JOURNAL OF VETERINARY AND APPLIED SCIENCES
VOLUME 14, ISSUE 2: 668 – 676 (2024)
Published by: Faculty of Veterinary Medicine, University of Nigeria, Nsukka, Nigeria
ISSN: 2315-6856; e-ISSN: 2636-5553; Website: www.jvasonline.com

Evaluation of the concentration of some heavy metals in cattle hides singed in Enugu and Nsukka abattoirs, Enugu State, Nigeria

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Abstract

Heavy metals are among hazardous chemicals that are of public health concern in food safety. In many African countries, like in Nigeria, hides are sold and consumed as cherished food item. The present study investigated the levels of heavy metals in singed, singed-washed and un-singed hides of cattle slaughtered at two major abattoirs in Enugu State, Nigeria (Enugu and Nsukka abattoirs). Using atomic absorption spectrophotometry, the levels of heavy metals were determined in a total of 480 samples of un-singed hides (USH), singed hides (SH) and singed-washed hides (SWH) collected from 160 cattle over a 12-month study period. Results showed that lead concentrations recorded in Enugu and Nsukka abattoir respectively were 0.0277 ± 0.0038 and 0.0207 ± 0.0025 mg/kg in SH, 0.0261 ± 0.0037 and 0.0196 ± 0.0024 mg/kg in SWH and 0.0176 ± 0.0030 and 0.0128 ± 0.0016 mg/kg in USH. For cadmium, 0.0035 ± 0.008, 0.0054 ± 0.0012 and 0.0045 ± 0.0010 mg/kg concentrations were recorded in Enugu abattoir for USH, SH and SWH, respectively. Cadmium concentrations recorded at Nsukka abattoir were 0.0033 ± 0.0068, 0.0047 ± 0.0103 and 0.0037 ± 0.0074 mg/kg in USH, SH and SWH, respectively. Copper concentration in hides sampled at Enugu abattoir were 0.0250± 0.0032 mg/kg for SH, 0.0168 ± 0.0027 mg/kg for USH and 0.0210 ± 0.0027 mg/kg for SWH, while for Nsukka abattoir, copper concentrations of hides were 0.0254 ± 0.0035 mg/kg for SH, 0.0166 ± 0.0029 mg/kg for USH and 0.0201 ± 0.0022 for SWH. Concentrations of lead, cadmium and copper were significantly higher ($p < 0.05$) in the singed hide when compared to un-singed hide. The heavy metal concentrations were relatively higher in dry than wet season. However, the concentration of lead, cadmium and copper recorded in SH, SWH and the majority of USH of the slaughtered cattle from the abattoirs in Nsukka and Enugu were below the maximum permissible level recommended by the World Health Organization and European Commission (0.1 mg/kg, 0.05 mg/kg and 20 mg/kg for lead, cadmium and copper, respectively).

Keywords: Heavy metals; Lead; Cadmium; Copper; Cattle hides; Singeing; Abattoir, Enugu State Nigeria.

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Article History: Initial manuscript submission received – February 29, 2024; Final revised form received – June 25, 2024; Accepted for publication – July 01, 2024; Published – July 08, 2024.

Introduction

In Nigeria singeing of hides of cattle is a common practice during the processing of animal products for human consumption. In singeing, hides obtained from cattle after skinning are placed on metal strips, then kept red-hot with limited wood fire underneath, to slowly burn the fur off the skinned cattle hide. Butchers use damaged tyres, plastics, polythene, spent engine oil and kerosene to generate the fire used in the burning process (Obiri-Danso *et al.,* 2008). This singeing procedure transforms the cattle hide into a local meat product called "kpomo" or "kanda.

Earlier reports have shown that singeing of hides using fire generated from the above listed substances (damaged tyres, plastics; polythene, spent engine oil and kerosene) could contaminate meat products, and may have adverse health implications (Okiei *et al.,* 2009). In addition, the environment and meat processors are also at risk (Okiei *et al.,* 2009). Instances of heavy metal contamination in meat products during processing have been severally reported (Santhi *et al.,* 2008; Brito *et al.,* 2005; Felix *et al.,* 2016a; Felix *et al.,* 2016b; Obioha *et al.,* 2023).

The use of fire generated from burnt tyres in meat processing has been raising serious health concern because of the possible adverse effects it may have on the meat consumers, processors and buyers at the processing units (Felix *et al.,* 2016b). In view of the fact that tyres contain many potentially harmful substances, singeing with scrap tyres imposes enormous risk of deposition of toxic elements and compounds on to the animal hide, which could significantly compromise meat quality (USFA, 1999). Regular consumption of such potentially contaminated meat product poses a great source of health risk to the consumers (Felix *et al.,* 2016a).

There is a dearth of information in available literature on the occurrence and levels of heavy metal contaminants in hides singed for human consumption using the above procedures. The present study evaluated the occurrence and levels of heavy metals (lead, cadmium and copper) in hides of cattle slaughtered and processed for human consumption at Enugu and Nsukka abattoirs in Enugu State, Nigeria.

Materials and Methods

Study area: The abattoirs in which the studies were carried out were located in Enugu metropolis and Nsukka urban in Enugu State, Nigeria (Figure 1). Enugu is situated at latitude of 6°27'30.12"N and a longitude of 7°30'37"E while Nsukka lies on latitude of 6°51'24"N and longitude of 7°23'45"E respectively (Obioha *et al*., 2023). These abattoirs slaughter cattle and process cattle meat that are consumed by people living in the environs.

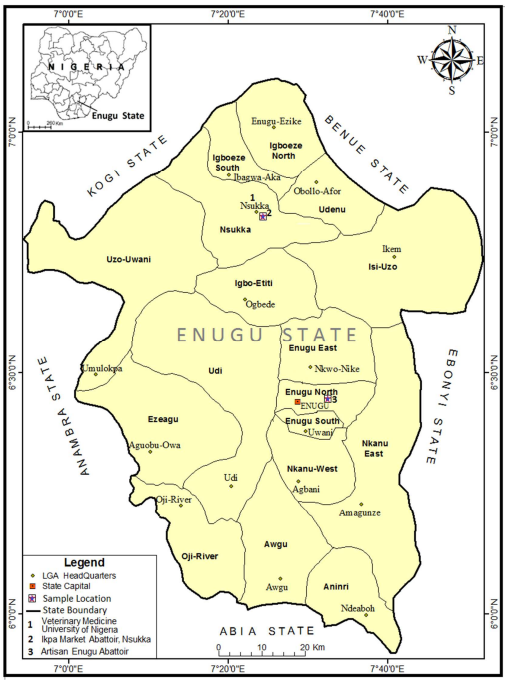

Figure 1: Map of Enugu State Nigeria, showing the location of the abattoirs in which samples for the study was collected (Obioha *et al*., 2023).

Sampling technique and Sample collection: Enugu and Nsukka were randomly selected for the study, out of the three zones in Enugu State, Nigeria. The two major abattoirs (Artisan Enugu Abattoir and Ikpa market abattoir in Nsukka) were purposively selected based on their slaughter capacity per day. Samples were randomly collected from singed, singed-washed and un-singed cattle hide in the abattoirs. Systematic random sampling was adopted to select one out of every five slaughtered cattle at the selected abattoirs depending on the number of cattle slaughtered during each visit, for a period of 12 months. About 20 g portion of the hides were cut from each selected cattle. A total number of 160 slaughtered cattle (hides) collected between the months of August 2020 to May, 2021 were used for the study.

Sample Processing and Evaluation for Heavy Metal Residues: Wet digestion procedure was used for processing the samples. Two grammes of the dried hide samples were weighed into a digestion flask after which 20 ml of the acid mixture (650 ml concentrated (conc.) HNO_3; 80 ml perchloric acid; 20 ml conc. H_2SO_4) was added. Heat was applied to the flask until a clear digest was obtained. The digest was diluted with distilled water to the 100 ml mark. The sample was thoroughly mixed by shaking, and 100 ml of it was transferred into a glass beaker of 250 ml volume, to which 5ml of conc. nitric acid was added and was heated to boil till the volume was reduced to about 15 – 20 ml and digested by adding conc. nitric acid in increments of 5 ml till all the residue were completely dissolved. The mixture was cooled, transferred and made up to 100 ml using metal free distilled water. The sample was aspirated into the oxidising air-acetylene flame. When the aqueous sample was aspirated, the sensitivity for 1% absorption was observed. A series of standard metal solutions in the optimum concentration range were prepared; the reference solutions were prepared daily by diluting the single stock element solutions with water containing 1.5 ml concentrated nitric acid/litre (Adrian, 1973; Obioha *et al*., 2023).

Data Processing and Analysis: Data generated from this study were statistically analyzed using IBM SPSS Statistics, version 20. Descriptive statistics was used to analyze the generated data, which was converted to percentages, and presented in tables. Chi square analysis was used to determine the association between the occurrence of heavy metals in the hides and season (dry or wet). Analysis of variance and post hoc test was performed to determine if there was statistical significant difference in the mean concentration of singed, un-singed and singed-washed hides. Probability levels less than 0.05 were considered to be significant. Results were presented as tables and bar charts.

Results

Occurrence of Lead, Cadmium and Copper in Hides of Cattle Slaughtered in Enugu and Nsukka abattoirs: The occurrence of lead in un-singed hide (USH), singed hide (SH) and in singed-washed hide (SWH) in Enugu abattoir were 73.75%, 75% and 78.75%, respectively (Table 1). Cadmium occurred in 27.5% of USH, 22.5% of SH and 25% of SWH at Enugu abattoir, while copper occurred in 73.5% of USH, 77.5% of SH and 75% of SWH (Table 1). In Nsukka abattoir however, lead was recorded in 71.25% of USH, 75% of SH and 77.5% of SWH, while cadmium occurred in 22.5% of USH, 45% of SH and 31.25% of SWH (Table 2). The occurrence of copper in hides at Nsukka abattoir were 73.75% in USH, 78.75% in SH and 78.75% in SWH (Table 2).

Table 1: Occurrence of lead, cadmium and copper in hides of cattle slaughtered at Enugu abattoir, Nigeria. [USH – Un-singed hide; SH – Singed hide; SWH – Singed and washed hide]

Heavy Metals	Status	No. of Cattle (%)	No. of Hides (%)			Total
			USH	SH	SWH	
Lead	Positive	61 (76.25%)	59 (73.75%)	60 (75%)	63 (78.75%)	182 (**75.8**%)
	Negative	19 (23.75%)	21 (26.25%)	20 (25%)	17 (21.25%)	58 (**24.2**%)
Cadmium	Positive	22 (27.5%)	18 (22.5%)	20 (25%)	20 (25%)	58 (**24.2**%)
	Negative	58 (72.5%)	62 (77.5%)	60 (75%)	60 (75%)	182 (**75.8**%)
Copper	Positive	62 (77.5%)	59 (73.75%)	62 (77.5%)	60 (75%)	181 (**75.4**%)
	Negative	18 (22.5%)	21 (26.25%)	18 (22.5%)	20 (25%)	59 (**24.6**%)
Total		**240**	**240**	**240**	**240**	**720**

Table 2: Occurrence of lead, cadmium and copper in hides of cattle slaughtered at Nsukka abattoir, Nigeria. [USH – Un-singed hide; SH – Singed hide; SWH – Singed and washed hide]

Heavy Metals	Status	No. of Cattle (%)	No. of Hides (%)			Total
			USH	SH	SWH	
Lead	Positive	62 (77.5%)	57 (71.25%)	60 (75%)	62 (77.5%)	179 (**74.6%**)
	Negative	18 (22.5%)	23 (28.75%)	20 (25%)	18 (22.5%)	61 (**25.4%**)
Cadmium	Positive	28 (35%)	18 (22.5%)	36 (45%)	25 (31.25%)	79 (**32.9%**)
	Negative	52 (65%)	62 (77.5%)	44 (55%)	55 (68.75%)	161 (**67.1%**)
Copper	Positive	63 (78.75%)	59 (73.75%)	63 (78.75%)	63 (78.75%)	185 (**77.1%**)
	Negative	17 (21.25%)	21 (26.25%)	17 (21.25%)	17 (21.25%)	55 (**22.9%**)
Total		**240**	**240**	**240**	**240**	**720**

Level/concentrations of lead, cadmium and copper in hides of cattle slaughtered at Enugu and Nsukka abattoirs: The lead concentrations in hides sampled at Enugu abattoir were 0.0176 ± 0.0030 mg /kg for USH, 0.0277± 0.0038 mg/kg for SH and 0.0261 ± 0.0037 mg/kg for SWH (Figure 2). In Nsukka abattoir, the lead concentrations in the hides were 0.0128 ± 0.0016 mg/kg for USH, 0.0207 ± 0.0025 mg/kg for SH and 0.0196 ± 0.0024 mg/kg for SWH (Figure 3). In both Enugu and Nsukka abattoirs, the concentration of lead in SH and SWH was significantly ($p < 0.05$) higher than that in USH (Figures 2 and 3).

For cadmium, the concentrations recorded for hides at Enugu abattoir were 0.0035 ± 0.008 mg/kg for USH, 0.0054 ± 0.0012 mg/kg for SH and 0.0045 ± 0.0010 mg/kg for SWH (Figure 2). Cadmium concentrations in hides sampled at Nsukka abattoir were 0.0033 ± 0.0068 mg/kg for USH, 0.0047 ± 0.0103 mg/kg for SH and 0.0037 ± 0.0074 mg/kg for SWH (Figure 3).

There were no significant variations ($p > 0.05$) in cadmium concentrations of USH, SH and SWH sampled in both abattoirs (Figures 2 and 3)

Copper concentration in hides sampled at Enugu abattoir were 0.0168 ± 0.0027 mg/kg for USH, 0.0250± 0.0032 mg/kg for SH and 0.0210 ± 0.0027 mg/kg for SWH (Figure 2), while for Nsukka abattoir, copper concentrations of hides were 0.0166 ± 0.0029 mg/kg for USH, 0.0254 ± 0.0035 mg/kg for SH and 0.0201 ± 0.0022 for SWH (Figure 3). The concentrations of copper in SH and SWH were significantly ($p < 0.05$) higher than that in USH sampled at both Enugu and Nsukka abattoirs (Figures 2 and 3).

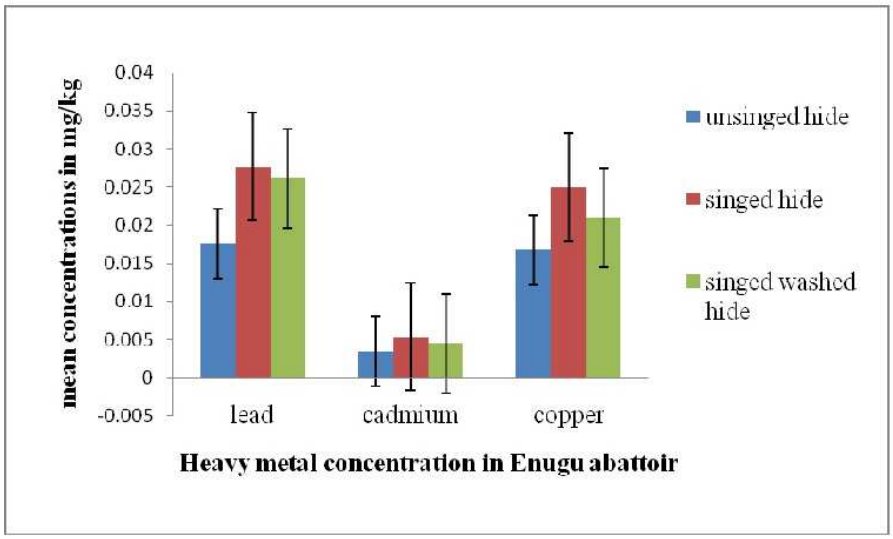

Figure 2. Concentrations of heavy metals (lead, cadmium and copper) in un-singed, singed, and singed and washed hides of cattle slaughtered at Enugu abattoir, Nigeria.

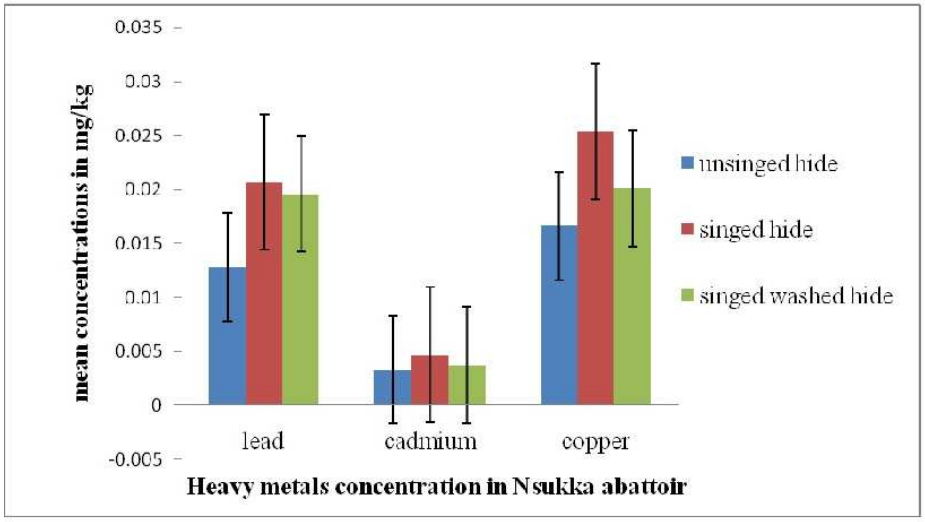

Figure 3. Concentrations of heavy metals (lead, cadmium and copper) in un-singed, singed, and singed and washed hides of cattle slaughtered at Nsukka abattoir, Nigeria.

Seasonal variations in the concentration of lead, cadmium and copper in hide samples obtained from cattle slaughtered at Enugu and Nsukka abattoirs: The seasonal variations in the concentrations of lead, cadmium and copper in unsigned, singed, and singed-washed hides in Enugu and Nsukka abattoirs are presented in Tables 3 and 4. There were no significant differences ($p > 0.05$) in heavy metal concentrations during dry and wet seasons in both abattoirs (Tables 3 and 4).

Discussion

The present study showed that at Enugu abattoir, 76.25% of hide had lead, 27.5% had cadmium and 77.5% had copper, while at Nsukka abattoir, the occurrence of lead, cadmium and copper were 77.5%, 35% and 78.75%, respectively. These findings in the present study are in contrast with the reports of Bala *et al.* (2012), which showed 100% occurrence of cadmium in hides at Sokoto State, Nigeria. Okoye and Ibeto (2008) reported high levels of lead, cadmium and copper in soils from Enugu State Nigeria, which they claimed could serve as a source of heavy metals in animals grazing in such areas of the State. The high occurrence of lead and copper in hides as recorded in this study could possibly be attributed to exposure of the cattle to heavy metals as they graze or as they scavenge in open waste or refuse dumps and drink polluted water, or during processing of the hides at the abattoir using fire made from kerosene, petrol, plastics and/or tyre as earlier reported (Obiri-Danso *et al.,* 2008; Okoye and Ugwu, 2010; Ekenma *et al.,* 2015; Felix., *et al* 2016b).

The findings in the present study showed that un-singed cattle hide from both the Enugu and Nsukka abattoirs contained varying degrees of heavy metals which increased in concentration after singeing. The higher lead, cadmium and copper concentrations could be as a result of the processing method observed during the study where butchers use fire made from plastics, tyres, petrol and kerosene to singe carcass hides. It could also be from the soil and pasture where the animals were grazed (Okoye and Ibeto, 2008). This finding in the present study however contrasts with that of Eremong *et al.* (2011) who reported decreasing levels of heavy metal residues in singed cattle hides.

Generally, there was relative higher concentration heavy metal during the dry season than in the wet season in both Enugu and Nsukka abattoirs, though these were not found to be statistically significant. These findings are in agreement with earlier reports by Muhammad *et al.* (2014) and Raji *et al.* (2016). The higher concentrations of the heavy metals during dry season may possibly be attributed to low availability of drinking water and higher evaporation rate with consequent concentration of the heavy metals. The seasonal variations in the concentrations of the heavy metals could also be attributed to differences in individual metal solubility, pH, leaching by acidic rain during the wet season and topography of the area (Iwegbue, 2007).

It was noted however that the mean values for heavy metals in all the hide sampled in this study were below the European Commission and WHO recommended maximum permissible levels of 0.1 mg/kg, 0.05 mg/kg and 20 mg/kg for lead, cadmium and copper, respectively (European Commission, 2002). Even as at that, it is felt that regular consumption of such potentially contaminated meat product poses a great source of health risk to the consumers, due to possible bio-accumulation.

Table 3: Concentrations of lead, cadmium and copper in un-singed, singed and, singed and washed hides obtained from cattle slaughtered at Enugu abattoir, Nigeria during the dry and wet seasons.

Heavy Metals	Hide type	Mean ± SEM of heavy metal concentration.		p-value
		Dry season	Wet season	
Lead	Un-singed	0.0186 ± 0.0048	0.0162 ± 0.0025	0.180
	Singed	0.0283 ± 0.0055	0.0270 ± 0.0052	0.691
	Singed and washed	0.0262 ± 0.0053	0.0280 ± 0.0049	0.761
Cadmium	Un-singed	0.0040 ± 0.0011	0.0028 ± 0.0012	0.232
	Singed	0.0060 ± 0.0016	0.0046 ± 0.0020	0.464
	Singed and washed	0.0050 ± 0.0014	0.0039 ± 0.0015	0.510
Copper	Un-singed	0.0157 ± 0.0030	0.0183 ± 0.0049	0.450
	Singed	0.0233 ± 0.0034	0.0274 ± 0.0049	0.288
	Singed and washed	0.0206 ± 0.0032	0.0216 ± 0.0046	0.847

No significant difference ($p > 0.05$) in concentrations obtained during the two seasons.

Table 4: Concentrations of lead, cadmium and copper in un-singed, singed and, singed and washed hides obtained from cattle slaughtered at Nsukka abattoir, Nigeria during the dry and wet seasons.

Heavy Metals	Hide type	Mean ± SEM of heavy metal concentration.		p-value
		Dry season	Wet season	
Lead	Un-singed	0.0127 ± 0.0018	0.0128 ± 0.0025	0.306
	Singed	0.0220 ± 0.0039	0.0198 ± 0.0033	0.646
	Singed and washed	0.0232 ± 0.0039	0.0169 ± 0.0030	0.734
Cadmium	Un-singed	0.0035 ± 0.0011	0.0031 ± 0.0010	0.830
	Singed	0.0059 ± 0.0018	0.0037 ± 0.0015	0.238
	Singed and washed	0.0048 ± 0.0013	0.0029 ± 0.0011	0.158
Copper	Un-singed	0.0173 ± 0.0027	0.0161 ± 0.0047	0.627
	Singed	0.0285 ± 0.0044	0.0232 ± 0.0052	0.851
	Singed and washed	0.0244 ± 0.0034	0.0170 ± 0.0028	0.299

No significant difference ($p > 0.05$) in concentrations obtained during the two seasons.

Conclusion: This study showed that hides from slaughtered cattle sourced from Enugu and Nsukka abattoirs contained different concentrations of lead, cadmium and copper. Although these heavy metals in the samples studied were below the maximum permissible levels, they are still believed to be of public health concern. It is thought that the presence of the heavy metals concentration in slaughtered cattle in the present study was possible as a result of singeing methods, environmental factors, and materials used for generating the fire used for singeing. It is advocated that veterinarians in these abattoirs educate the butchers on the deleterious effects of using fire generated from tyres and plastics for singeing. Also, consumers need to be educated on the risks involved in the consumption of hides singed with fire generated from items such as used tyres, plastics, polythene, spent engine oil and kerosene.

Conflict of Interests

The authors have no conflict of interest.

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