NIGERIAN VETERINARY JOURNAL
ISSN 0331-3026
Nig. Vet. J., December 2024 Vol 45(4): 26- 36.
https://dx.doi.org/10.4314/nvj.v45i4.3 ORIGINAL ARTICLE

Heavy Metal Residues: Effect of Boiling on Different Singeing Methods in Enugu State, Nigeria.

Felix Chidiebere Obioha[1*], John Anelom Nwanta[1], Aruh O Anaga[2].

[1]Department of Veterinary Public Health and Preventive medicine, University of Nigeria Nsukka, [2]Department of Veterinary physiology and pharmacology, University of Nigeria Nsukka., *Corresponding author: Email: askdrfelicity@gmail.com; Tel No: +2348035419080

ABSTRACT

Hides of cattle are cherished as food source. Heavy metal contamination of hide is of great food safety concern due to the materials used in singeing and methods of processing of slaughtered cattle. The study aims to assess the concentration of heavy metal residues and the effect of boiling on singed hides in Enugu State, Nigeria. Twenty hide samples were divided into five equal portions and assigned to group A-E (singed with plastic (A), firewood (B), tyre (C), combination of the above (D), and un-singed (E)). After singeing, each group was boiled at 1000C for 30 minutes and the meat tested for heavy metal concentration. The toxicity of the water effluent from singed washed hide was analysed using brine shrimp lethality test with 450 larvae assigned in groups of A to E of 10 each in triplicates. Data generated were subjected to one way ANOVA and significance was accepted at $p < 0.05$. The study showed that group A-D from Enugu slaughterhouse had mean concentrations of lead 0.0549 ± 0.0099, 0.0394 ± 0.0081, 0.0446 ± 0.0086, 0.0806 ± 0.0678 and 0.0220 ± 0.0057 mg/kg respectively. Boiling of the singed hides did not significantly ($P > 0.05$) reduce the heavy metal concentration. The brine shrimp lethality test showed that the LC50 of effluents singed with plastic, firewood, tyres and combination of the three methods were 1051.27, 1292.29, 1384.25 and 1258.65 ppm at 95% confidence interval, respectively. Few samples that exceeded the maximum permissible levels may pose human health risk to beef consumers.

Key words: Heavy metals, singeing, brine shrimp, lead, cadmium, copper.

INTRODUCTION

Environmental pollution and contamination with heavy metals is regarded as one of the major public health problems as the metals cannot be degraded and may stay permanently in the environment (Obioha *et al.,* 2016). Singeing of hides is a common practice in Southeast, Nigeria where butchers use different materials such as damaged tyres, plastics, polythene, spent engine oil and kerosene to fuel woods during singeing process. In African countries, singeing is largely favored because it maintains the carcass hide for consumption and evokes flavors in meat that are

highly acceptable by the local populace (Food and Agriculture Organization (FAO), 1985).

In Nigeria, cattle graze and drink water from ditches, rivers, streams which are possible contaminated water sources (Felix *et al*. 2016a). They also graze along water runways and other water sites that might have been contaminated with heavy metals substances hence the risk of exposure to high levels of metal contaminant which accumulates in organs and other tissues of animals. Heavy metals toxicity can also be transferred to meat by intake of feed contaminated with agricultural chemicals, respiration of polluted air, automobile emissions, and drinking of polluted water (Felix *et al*. 2016a). These heavy metals bio-accumulate mostly in organs and tissues of these animals and toxicity depends on dosage, method of processing and duration of exposure (Felix *et al*. 2016a; Felix *et al*. 2016b). Heavy metals have been reported to accumulate in muscle, liver and kidney of cattle by some researchers (Akan *et al.,* 2010; Ambushe *et al.,* 2012; Bala, *et al*., 2012 and Badis *et al.* 2014). Okiei *et al.* (2009) reported that singeing of hides damaged tyre could contaminate the environment, meat products, and have strong adverse health effect in humans. Food is one of the principal environmental sources of Cadmium (Cd) in humans (Baykov *et al.,* 1996; Felix *et al.,* 2016a). Cupper (Cu) is reported to accumulate more in the liver and kidney, with excessive levels resulting in Wilson's disease condition (Gautam and Irfan, 2011; Obioha *et al.,* 2022). Higher dose of Lead (Pb) in the body was reported to result in "Lead poisoning" toxicity (WHO, 1996, Felix *et al.,* 2016b). Information about the level of heavy metal residues in slaughtered cattle; brine shrimp lethality assay using the effluents from washing of hides contaminated with heavy metals; and the effect of boiling on different singeing methods in Enugu State, Nigeria is largely unknown. Therefore, the aim of this study was to assess heavy metal residues in slaughtered cattle; conduct brine shrimp lethality assay using the effluents from washing of hides contaminated with these substances; and the effect of boiling on different singeing methods in Enugu State, Nigeria.

MATERIALS AND METHODS

Study Area

The study areas are Enugu metropolis and Nsukka urban in Enugu State, Nigeria (fig 1). The State is made up of 17 Local Government Areas, which are grouped into three Senatorial zones namely Enugu North, Enugu West and Enugu East. The State population is estimated to be 3,257,293 according to National population Commission in 2006 (NPC). The major towns in Enugu State are Enugu metropolis and Nsukka urban. Enugu metropolis is on latitude of 6°27'30.12"N and a longitude of 7°30'37"E with a population of 722,664 people. While Nsukka urban lies at the latitude of 6°51′24″N and longitude of 7°23′45″E with a population of 309, 633 people (Obioha *et al.,* 2022 and Obioha *et al.,* 2024).

Study Design

Experiment1: Effect of different singeing methods on the concentration of heavy metal residues in the hides of cattle

Method of Adam *et al*. (2013) was used with little modification. Twenty cattle were selected from Nsukka slaughterhouse using systematic random sampling. Twenty hide samples (200 g) were collected and each of the hides was divided into 5 equal parts (20g) and was assigned into five groups which were subjected to singeing

using 4 different materials; plastic /polystyrene materials (A); firewood mixed with kerosene (B); spent tyres (C); combination of A, B & C (D); and Un-singed hide was used as control (E). After singeing, each group was boiled at 100^0C for 30 minutes. Ten gram of the hide samples were used for the analysis.

Experiment 2: Brine Shrimp lethality test of the waste water samples

About 20 ml of waste water from each group (i-iv) were collected and tested for heavy metal concentration. Water samples from washing of singed hides were collected using clean plastic containers free of debris. They were separated into 4 groups of triplicates. Graded concentrations of the effluent (10, 100 and 1000 ppm) of the sample was added to each group and sea water was added to the control group (Eke *et al*., 2013). The nauplii were incubated at room temperature for 24 hours after which the survivors in each group were counted. The mean surviving nauplii were determined for each concentration of the effluent and compared with that of the control (Eke *et al*., 2013). Median concentration or LC_{50} was determined using Finney Probit Analysis computer software.

Sample Processing and Screening for Metal Residues (Wet digestion)

The methods of Adrian, (1973) and Obioha *et al*. (2022) were used. About 2 g of the dried sample 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) were added. Samples were heated until a clear digest was obtained. Each digested sample was later diluted with distilled water to the 100 ml mark. Each 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 residues were completely dissolved. The mixture was cooled, transferred to a beaker and made up to 100ml using metal free distilled water. The sample was aspirated into the oxidizing air-acetylene flame and the sensitivity of 1% absorption was observed in the process**.**

Data Processing and Analysis

Data generated from the study were statistically analyzed using SPSS version 20. Descriptive statistics was performed on the generated data, which was converted to percentages, and presented in tables and graphs. The generated data were subjected to one-way analysis of variance (ANOVA) and significance was accepted at $p < 0.05$.

RESULTS

Concentration of heavy metals using different singeing methods

For lead, mean concentrations of 0.0549 ± 0.0099 mg/kg, 0.0394 ± 0.0081 mg/kg, 0.0446 ± 0.0086 mg/kg, 0.0806 ± 0.0678 mg/kg and 0.0220 ± 0.0057 mg/kg were recorded in samples singed with plastic (A), singed with firewood (B), singed with tyre (C), combination of plastic, firewood and tyre (A,B,C), and un-singed hide respectively (Figure 2). Hides singed with plastic materials were significantly ($p < 0.05$) higher when compared with un-singed hide Concentrations of heavy metals observed with the three singeing materials in the hide samples were significantly ($p < 0.05$) higher than those of the individual singeing materials (firewood and tyre). Cadmium recorded mean concentrations of

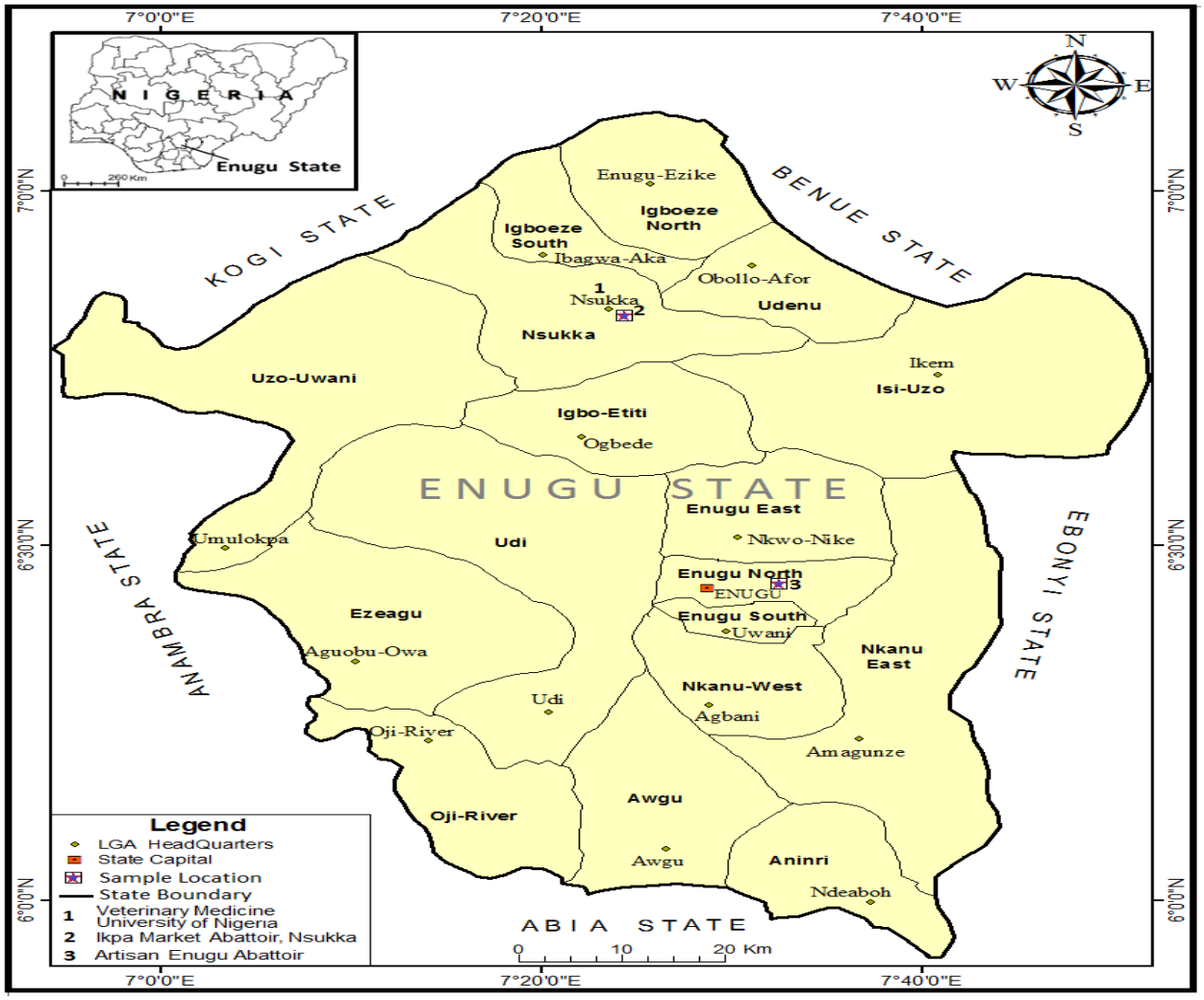

Figure 1: map of the study area showing the sample collection points (Obioha *et al*., 2022 Obioha *et al*., 2024)

0.0093 ± 0.0022 mg/kg, 0.0051 ± 0.0015 mg/kg, 0.0044 ± 0.0013 mg/kg, 0.0145 ± 0.0027 mg/kg and 0.0057 ± 0.0045 mg/kg in samples singed with plastic, singed with firewood, singed with tyre, combination of plastic, firewood and tyre, and un-singed hide respectively (Figure 2). There was no statistical significant difference ($p > 0.05$) observed with the three singeing materials in the hide samples when compared with those of the individual singeing materials and the un-singed. Copper had mean concentrations of 0.0098 ± 0.0019 mg/kg, 0.0077 ± 0.0017 mg/kg, 0.0092 ± 0.0020 mg/kg, 0.0182 ± 0.0031 mg/kg and 0.0034 ± 0.0011 mg/kg in samples singed with plastic, singed with firewood, singed with tyre, combination of plastic, firewood and tyre, and un-singed hide respectively (Figure 2). Hides singed with plastic materials were significantly ($p < 0.05$) higher when compared to un-singed hide. Concentrations of heavy metals observed with the three singeing materials in the hide samples were significantly ($p < 0.05$) higher than those of the individual singeing materials (firewood, tyre and plastic).

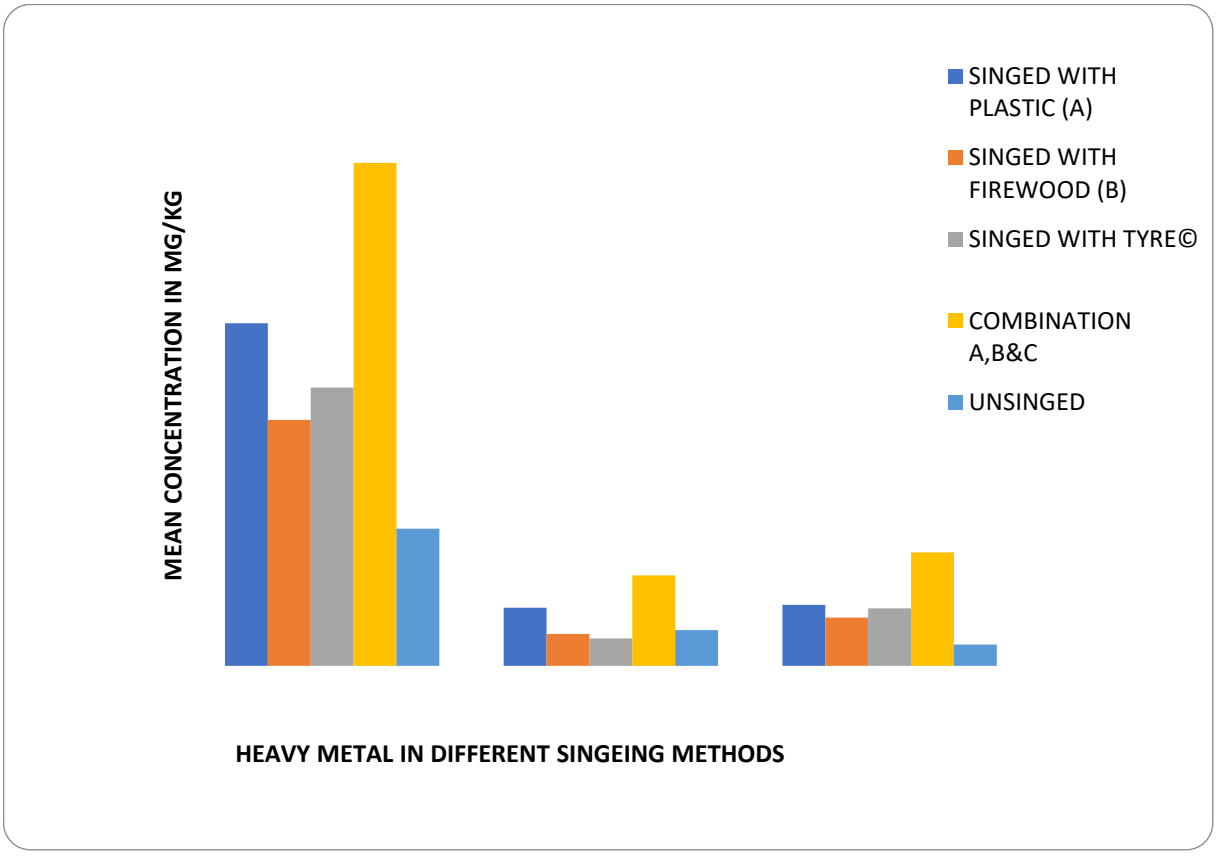

Figure 2: Concentration of heavy metal in different singeing methods

The effect of waste water/effluents from the washing of carcasses on brine shrimp lethality (*Artemia salina* lethality).

The waste water from the washing of the samples singed with plastic materials recorded a mortality rate of 46.7 %, 23.3 % and 3.3 % in concentration of 1000 ppm, 100 ppm and 10 ppm respectively (Table 1). While samples singed with firewood had the mortality rate of 43.3 %, 26.7 % and 3.3 % in concentration of 1000 ppm, 100 ppm and 10 ppm respectively (table 1). Samples singed with spent tyres had a mortality rate of 26.7%, 23.3 %, and 6.7% in concentration of 1000 ppm, 100 ppm and 10 ppm respectively (Table 1). Samples singed with combination of plastic materials, firewood and tyres had a mortality rate of 43.3 %, 26.7 % and 10 % in concentration of 1000 ppm, 100 ppm and 10 ppm respectively (Table 1). The waste water from the un-signed hides recorded zero percent mortality in all the concentrations (1000 ppm, 100 ppm and 10 ppm). Brine shrimp lethality test as shown in Table 1, gave the LC_{50} of the waste water singed with plastic material 1051.27 ppm, firewood 1292.29 ppm, tyres 1384.25 ppm and combination of all the methods 1258.65 ppm at 95 % confidence interval respectively.

Effect of boiling on heavy metal content in singed hides

For lead, mean concentrations of 0.0549 ± 0.0099 mg/kg, 0.0394 ± 0.0081 mg/kg, 0.0446 ± 0.0086 mg/kg and 0.0806 ± 0.0678 mg/kg were recorded in samples singed with plastic materials (A),

firewood (B), tyres (C) and combination of A, B & C before boiling while 0.0375 ± 0.0076 mg/kg, 0.0294 ± 0.0070 mg/kg, 0.0289 ± 0.0064 mg/kg and 0.0492 ± 0.0096 mg/kg were recorded in samples singed with plastic (A), firewood (B), tyre (C) and combination of plastic, firewood and tyre after boiling respectively (Fig.3) . For cadmium mean concentrations of 0.0093 ± 0.0022 mg/kg, 0.0051 ± 0.0015 mg/kg, 0.0044 ± 0.0013 mg/kg and 0.0145 ± 0.0027 mg/kg were recorded in samples singed with plastic materials (A), firewood (B), tyres (C) and combination of A, B & C before boiling while 0.0093 ± 0.0022 mg/kg, 0.0051 ± 0.0015 mg/kg, 0.0044 ± 0.0013 mg/kg and 0.0145 ± 0.0027 mg/kg were recorded in samples singed with plastic (A), firewood (B), tyre (C) and combination of plastic, firewood and tyre after boiling respectively (Fig.3) .Copper had mean concentrations of 0.0098 ± 0.0019 mg/kg, 0.0077 ± 0.0017 mg/kg, 0.0092 ± 0.0020 mg/kg and 0.0182 ± 0.0031 mg/kg recorded in samples singed with plastic materials (A), firewood (B), tyres (C) and combination of A, B & C before boiling while 0.0079 ± 0.0022 mg/kg, 0.0055 ± 0.0017 mg/kg, 0.0066 ± 0.0018 mg/kg and 0.0115 ± 0.0025 mg/kg were recorded in samples singed with plastic (A), firewood (B), tyre (C) and combination of plastic, firewood and tyre after boiling respectively (Fig.3). Combination of the three singeing materials in the lead and copper samples showed that boiling significantly ($p < 0.05$) decreased the mean concentration of lead and copper than in those of the individual singeing materials and un-singed hide.

DISCUSSION

Concentration of heavy metals using different singeing methods were recorded to be highest in samples singed with combination of the three singeing materials (plastic, firewood and tyres), followed by the samples singed with plastic materials, then samples singed with tyres was the third followed by samples singed with firewood and the un-singed samples were the least. Hide singed with plastic materials were significantly ($p < 0.05$) higher when compared to un-singed hide. Concentrations of heavy metals observed with the three singeing materials in the hide samples were significantly ($p < 0.05$) higher than those of the individual singeing materials (firewood, tyre and plastic). This study is an indication that the mode of processing and the source of water for washing singed carcasses contributed to accumulation of these heavy metals concentrations in the singed hides. Our result are in agreement with other findings by Essumang *et al*. (2007), Obiri-Danso *et al.* (2008) and Adam *et al*. (2013) who reported high levels of heavy metal concentration in the hides of cattle singed with damaged tyres. However, this result finding contradicts the work of Eremong *et al.* (2011) who reported decreased level of heavy metal concentration in singed cattle hides.

The Brine shrimp lethality test (BSLT) in this study established the fact that the water effluent contains little potent bioactive compounds. Based on toxicity grading criterion for assessment of effluents and plant extracts (effluents with LC_{50} above 1000 ppm are non-toxic, LC_{50} of 500 - 1000 ppm are low toxic, effluents with LC_{50} of 100 - 500 ppm are medium toxic, effluents with LC_{50} of 0 - 100 ppm are highly toxic) by Meyer *et al.*1982, McLaughlin *et al.* 1991 and Clarkson *et al.* 2004, the compounds were rated non-toxic because of higher LC_{50} (plastic material 1051.27 ppm, firewood 1292.29 ppm, tyres 1384.25 ppm and combination of all the methods 1258.65 ppm).

Table 1: The effect of waste water/effluents from the washing of the singed hides on brine shrimp lethality test

GROUPS	CONCENTRATION (PPM)	NO ALIVE	NO DEAD	% MORTALITY	LC50 (PPM)
(A) SINGED WITH PASTIC	1000 1000 1000 100 100 100 10 10 10	5 7 4 9 5 9 10 10 9	5 3 6 1 5 1 0 0 1	46.7 23.3 3.3	1051.27
(B) SINGED FIREWOOD	1000 1000 1000 100 100 100 10 10 10	7 4 6 7 7 8 10 9 10	3 6 4 3 3 2 0 1 0	43.3 26.7 3.3	1292.29
(C) SINGED WITH TYRE	1000 1000 1000 100 100 100 10 10 10	7 7 8 8 7 8 10 9 9	3 3 2 2 3 2 0 1 1	26.7 23.3 6.7	1384.25
(D)SINGED COMBINATION A,B&C	1000 1000 1000 100 100 100 10 10 10	4 6 7 7 8 7 10 7 9 8	6 4 3 3 2 3 0 1 2	43.3 26.7 10	1258.65

But, continuous consumption of these hides over time might accumulate in the tissues and organs leading to heavy metals toxicity. The Effective concentration$_{50}$ (EC_{50}) value per general bioactivity was approximately 1/10th of the value of the LC_{50} in BSLT (McLaughlin *et al.,* 1991). The EC_{50} of the water effluent was approximated to be 105.13 ppm in plastic material, 129.23 ppm in firewood, 138.43 in tyres and 125.87 ppm in combination of all the methods. The surviving nauplii were dull and inactive which was an indication of central nervous system depression, and possibly the bacteria growth in the water effluent (Mac Laughlin *et al.,* 1991; Allurin *et al.,* 2005).

Boiling of singed hides marginally decreased the mean concentrations of Cu and Pb in all the singeing methods except in cadmium concentrations were there was no reduction in the mean concentration. This report revealed that the concentrations of Cu and Pb were still below the recommended Maximum Permissible Levels of the European Commission Regulations and WHO. Our results are in agreement with the findings by Adam *et al*. (2013). It was speculated that boiling could aid in reducing the heavy metal contents of these meats. The studies however, indicated that boiling singed hides in water has minimal effect on their heavy metal concentrations. Santhi *et al*. (2008) revealed that heavy metals are not destroyed by heat, and therefore cooking might reduce the heavy metal contents of food products, but these substances are not permanently removed from the meat products.

CONCLUSION

The present study showed clearly that slaughtered cattle bio-accumulates different concentrations of heavy metals in hides. The content of lead, cadmium, and copper recorded in slaughtered cattle from Enugu and Nsukka slaughterhouses in the study area falls within similar range recorded in other studies (Essumang *et al*., 2007; Obiri-Danso *et al.,* 2008; Obioha *et al.,* 2022 and Obioha *et al.,* 2024). But, levels of those samples that far exceeded the maximum permissible levels may therefore pose human health risk to cattle consuming populace of the Nsukka and Enugu communities. It could also be concluded that the presence of the lead, cadmium, and copper concentration in slaughtered cattle in the present study was as a result of environmental factors such as soil, topography and rainfall, singeing methods and materials. Furthermore, singeing of cattle with tyres, plastic materials and firewood increases the contents of heavy metal concentration in the hides. Boiling of these singed hides marginally reduced the heavy metal contamination. Therefore, meat and meat products of slaughtered cattle at Enugu and Nsukka slaughterhouses, Enugu State, Nigeria, seem to be safe for consumption based on the international recommended level.

REFERENCES

ADAM, I., OKYERE, D., AND TEYE, M. (2013): Assessment of heavy metal residues in hides of goats singed with tyres, and the effect of boiling on the heavy metal concentrations in the hides. *Journal of Veterinary Advances*, 3: 165-169. DOI: 10.5455/jva.20130531104440

ADRIAN W.J. (1973):A Comparison of a Wet Pressure Digestion Method with Other Commonly Used Wet and Dry – Ashing Methods. Analyst 98,213.

AKAN, J.C., ABDULRAHMAN, F.I., & SADIPO, O.A. (2010): Distribution of heavy metals in the liver, kidney and meat

of beef mutton caprine and chicken from kasuwanshanu market in Maiduguri metropolis Borno State Nigeria. *Research J of Appl Sci Engg Technol*. pp743-748.

ALLURIN., U.K., TAYI, V.M., ROA-DODDA ,S., MULABAGAL, V., HSIN-SHIN, T., & GUTTUMUKKAVA, V.S. (2005): Assessment of bioactivity of India medicinal plant using brine shrimps. *International J. Appl. Sci. Eng*, 3:125-134.

AMBUSHE , A.A., HLONGWANE ,M.M., MCCRINDLE, R.I.,& MCCRINDLE, C.M.E. (2012): Assessment of Levels of V, Cr, Mn, Sr, Cd, Pb and U in Bovine Meat. *S. Afr. J. Chem*, 65:159–164,

BADIS, B., RACHID, Z AND ESMA, B (2014): Levels of selected heavy metals in fresh meat from cattle sheep, chicken and camel produced in Algeria. *Ann Res Rev Biol*, 4: 1260-1267.

BALA, A., MUHAMMADA, L. U., JUNAIDUB, A.U., SALIHUB, M. D., MAGAJIB, A.A., FALEKE, O.O., SAULAWAB, M.A., ANZAKUC, S. A., ONIFADE K.I., PEWAND, S.B., & EMENNA P. (2012): survey of lead residue in kidney and liver of slaughtered Cattle in Sokoto central abattoir, Sokoto State, Nigeria. *Journal of Veterinary advances*, 2(3): 132-138

BAYKOV, B.D., STOYANOV, M.P., & GUGOVA, M.L (1996): Cadmium and lead bioaccumulation in male chickens for high food concentrations. *Toxicological and Environmental Chemistry*, 54: 155-159.

CLARKSON, C., MAHARAJ, V.J., CROUCH, N.R., GRACE, O.M., PILLAY, P., MATSABISA, M. G., BHAGWANDIN, N., SMITH, P.J & FOLB, P.I. (2004): *In vitro* antiplasmodial activity of medicinal plants native to or naturalized in South Africa. *J Ethnopharm*, 92: 177-191.

EKE, I. G., OBIOHA, F.C & ANAGA, A.O (2013): Evaluation of the Methanolic Rhizome Extract of Anchomanes difformis for Analgesic and Antipyretic Activities *International Journal of Basic and Applied Sciences*, 2 (4): 289-296

ESSUMANG, D.K., DODOO, D.K., ADOKOH, K.C., KOKA, V., NKRUMAH, B.N & NUER, A.C.D (2007): Heavy metal levels in singed cattle hide (wele) and its human health implications. Proceedings – The First International Conference on Environmental Research, Technology and Policy, ERTEP 2007, Accra, Ghana. Book of Abstracts, p.19.

EREMONG, D.C., AKWETEY, W.Y & DONKOH, A (2011): Chemical composition of cattle hide processed using four different procedures. Proceedings of the Seventeenth Biennial Conference of the Ghana Society of Animal Production, Pp 69-73.

FAO (FOOD AND AGRICULTURE ORGANIZATION) (1985): Manual of the Slaughter of Small Ruminants in developing countries: Slaughtering practices and techniques. *FAO Animal Production and Health Paper* No. 49.

FELIX, O.C., EKENE E., JOHNBOSCO, U.C & ANELON, N.J (2016a): Assessment of

cadmium (Cd) residues in organs and muscles of slaughtered pigs at Nsukka and environs in Enugu State, Nigeria. *J. Vet. Med. Anim. Health,* 8(11): 199-206.

FELIX, O.C., JOHN, N.A & EKENE, E.V (2016b): Assessment of lead (Pb) Residues in Organs and Muscles of Slaughtered Pigs at Nsukka and Environs in Enugu State, Nigeria. *Journal of Advanced Veterinary and Animal Research,* 3(4): 392-398

GAUTAM, P & IRFAN A (2011): Heavy metals contamination assesment of Kanhargaon Dam water near Chhindwara city. *Acta Chim. Pharm. Indica,* 1(1): 7-9

MCLAUGHLIN, J.L., CHANG, C & SMITH, D.L (1991): Bench-top bioassays for the discovery of bioactive natural products; An Update. In: Rhaman AU (Ed.), Studies in Natural Products Chemistry. Elsevier, Oxford. pp. 383-409.

MEYER, B.N., FERRIGNI, N.R., PUTNAM, J.E., JACOBSEN, L.B., NICHOLS, D.E & MCLAUGHLIN, J.L (1982): Brine Shrimp: A convenient general bioassay for active plant constituents. *Planta Medica*. 45: 31-34.

NATIONAL POPULATION COMMISSION (NPC) (2006). Census data. National Population Commission. Nigeria.

OBIOHA, F. C., OBODOECHI, L.O & UKOHA, J.C (2016): Evaluation of mercury (hg) andarsenic (as) residues in organs and muscles of slaughtered pigs at Nsukka slaughter house in Enugu State, Nigeria. *Int J Cur Res Rev*, 8(24): 26-32.

OBIOHA, F.C., NWANTA, J.A., AND ANAGA, A.O. (2022): Survey of Heavy Metals Residues in muscle and internal organs of Slaughtered Cattle in Enugu State, Nigeria. *Journal of Agriculture and Veterinary Science (IOSR-JAVS).* 15 (12):31-38. DOI: 10.9790/2380-1512013138

OBIOHA F.C., ANAGA, A.O., AND NWANTA, J.A. (2024). Evaluation of the concentration of some heavy metals in cattle hides singed in Enugu and Nsukka abattoirs, Enugu State, Nigeria. Journal of veterinary and applied sciences, 14(2): 668 – 676

OBIRI-DANSO, K., HOGARH, J.N & ANTWI-AGYEI, P (2008): Assessment of contamination of singed hides from cattle and goats by heavy metals in Ghana, *African Journal of Environmental science and Technology*, 2(8): 217-221.

OKIEI, W., OGUNLESI, M., ALABI, F., OSIUGHWU, B & SOJINRIN, A. (2009): Determination of toxic metal concentrations in flame treated meat products, Ponmo. *African Journal of Biochemistry Research,* 3(10), 332 - 339

SANTHI, D., BALAKRISHNAN, V., KALAIKANNAN, A & RADHAKRISHNAN, K.T (2008). Presence of heavy metals in pork products in Chennai (India). *Amer. J. Food Tech*, 3(3): 192-199.

WHO (1996): Trace elements in human nutrition and health. World Health Organization, Geneva.