for KPM to 81.05±1.40 mg/kg for KCW and the values of Cu ranged from 0,68±0.06 mg/kg for KPM to 2.24±0.23 mg/kg for KCM while Cd, Cr and Pb were not detected in any of the kidney samples. The results showed that Zn is higher all the kidney samples than Cu. Similarly, Zn was higher in liver samples as compared to Cu while Cd, Cr and Pb were not detected in the samples. The values of Zn ranged from 79.34±0.57 mg/kg for LCW to 135.13±2.20 mg/kg for LPM. Among the three internal organs analysed (Tables 3 – 5), the livers of the animals showed the highest concentrations of copper and zinc meanwhile Cd, Cr and Pb were not detected in any of the organs. All the concentrations of zinc were below the maximum limit of 100 mg/kg set by Food and Agriculture Organization [21].

Table 4: Mean Concentration of Heavy Metals in Kidney of Cattle and Pig

Sample/Metals (mg/kg)	Cd	Cr	Cu	Pb	Zn
KCM	ND	ND	2.24±0.23	ND	69.56±1.17
KPM	ND	ND	0,68±0.06	ND	37.69±0.89
KCW	ND	ND	1.15±0.13	ND	81.05±1.40
KPW	ND	ND	1.43±0.18	ND	68.83±1.46

ND = Not detected

Table 5: Mean Concentration of Heavy Metals in Liver of Cattle and Pig

Sample/Metals (mg/kg)	Cd	Cr	Cu	Pb	Zn
LCM	ND	ND	11.07±0.33	ND	89.38±2.34
LPM	ND	ND	2.82±0.32	ND	135.13±2.20
LCW	ND	ND	6.57±0.37	ND	79.34±0.57
LPW	ND	ND	0.85±0.05	ND	92.90±0.33

ND = Not detected

The concentrations of heavy metals in the skins of cattle and pig are presented in Table 6. The values of Zn have continued to be higher than Cu in all the samples while Cd, Cr and Pb have not been detected in the skin samples as well as in the offals. However, the levels of Zn and Cu in the skin samples are lower than those detected in each of the internal organs (offals). The concentrations of Zn in the skin samples ranged from 10.15±0.13 mg/kg to 37.96±0.69 mg/kg while that of Cu ranged from Nd to 0.73±0.16 mg/kg.

In general the levels of Cu and Zn (mg/kg) in all the samples analysed ranged from ND – 11.07±0.33 and 10.15±0.13 – 135.13±2.20 respectively. The values of Cu were higher than those reported in meat and meat products from Egyptian Markets while the values of Zn were lower than those reported in the Markets [22].

Although, Cu and Zn are essential for good health their intake above the recommended levels can cause health problems [23 - 24]. The recommended daily intake of Cu for healthy adult is between 0.9 and 1.3 mg [25], and for Zn is between 3.3 and 3.8 mg [26]. Meanwhile the Food and Agriculture Organization (FAO) has set the maximum limits of Cu and Zn in all foodstuffs to be 10 mg/kg and 100 mg/kg respectively [21]. The values of copper and zinc in this research were below the maximum limits set by

FAO except in liver of cattle and liver of pig at Modern Market Abattoir where Cu was 11.07 mg/kg and Zn was 135.13 mg/kg.

Table 6: Mean Concentration of Heavy Metals in Skin of Cattle and Pig

Sample/Metals (mg/kg)	Cd	Cr	Cu	Pb	Zn
SCM	ND	ND	ND	ND	10.15±0.13
SPM	ND	ND	0.30±0.13	ND	20.68±0.25
SCW	ND	ND	0.65±0.09	ND	37.96±0.69
SPW	ND	ND	0.73±0.16	ND	28.16±0.80

ND = Not detected

Human health risks of heavy metals in the meat samples

The calculated Hazard Index (HI) for copper in the offals and skins of cattle and pigs are presented in Table 7. The results showed that the values at the Modern Market Abattoir ranged from 1×10^{-4} – 4.0×10^{-3} for skin of pig and skin of cattle respectively while at Wurukum Abattoir the results ranged from 8.6×10^{-5} – 6.4×10^{-4} for liver of cattle and heart of cattle respectively. All the HI values for the offals and skin of the animals are less than one (1). This implies that there is no non-carcinogenic risk posed to human health [5].

Table 7: Calculated Hazard Index (HI) for Copper in the Offals and Skins of Cattle and Pigs

Sample	**HI×10^{-4}**	**Sample**	**HI ×10^{-4}**
HCM	1.2	HCW	6.4
KCM	8	KCW	4.1
LCM	39	LCW	0.86
SCM	40	SCW	2.3
HPM	33	HPW	2.1
KPM	2.4	KPW	5
LPM	9	LPW	2.1
SPM	1	SPW	2.6

The calculated HI values for zinc in the offals and skins of cattle and pigs are presented in Table 8. The results showed that the hazard index at the Modern Market Abattoir ranged from 2.0×10^{-3} – 9.2×10^{-3} for skin of pig and liver of cattle respectively while at Wurukum Abattoir the results ranged from 1.0×10^{-3} – 4.1×10^{-3} for skin of pig and liver of pig respectively. All the HI values for the offals and skin of the animals are less than one (1). This implies that there is no non-carcinogenic risk posed to human health based on the HI values [5].

Table 8: Calculated Hazard Index (HI) for Zinc in the Offals and Skins of Cattle and Pigs

Sample	HI ×10^{-3}	Sample	HI ×10^{-3}
HCM	4.7	HCW	3.1
KCM	3.1	KCW	3.1
LCM	4.1	LCW	3.1
SCM	4	SCW	2.1
HPM	4.1	HPW	2.1
KPM	2	KPW	3.1
LPM	6.2	LPW	4.1
SPM	9.2	SPW	1

Correlation of heavy metal concentrations in the meat samples

The results of the correlations between the concentrations of zinc in the offals and skin of pigs are shown in Table 9 while the correlations between the concentrations of zinc in the offals and skin of cattle are shown in Table 10. A perfect correlation which was significant at 99 % confidence level existed between the concentrations of zinc in the kidney of pig at Wurukum (KPW) and heart of pig at Modern Market (HPM) abattoirs. The concentrations of zinc in KPW and HPM showed significant negative relationship with KPM while the correlations between the other samples were not significant but either positive or negative. The positive correlations indicate the likelihood of finding zinc in the other parts at similar levels while negative correlations indicate lack of connection between the levels of zinc in the parts of the meat.

Table 9: Correlation between Concentrations of Zinc in the Heart, Kidney, Liver and Skin of Pigs in Wurukum and Modern Market Abattoirs

	HPW	KPW	LPW	SPW	HPM	KPM	LPM	SPM
HPW	1	.945	.667	-.176	.942	.925	-.837	.374
KPW		1	.388	.154	1.000**	-.998*	-.613	.657
LPW			1	-.851	.379	-.334	-.966	-.441
SPW				1	-.164	-.211	.686	.847
HPM					1	-.999*	-.606	.663
KPM						1	.566	-.699
LPM							1	.194
SPM								1

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).

The correlations between the concentrations of zinc in the cattle samples were either positive or negative but none of the positive correlations was significant at 95 or 99 % confidence levels (Table 10)

Table 10: Correlation between Concentrations of Zinc in the Heart, Kidney, Liver and Skin of Cattle in Wurukum and Modern Market Abattoirs

	HCW	KCW	LCW	SCW	HCM	KCM	LCM	SCM
HCW	1	.678	-.996	.942	-.814	.971	-.979	-.946
KCW		1	-.738	.885	-.125	.483	-.514	-.403
LCW			1	-.968	.761	-.947	.958	.915
SCW				1	-.573	.835	-.855	-.783
HCM					1	-.929	.915	.959
KCM						1	-.999*	-.996
LCM							1	.992
SCM								1

* Correlation is significant at the 0.05 level (2-tailed).

The results of the correlations between the concentrations of copper in the offals and skin of pigs are shown in Table 11 while the correlations between the concentrations of copper in the offals and skin of cattle are shown in Table 12. There was a significant positive correlation at 95 % confidence level between the concentrations of copper in the skin of pig at Wurukum (SPW) and skin of pig at Modern Market (SPM) abattoirs. The other correlations were between the concentrations of copper in other samples of both the pigs and cattle were either positive or negative but not significant

Table 11: Correlation between Concentrations of Copper in the Heart, Kidney, Liver and Skin of Pigs in Wurukum and Modern Market Abattoirs

	HPW	KPW	LPW	SPW	HPM	KPM	LPM	SPM
HPW	1	-.395	.340	-.644	.540	-.946	-.861	-.612
KPW		1	-.998*	.957	.559	.077	.807	.968
LPW			1	-.938	-.608	-.017	-.771	-.952
SPW				1	.296	.362	.944	.999*
HPM					1	-.783	-.037	.335
KPM						1	.650	.323
LPM							1	.929
SPM								1

* Correlation is significant at the 0.05 level (2-tailed)

Table 12: Correlation between Concentrations of Copper in the Heart, Kidney, Liver and Skin of Cattle in Wurukum and Modern Market Abattoirs

	HPW	KPW	LPW	SPW	HPM	KPM	LPM	SPM
HPW	1	-.256	-.788	-.998*	-.647	-.060	-.994	.[b]
KPW		1	.796	.190	-.572	.980	.149	.[b]
LPW			1	.745	.040	.661	.716	.[b]
SPW				1	.696	-.007	.999*	.[b]
HPM					1	-.723	.726	.[b]
KPM						1	-.049	.[b]
LPM							1	.[b]
SPM								.[b]

* Correlation is significant at the 0.05 level (2-tailed).
b cannot be computed because at least one of the variables is constant

Conclusion

This study investigated heavy metals in heart, kidney, liver and skin of cattle and pigs from Wurukum and Modern Market Abattoirs in Makurdi Metropolis as well as the human health risks associated with them. Among the heavy metals investigated copper and zinc were found to be present in all the samples at different concentration levels while cadmium, chromium and lead were not detected in any of the samples. The values of copper and zinc in this research were below the 10 mg/kg and 100 mg/kg respective maximum limits set by Food and Agriculture Organization (FAO) for all foodstuffs except in livers of cattle and pig at Modern Market Abattoir where Cu was 11.07 mg/kg and Zn was 135.13 mg/kg. Some of the correlations between the levels of copper and levels of zinc in the samples were significant at 95 % or 99 % confidence level while most the correlations were either positive or negative but not significant. The human health assessment based on the hazard index values indicated that there was no risk posed to human health.

References

[1] Ubwa, S.T., Rose, E., Patrice-Anthony, C.O. and Qrisstuberg, M.A. (2017). **Assessment of Heavy Metals in the Blood and Some**

Selected Entrails of Cows, Goat and Pigs Slaughtered at Wurukum Abattoir, Makurdi-Nigeria. *Advances in Analytical Chemistry.* 7(1):7-12.

[2] Ahmad, R.S., Imran, A., Hussain, M. B. (2018). **Nutritional Composition of Meat**. https://www.intechopen.com/chapters/61245. Accessed 14th October, 2023: 6-20.

[3] Bovalino, S. Charleson, G., Szoeke, C. (2016). **The impact of red and processed meat consumption on cardiovascular disease risk in women.** *Nutrition.* 49-354.

[4] Han, J. J., Pan, X. D., Chen, Q. (2022). **Distribution and safety assessment of heavy metals in fresh meat from Zhejiang, China.** Scientific Reports. 12(3241): 1-8.

[5] Kamaly, H. F. and Sharkawy, A. A. (2023). **Health risk assessment of metals in chicken meat and liver in Egypt**. *Environmental Monitoring and Assessment*, 195(802): 1-17.

[6] Egwumah, J.A., Eneji, I.S., Wuana, R.A., Itodo, A.U. (2023). **Determination of Heavy Metals Levels in Palm Oil obtained from Ankpa, Olamaboro and Dekina Local Government Areas of Kogi State, Nigeria.** *FUAM Journal of Pure and Applied Science*, 3(2): 55-60.

[7] Kasozi, K.I., Hamira, Y., Zirintunda, G., Alsharif, K. F., Altalbawy, F. M. A., Ekou, J., *et al.* (2021). **Descriptive Analysis of Heavy Metals Content of Beef From Eastern Uganda and Their Safety for Public Consumption.** *Frontiers in Nutrition,* 8(592340): 1-10.

[8] Ahsan, A., Siddique, A. B., Munni, M. A., Akbor, A., Bithi, U. H., Mia, Y. (2018). **Analysis of major heavy metals in the available fish species of the Dhaleshwari River, Tangail, Bangladesh.** *International Journal of Fisheries and Aquatic Studies,* 6(4): 349-354

[9] Achadu, O. J., Ochimana, O. I., Ochefu, A. A., Njoku, U. P. (2016). **Assessment of Heavy Metals Levels and Leaching Potentials in Dumpsites Soils in Wukari, North-Eastern Nigeria.** *International Journal of Modern Analytical and Separation Sciences*. 5(1): 20-31

[10] Soliman, N. F., Nasr, S. M., Okbah, M. A. (2015). **Potential ecological risk of heavy metals in sediments from the Mediterranean coast, Egypt.** *Journal of Environmental Health Science & Engineering,* 13(70): 1-12.

[11] Eneji, I. S., Sha'Ato, R.., Annune, P. A. (2012). **An assessment of heavy metals loading in River Benue in the Makurdi metropolitan area in Central Nigeria.** *Environmental Monitoring and Assessment*, 184(1):201-7.

[12] Khan, S., Cao, Q., Zheng, Y.M., Huang Y.Z., Zhu, Y.G. (2008). **Health risks of heavy metals in contaminated soils and food crops irrigated with wastewater in Beijing, China.** *Environmental Pollution,* 152: 686-692.

[13] Sabuwa, M. A.B., Salihu, M.D., Baba, M. K., Bala, A. (2019). **Determination of concentration of some heavy metals in the blood of Holstein-Friesian cattle on a farm in Nasarawa State, Nigeria.** *Sokoto Journal of Veterinary Sciences*, 17(3): 17 – 23.

[14] Emami, M. H., Saberi, F., Mohammadzadeh, S., Fahim, A., Abdolvand M., Dehkordi S., Samane, M., Fstemeh, M. (2023). **A Review of Heavy Metals Accumulation in Red Meat and Meat Products in the Middle East**. *Journal of Food Protection,* 86: 1-13.

[15] Baharoma, Z. S. and Ishak, M. Y. (2015). **Determination of heavy metal accumulation in fish species in Galas River, Kelantan and Beranang mining pool, Selangor.** *Procedia Environmental Sciences,* 30 : 320 – 325.

[16] El-Moselhy, Kh. M., Othman, A.I., Abd El-Azem, H., El-Metwally M.E.A. (2014). **Bioaccumulation of heavy metals in some tissues of fish in the Red Sea, Egypt.** *Egyptian Journal of Basic and Applied Sciences,* 1: 97 – 105

[17] Luo, X.S., Ding, J., Xu, B., Wang, Y.J. (2012). **Incorporating bioaccessibility into human health risk assessments of heavy metals in urban park soils.** *Science Total Environment,* 424:88–96.

[18] Praveena, S.M., Abdul, M.N.S. and Aris, A.Z. (2015). **Determination of heavy metals in indoor dust from Primary Schools (Sri Serdang, Malaysia): estimation of the health risks.** *Environmental Forensic*, 16:257-263.

[19] United States of Environmental Protection Agency (USEPA), (2011). **Exposure factors handbook.** National Center for Environmental Assessment. Washington, DC (EPA/600/R-09/052F): 5-18.

[20] United States of Environmental Protection Agency (USEPA) (2012). **Integrated risk information system**. Washington DC: US EPA. Resource document. (http://www.epa.gov/IRIS/): 25-29

[21] Nauen, C. E. (1983). **Compilation of Legal Limits for Hazardous Substances in Fish and Fishery Products.** Food and Agriculture Organization (FAO) Fisheries Circular 764(102): 1-15.

[22] Zahran, D. A. and Hendy, B. A. (2015). **Heavy Metals and Trace Elements Composition in Certain Meat and Meat Products Sold in Egyptian Markets.** *International Journal of Sciences: Basic and Applied Research*, 20(1): 282-293.

[23] Agency for Toxic Substances and Disease Registry (ATSDR) (2005). **Toxicological Profile for Zinc.** https://www.atsdr.cdc.gov/ToxProfiles/tp60.pdf. Accessed 18th October, 2023: 1-15.

[24] ATSDR (2022). **Toxicological Profile for Copper**, Draft for Public Comment. https://www.atsdr.cdc.gov/ToxProfiles/tp132.pdf. Accessed 18th October,2023: 1-10.

[25] Stern, B. R. (2010). **Essentiality and toxicity in copper health risk assessment: overview, update and regulatory considerations.** *Journal of Toxicology and Environmental Health, Part A*, 73: 114–27.

[26] Boreiko, C. J. (2010). **Essentiality and toxicity in copper health risk assessment: overview of health risk assessments for zinc.** *Journal of Toxicology and Environmental Health, Part A*, 73: 166–74.

Cite this article

Tongu S. M., Ande S. and Odoh J. G. (2024). Health Risk Assessment of Heavy Metals in Selected Offals and Skin of Cattle and Pigs Slaughtered in some Abattoirs in Makurdi Metropolis. FUAM Journal of Pure and Applied Science, **4(1)**:55-64