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COMPARATIVE ANALYSIS OF CATTLE HIDE SINGED WITH SCRAP TYRE AND CATTLE HIDE SINGED WITH FIREWOOD IN ABUJA, NIGERIA

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ABSTRACT

Cattle hide (kanda) meant for consumption is often processed by singeing with scrap tyres as substitute for firewood by many local butchers in Nigeria. This study examined such singed hides from five cattle in a local abattoir in Kubwa, Abuja, for proximate composition and heavy metals (Mn, Cu, Zn, Ni, Mg, Cd and Pb) contamination using standard methods. The proximate composition of the kanda singed with scrap tyres (KT) and the kanda singed with firewood (KF) were: KT, KF; 54.38, 57.86; 1.62, 2.01; 42.17, 38.25; 1.07, 1.05; 0.40, 0.45; 0.36, 0.38; for moisture, fat, protein, ash, carbohydrate, fibre respectively as compared to the control (KC) which was processed by scalding using hot water: 56.24, 1.43, 39.65, 0.48, 0.89, 1.31 respectively. Further, the mean concentrations (mg/kg) of Mn, Cu, Zn, Ni, Mg, Cd and Pb in KT and KF were 1.21, 0.34; 24.83, 18.13; 195.86, 170.13; 2.55, 1.29; 73.01, 52.04; 2.18, 2.00; and 2.45, 2.10 respectively as against the control (0.32, 15.62, 158.60, 1.20, 38.10, 2.01, 4.63) respectively. These results indicated no significant different ($p < 0.05$) in the proximate composition between the two methods and the control. KT had higher heavy metal contents than KF with Zn recorded as the highest concentration in all. Pb values were lower in both KT and KF than in the control. It was observed that high concentrations of the heavy metals in singed hides could not be wholly attributed to the singed treatment as considerable background levels of heavy metals were recorded in the control samples.

Keywords: Contamination, heavy metals, proximate composition, singed cattle hide,

INTRODUCTION

Abattoirs and slaughterhouses are where animals such as cattle, sheep and goats are slaughtered and processed for human consumption as meat. When these animals are slaughtered, the skin/hide is often separated from the flesh for proper treatment by method of singeing.

Meat is generally consumed as a source of protein with a great quantity of it eaten as beef and/or processed to obtain cattle hide popularly known as “kanda” in the northern part or “ponmo” in the southern part of Nigeria [1, 2]. Although hide and skin are mainly used in leather production in most countries including Nigeria, a good number of it are processed by singeing into kanda or ponmo which serves as delicacies (local dishes like Nkwobi, Ngwongwo, Isiewu, etc) in many homes and eateries in Nigeria [3, 4]. In other West African countries such as Ghana, kanda or welle as popularly called in Ghana and the Caribbeans, are important ingredients of stews and soups [1, 5].

The method of processing this kanda by singeing with scrap tyres as substitute for firewood by many local butchers in Nigeria is of great concern due to associated contamination by heavy metals and other related contaminants thereby putting the health of end users at risk [2, 6].

In a local abattoir in Kubwa, Abuja, singeing with scrap tyre or firewood as a source of fuel is a common practice and have become the major method of removing the hair from the skin of slaughtered ruminant animals such as cattle. In recent times, there has been a surge in the use of scrap tyres as fuel source for the singeing which is attributed to the scarcity and high cost of firewood [7-9]. The practice, though unconventional and potentially dangerous, is increasingly favoured by local butchers who resort to use it as alternative source of fuel with some other reasons that fire from the scrap tyres is able to selectively burn off the animal fur without cracking the hide [4, 10].

Scrap tyres are known to contain hazardous compounds such as styrene, furan, 1, 3-butadienes, polycyclic aromatic hydrocarbons (PAH), benzene and a host of heavy metals which are detrimental to health due to their carcinogenic and other poisonous attributes [7, 11-13]. Ziadat and Sood reported that the Environmental Protection Agency (EPA) does not consider scrap tyres to be hazardous, but the burning of the scrap tyres is documented to be hazardous due to the array of carcinogenic, teratogenic, and mutagenic chemical compounds emitting from the process [14]. This process of singeing slaughtered animals with scrap tyres may act as a predisposing factor for the contaminants to accumulate in the hide and skin of animals which in effect may compromise the quality by rendering it unsafe for human consumption [15 -17]. The danger associated with heavy metals such as lead, mercury, cadmium, chromium, zinc, arsenic, iron, etc. from scrap tyres when used as source of fuel for singeing is becoming alarming due to persistent practice and potential contamination of cattle hide in respect of food safety and consumer health [16]. These heavy metals are of public health concern because of their toxic nature even at relatively minute concentrations, bioaccumulation and bio magnifications in the food chain [5, 18]. According to Odipe *et al* food safety has become one of the ten threats to global health as the outbreaks of food-borne diseases had caused approximately 76 million illness, 325,000 hospitalizations and 5000 deaths yearly [19]. However, 60-75% of such illness is associated with the consumption of contaminated foods of animal origin.

Researchers have shown that heavy metals have also been associated with some adverse health effect including allergic reactions, neurotoxicity, nephrotoxicity and cancer [4, 20-24]. Although some hazardous substances may occur naturally through some natural phenomenon (like earthquake and volcanic eruption), man and his activities still remain the major source of these noxious constituents [20, 22].

Although kanda is consumed widely and is part of the Nigerian food culture, there are controversies concerning its production and consumption [25]. Consumers have misconceptions about the nutritional quality of kanda with the belief that it has little or no nutrient [9, 26]. This could be due to inadequate data available in some food composition tables like kanda and the processing methods applied to boost its eating quality and consumers' acceptability.

This study therefore aimed at evaluating the proximate composition and heavy metals accumulation in scrap tyre-singed hide compared to that singed with fire wood. The work will benefit the teaming populace to have a broad knowledge about kanda or ponmo and also assist policy makers to have more information to enable better decision making.

MATERIALS AND METHODS

Description of the Study Area

Abuja is the capital and eighth most populous city of Nigeria and makes up approximately 6% of the land area of Nigeria. It has been reported to cover an area of approximately 1,769 km² (683 m^2) representing about 6.15% of Nigeria [27]. At the 2006 census, the city of Abuja had a population of 776,298 making it one of the ten most populous cities in Nigeria (placing eighth in 2006). According to the United Nations, Abuja grew by 139.7% between 2000 and 2010, making it the fastest growing city in the country. As at 2021, the population of Abuja is estimated at 3,652,029 with a growth rate of 5.42% [28]. Abuja lies approximately between Longitude 7° 29' 28.6872" East and Latitude 9° 4' 20.1504" North of the equator. It has six Area Councils namely:

Abaji, Abuja Municipal, Kwali, Gwagwalada, Kuje, and Bwari. Kubwa is a satellite town in Bwari Area Council where the study was carried out. The indigenous inhabitants of Abuja are the Gbagyi (Gwari), with the Gbagyi language being the major of the regional languages which are Bassa, Gwandara, Gade, Dibo, Nupe and Koro [28].

REAGENTS

All chemicals and reagents were of analytical grade and of the highest purity. They were supplied by BDH Labs (UK), BDH Chemicals Limited, Poole, England. These include: sodium hydroxide, sulphuric acid, ethyl alcohol, Antifoam emulsion, potassium sulphate, copper sulphate, hydrochloric acid, boric acid, methyl red, bromocresol green, petroleum ether, chloroform, methanol and nitric acid.

SAMPLE COLLECTION, PREPARATION AND TREATMENT

Freshly slaughtered cattle hides were purchased from a local abattoir in Kubwa, Abuja, Nigeria and the total number of cattle hide used for this study was fifteen (15) samples from five (5) cattle. The samples were divided into three groups coded KT, KF and KC. Each group was allocated to a different singeing treatment process. Sample KT was processed by singeing with scrap tyres as fuel source while Sample KF was processed by singeing with firewood. The processed hide was taken from each treatment, scrapped and washed in excess clean water. Sample KC, which served as the control, was processed by scalding using hot water at 100 ^oC for sixty (60) minutes to allow softening of the hair, after which the hair was scrapped off from the skin using a newly purchased razor blade to obtain fine smooth skin. The shaved skin was rinsed properly with clean water to get rid of hair particles. Samples were carefully cut into pieces and placed in an air tight bag in an ice box and immediately transported to the laboratory for further analysis. Each sample was oven dried at 105 ^oC to a constant weight and the resulting samples were pulverized in a porcelain mortar and then stored in a desiccator for chemical analysis.

DETERMINATION OF PROXIMATE COMPOSITION

Samples of cattle hides processed with scrap tyre, firewood, and control were analyzed for proximate composition (moisture, ash, carbohydrate, crude protein, crude lipid and crude fibre) according to the method of AOAC [29]. All determinations were carried out in triplicate and reported in percentage. The moisture content was determined by the measurement of weight loss due to evaporation of moisture in hot air oven and the weight loss after drying at 105 ^oC to a constant weight. Micro-Kjeldahl's method was employed in determining the crude protein from the total nitrogen content of the sample, which is mainly from the protein and other non-protein nitrogenous compounds such as amides and ammonium compounds. Crude fibre was determined gravimetrically after chemical digestion and solubilization of other materials present. The fibre residue weight was then corrected for ash content after ignition. Crude lipid was determined by subjecting the dried sample to extraction with petroleum ether using the soxhlet apparatus. The organic soluble substances thus removed were collected in a flask, dried and weighed. Ash content was determined by igniting a known amount of moisture free sample in a muffle furnace at 550 ºC for 4 hours and then weighed after cooling to room temperature. The carbohydrate was determined by calculating the percent remaining after all the other components have been measured based on methods outlined in AOAC [29].

DETERMINATION OF HEAVY METALS CONTENT

The heavy metals concentrations were determined using wet digestion method according to Napoleon *et al* with slight modification [2]. About 1g of each sample was carefully weighed into a 100 ml volumetric flask and 10 ml of binary acid mixture HNO_3: HCI (3:1) was added to the sample. The flask was gently swirled for the content to mix thoroughly. The flask with the content was then placed on a hotplate and heated at 200 ˚C in a fume hood until the solution became clear with no fumes. The flask was allowed to cool and the content was made up with distilled water to 50 ml in the volumetric flask and filtered through whatman No.1 filter paper into another 50 ml volumetric flask. The final digest was used for determination of the heavy metals (Mn, Cu, Zn, Ni, Mg, Cd and Pb) using atomic absorption spectrophotometer (AAS) (iCE 3000 Series). Blank solution was also prepared similarly as the entire digestion process but without the cattle hide sample [30].

PREPARATION OF CALIBRATION STANDARDS

For calibration of the instruments, a series of five standard solutions were prepared by serial dilution of the stock standard solutions (1000 mg/l) of the metals to be analyzed.

STATISTICAL ANALYSIS

All the statistical analyses were performed using statistical software SPSS version 25.0. Means among applied treatments were compared by one-way analysis of variance (ANOVA). The relationship among the parameters determined was carried out using pearson correlation analysis.

RESULTS AND DISCUSSION

The results of the proximate composition analysis are presented in Table 1 while the Descriptive Statistics of the analyzed parameters are presented in Table 2. From the results, the kanda singed with firewood, sample KF, had the highest moisture content of 57.86% followed by sample KC which acted as the control with a moisture content of 56.24% while sample KT which involved singeing with scrap tyre as source of fuel had the least moisture content of 54.38%. It was observed that there was no significant difference ($p > 0.05$) in the moisture content of all the three (3) samples. The moisture contents recorded from the samples in this study was higher than the moisture contents (17.37% - 20.01%) of boiled and singed hides reported by Ijeoma *et al* [3] and the moisture contents of similar research reported by Woko *et al* [13] except in their control sample which recorded 62.19%. According to Woko *et al* [13], samples with high moisture content have low shelf life because micro-organisms thrive or grow more in food with high moisture content. High moisture content of some foods reduces its keeping quality and storage value [3].

Table 1: Proximate Composition of the Analyzed Samples

Parameters (%)	Sample KT (%)	Sample KF (%)	Sample KC (%)
Moisture Content	54.38	57.86	56.24
Crude Fat	1.62	2.01	1.43
Crude Protein	42.17	38.25	39.65
Ash Content	1.07	1.05	0.48
Carbohydrate	0.40	0.45	0.89
Fibre Content	0.36	0.38	1.31

The highest fat content (2.01%) was recorded in sample KF while sample KT had a fat content of 1.62% which was higher than the control. The control sample had the least fat content which was significantly ($p < 0.05$) lower than the fat content of the rest of the samples. The difference in the fat content may be attributed to the source of heat and duration of singeing of the cattle hides. [25]. Percentage crude protein values for samples KT, KF, KC were 42.17, 38.25 and 39.65 respectively (Table 1). It was observed that sample KT had protein value higher than samples KF and KC with sample KF having the lowest crude protein of 38.25%. There was significant difference ($p < 0.05$) between the crude protein values of the two singeing methods but the difference between the protein values of samples KF and KC was not statistically significant ($p >$

0.05). The percentage crude protein values recorded in the present study are higher than those reported by Ahmed *et al*. [26] and similar to the report of Woko *et al* [13] but lower than the values of the work of Akwetey *et al* [1].

The ash contents recorded for samples KT, KF and KC were 1.07%, 1.05% and 0.48% respectively which showed that the singed samples (samples KT and KF) had higher percentage ash contents than the boiled sample (control). This could be attributed to the singeing effect brought about by the processing methods. It was observed that there was no significant ($p > 0.05$) difference between the ash contents of samples KT and KF, but there was a significant difference ($p < 0.05$) between the control and the singed samples.

Table 2: Descriptive Statistics of the Analyzed Parameters

Parameters	Units	Minimum	Maximum	Mean	Std. Deviation	% CV
Moisture Content	%	54.38	57.86	56.54	1.61	2.85
Crude Fat	%	1.43	2.01	1.76	0.30	18.96
Crude Protein	%	38.25	42.17	40.71	1.92	4.71
Ash Content	%	0.48	1.07	0.78	0.26	28.37
Carbohydrate	%	0.40	0.89	0.60	0.21	33.31
Fibre Content	%	0.36	1.31	0.73	0.43	67.22
Manganese (Mn)	mg/kg	0.32	1.21	0.68	0.41	59.37
Copper (Cu)	mg/kg	15.62	24.83	19.29	3.52	24.78
Zinc (Zn)	mg/kg	158.60	195.86	172.28	14.23	8.26
Nickel (Ni)	mg/kg	1.20	2.55	1.61	0.55	35.36
Magnesium (Mg)	mg/kg	38.10	73.01	50.31	13.64	22.80
Cadmium (Cd)	mg/kg	2.00	2.18	2.15	0.14	9.91
Lead (Pb)	mg/kg	2.10	4.63	3.30	1.03	31.18

The carbohydrate values for samples KT and KF which recorded 0.40% and 0.45% respectively were lower than that recorded for sample KC, 0.89% which was the control. This signified that singeing reduced the carbohydrate contents of the cattle hide. There was a significant difference ($p < 0.05$) between the singed and the unsinged samples but the differences observed between the carbohydrate contents of samples KT and KF were statistically not significant ($p > 0.05$). The fibre contents as recorded for samples KT, KF, and KC were 0.36%, 0.38% and 1.31% respectively (Table 1). The percentage fibre contents of samples KT and KF were significantly lower ($p < 0.05$) than the fibre content of the control sample which indicated that percentage fibre decreased with singeing. Similarly, there was a significant difference ($p < 0.05$) between the fibre contents of the singed and unsinged samples but the differences observed between samples KT and KF were not statistically significant ($p > 0.05$). The processed cattle hide (kanda or ponmo) in either form is rich in fibre and is a good source of roughage in meal [16]. The fibre contents of the samples recorded in this study is in agreement with the work of Woko *et al*. [13] but lower than the values recorded by Okeola *et al*. [16].

Results of the different singeing methods on the concentration of heavy metals in the cattle hide are presented in Table 3. The concentration of manganese in sample KT (1.21 mg/kg) and sample KF (0.34 mg/kg) were higher than that of the control sample (0.32 mg/kg) with a mean concentration of 0.6160±0.37 mg/kg (Table 2). More so, the concentration of manganese in sample KT singed with scrap tyre was significantly higher ($p < 0.05$) than the manganese contents in sample KF processed with firewood but there was no significant ($p > 0.05$) difference between the manganese contents in samples KF and KC.

Table 3: Heavy Metals Concentration of the Analyzed Samples (mg/kg)

Heavy Metals	Sample KT	Sample KF	Sample KC
Manganese (Mn)	1.21	0.34	0.32
Copper (Cu)	24.83	18.13	15.62
Zinc (Zn)	195.86	170.13	158.60
Nickel (Ni)	2.55	1.29	1.20
Magnesium (Mg)	73.01	52.04	38.10
Cadmium (Cd)	2.18	2.00	2.01
Lead (Pb)	2.45	2.10	4.63

Copper concentration was highest in sample KT (24.83 mg/kg) which was above the maximum permissible limit of 20.0 mg/kg set by USDA and ECR [31, 32]. This was followed by sample KF (18.13 mg/kg) and the least Cu concentration was recorded in sample KC (15.62 mg/kg) with a mean concentration of 18.40±4.56 mg/kg (Table 2). The concentrations of Cu in sample KT and sample KF were significantly higher ($p < 0.05$) than the concentration in sample KC which was the control. High concentrations of Cu had been reported to cause anorexia, fatique, premenstrual syndrome, depression, anxiety, liver and kidney damage, migraine headaches, allergies and childhood hyperactivity [10, 15].

Similar trend was observed in the concentrations of zinc (Zn), nickel (Ni) and magnesium (Mg) for sample KT (195.86 mg/kg, 2.55 mg/kg and 73.01 mg/kg), sample KF (170.13 mg/kg, 1.29 mg/kg and 52.04 mg/kg) and sample KC (158.60 mg/kg, 1.20 mg/kg and 38.10 mg/kg) respectively. Zinc recorded the highest values among all the metals analyzed in all the samples and the concentrations of Zn and Ni exceeded the USDA recommended limits of 50 mg/kg and 0.05 mg/kg in meat respectively. However, the values of Zn, Ni and Mg as reported cannot be attributed to the singeing methods only considering the corresponding high values of these metals recorded in the control sample. It has been reported that there was a close relationship between heavy metal concentration in cattle tissues and their concentrations in associated soils, feeds and sources of drinking water [1, 19, 33]. Therefore, the results recorded in this study are in agreement with the works of other researchers that attributed heavy metals in cattle hide to other environmental conditions rather than the processing methods only [1, 17, 18]. Sample KT recorded the highest level of Cd (2.18 mg/kg) compared to sample KF with firewood (2.00 mg/kg) and the control (2.01 mg/kg) with a mean concentration of 2.2040±0.22 mg/kg. More so, the concentrations of Cd in all the samples were above the maximum permissible limit of 0.05 mg/kg in meat sample but the differences of Cd concentrations observed across the samples were not statistically significant ($p > 0.05$). Cadmium may accumulate in the kidney and liver and because of its long biological half-life may lead to kidney damage [3]. It has been reported that consumption of Cd even at very low concentrations can be toxic and it has no known bio-importance in human biochemistry and physiology [15, 20].

The concentrations of Pb in samples KT and KF were 2.45 mg/kg and 2.10 mg/kg respectively which was seen to be significantly lower ($p < 0.05$) than the Pb concentration (4.63 mg/kg) in sample KC. However, in all samples KT, KF and KC, the concentration of Pb also exceeded the USDA and ECR recommended threshold of 0.1 mg/kg in meat sample with a mean value of 3.32±1.04 mg/kg. The high value of Pb recorded in sample KC could be due to the source of water used during the sample preparation. The pattern of Pb concentrations recorded in this study is in consonance with the works of Obiri-Danso *et al* [17] and Ekenma *et al*. [15] but in variance with the works of Napoleon *et al* [2] and Egwuonwu *et al* [5] who recorded increase in the concentrations of all metals in the singed cattle hides analyzed compared to the unsinged control sample. Further, the observations of Pb recorded in this work contradict the findings of Akwetey *et al* [1] and Woko *et al* [13] who did not detect Pb in any of the singed and unsinged samples. Pb is known for its neurotoxic and nephrotoxic effect even in minute concentrations and chronic/acute lead poisoning could result to cardiac and vascular damage [23, 33]. It can also cause severe health problems such as reduced haemoglobin formation, thus leading to anemia [2, 10, 23]. High level of Lead in foods can cause lead encephalopathy in adults with early symptoms including dullness, headache, muscular tremor and loss of memory. [3].

EVALUATION OF THE RELATIONSHIP OF THE PARAMETERS ANALYSED

The results of the correlation analysis of the examined parameters are displayed Tables 4. The result obtained showed that positive and negative correlations existed between the examined parameters.

Table 4: Pearson Correlation Coefficient Matrix for the Samples

	Moisture	Fat	Protein	Ash	CBH	Fibre	Mn	Cu	Zn	Ni	Mg	Cd	Pb
Moisture	1												
Fat	0.077	1											
Protein	-0.662	0.194	1										
Ash	-0.245	0.385	-0.034	1									
CBH	0.351	-0.625	-0.268	-.926*	1								
Fibre	-0.165	-0.119	0.163	-0.805	0.661	1							
Mn	-0.299	-0.326	0.490	0.309	-0.294	-0.583	1						
Cu	-0.410	-0.163	0.390	0.637	-0.586	-0.748	.924*	1					
Zn	-0.701	0.121	0.517	0.773	-0.805	-0.574	0.676	0.873	1				
Ni	-0.795	-0.031	0.643	0.597	-0.650	-0.425	0.743	0.869	.970**	1			
Mg	-0.599	0.034	0.304	0.851	-0.796	-0.688	0.652	.886*	.971**	.911*	1		
Cd	0.009	0.069	0.688	-0.154	-0.055	-0.178	0.682	0.441	0.215	0.309	0.070	1	
Pb	-0.016	-0.373	0.181	-.961**	0.854	.912*	-0.322	-0.611	-0.637	-0.440	-0.744	0.087	1

*. Correlation is significant at the 0.05 level (2-tailed).**. Correlation is significant at the 0.01 level (2-tailed). '-' sign denoted negatively correlated

Statistically, a high positive correlation (> +0.65) indicates that a change in one parameter will cause a similar change in the other parameter and a high negative correlation (< -0.65) indicates that a change in one parameter will cause a change in the other parameter but in the opposite direction [28].

From Table 4, a strong positive significant relationship was observed between Zn versus Ni (r = 0.970, p< 0.01) and Zn versus Mg (r = 0.971, *p*<0.01) deducing that they could be from similar source. Further, a moderately positive significant correlation was seen between Fibre versus Pb (r = 0.912, *p*< 0.05), Mn versus Cu (r = 0.924, *p*<0.05), Cu versus Mg (r = 0.886, *p*<0.05) and Ni versus Mg (r = 0.911, *p*<0.05) in the correlation matrix. More so, a strong negative significant correlation was observed between Ash versus Pb (r = -0.961, *p*< 0.01) and a moderately negative significant relationship was seen between Ash versus Carbohydrate (r = -0.926, *p*< 0.05). Other relationships between various quantitative variables were also seen with the least correlation values. These results of correlation can prove useful in understanding the relationships between the proximate composition and heavy metals of the cattle hide samples.

CONCLUSION

This study was carried out to evaluate the proximate composition and heavy metals accumulation in scrap tyre-singed hide compared to that singed with fire wood. This result indicated that there was no significant different ($p < 0.05$) in the proximate composition between the two methods of singeing while also showing that cattle hides from Kubwa abattoir accumulated varying amounts of heavy metals. Sample KT had higher heavy metal contents than sample KF with Zn recorded with the highest amount of heavy metal in all samples. Pb values were lower in both samples KT and KF than KC. These reports are indications that the mode of processing and the source of water used during treatment may have direct effects on the heavy metal concentrations of the cattle hide. High concentrations of the heavy metals in singed hides could not be wholly attributed to the singed treatment alone, due to the considerable background levels of heavy metals recorded in the control sample, a situation that reveal a bigger problem of heavy metal contamination in what we consume.

REFERENCES

[1] Akwetey, W.Y., Eremong, D.C. & Donkoh, A. (2013). Chemical and nutrient composition of cattle hide ("welle") using different processing methods. *Journal of Animal Science*. 3(4),176-180. DOI: 10.5455/jasa.20130430123444

[2] Napoleon, J. M., Samuel, A., Servacious, A., Bayaa, M., Bieranye, S. & Sebiawu, E. G. (2019). Residual Levels of Heavy Metal Contaminants in Cattle Hides Singed with Scrap Tyre and Firewood Fuel Sources: A Comparative Study in the Wa Municipality of Ghana. *American Journal of Environmental Science & Technology*. 3(1), 1 – 11.

[3] Ijeoma, L., Ogbonna, P. & Effiong, I. D. (2015). Effects of various methods of singeing on the heavy metal, proximate and sensory properties of singed cow hide (Ponmo). *Scholars Research Library, Archives of Applied Science Research.* 7(4), 44-50.

[4] Godwin, A. E., Emmanuel, U. D. & Uwemedimo, E, U. (2020). Effect of Singeing Materials on Distribution of Some Metals in Liver and Kidney Samples of Capra aegagrushircus Slaughtered in Uyo Village Road Abattoir in Niger Delta Region of Nigeria and Health Risk Assessment. *International Research Journal of Pure & Applied Chemistry*. 21(2), 34-45.

[5] Egwuonwu, F. C., Abubakar, A. & Hamzah, R. U. (2019). Effect of different dehairing methods on the concentrations of some heavy metals in cow tail sold in Minna Abattoir. *GSC Biological and Pharmaceutical Sciences,* 8(3), 79-84.

[6] Oladapo, T., Okareh, O., Oshinloye, A. & Dada, A. (2021). Polycyclic Aromatic Hydrocarbon Accumulation in Meats Singed with Kerosene and Waste Tyres: A Case for Public Health Concern in Nigeria. *World News of Natural Sciences*. 38, 49-59.

[7] Nnaji. J., Madu, E. & Chukwuemeka-Okorie, O. (2017). Polycyclic aromatic hydrocarbons (PAHs) content in cattle hides and meat singed with scrap rubber tyres. *JASEM*. 21(6), 1105-1110.

[8] Adam, I., Okyere, D. & 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(5), 165-169. DOI: 10.5455/jva.20130531104440

[9] Ebuete, A. W., Isiya, S., Ndiwari, L. E., Ebuete, I. Y. & Walson, P. T. (2020). The Food and the Poison, a Retrospect of Abattoir, Butcher Markets and Buckateria in Nigeria: An Emperical Study. *American J Epidemiol Public Health*. 4(1), 024-031.

[10] Okiei, W., Ogunlesi, M., Alabi, F., Osiughwu, B. & Sojinrin, A. (2009). Determination of toxic metal concentrations in flame treated meat products, ponmo. *Afr. J. Biochem. Res*. 3(10),332-339.

[11] Ofomata, I. B., Nwankwo, I. O., Ogugua, A. J., Ezenduka, E.V., Nwanta, J. A. & Obidike, R. I. (2020). Detection of polycyclic aromatic hydrocarbons in hide and skin of slaughtered cattle and goats in Anambra State, Nigeria. *Journal of Food Quality and Hazards Control*. 7, 119-127.

[12] Emmanuel, U. D., Uwemedimo, E. U., Godwin, A. E. & Akaninyene, U. U. (2020). Health Risk Assessment of Polycyclic Aromatic Hydrocarbons (PAHs) in Singed Capra aegagrusHircus Meat from Uyo Municipal Abattoir in Southern Nigeria. *Journal of Applied Sciences.* 20, 67-75.

[13] Woko, E. C, Ibegbulem, C.O. & Alisi, C.S. (2021). Polycyclic Aromatic Hydrocarbon, Heavy Metal, Derivable Metabolic Water and Energy Content of Cattle Hides Processed by Singeing. *IOSR Journal of Environmental Science, Toxicology and Food Technology*. 14(7): 07-13. DOI: 10.9790/2402-1507010713

[14] Ziadat, A. H. & Sood, E. (2014). An Environmental Impact Assessment of the Open Burning of Scrap Tires. *Journal of Applied Sciences.* 1(4), 2695-2703.

[15] Ekenma, K., Anelon, N. J. & Ottah, A. A. (2015). Determination of the presence and concentration of heavy metal in cattle hides singed in Nsukka abattoir. *Journal of Veterinary Medicine and Animal Health.* 7(1),9-17.

[16] Okeola, F.O., Babamale, H.F. & Ifia, O.H. (2019). Comparative Study of Proximate and Mineral Compositional Values of Processed CowHide and Soya Bean Cheese. *International Journal of Phytofuels and Allied Sciences.* 8(1), 32-38.

[17] 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.

[18] Nkansah, M. A. & Ansah, J. K. (2014). Determination of Cd, Hg, As, Cr and Pb Levels in Meat from the Kumasi Central Abattoir. *International Journal of Scientific and Research Publications*. 4(8), 57 – 68.

[19] Odipe, O. E., Olalekan, R. M., Sanchez, N. D., Abdulraheem, A. F., Okolosi, P. E., Habeeb, M. L. & Fadeyibi, M. (2019). Assessment of environmental sanitation, food safety knowledge, handling practice among food handlers of bukateria complexes in Iju Town, Akure North of Ondo-State, Nigeria. *Acta Scientific Nutritional Health*. 6: 186-200. https://bit.ly/2W9zJnp

[20] Young, R. A. (2005). Toxicity Profiles: Toxicity Summary for Cadmium: Risk Assessment Information System, University of Tennessee.

[21] Hezbullah, M., Sultana, S., Chakraborty, S. R. & Patwary, M. I. (2016). Heavy metal contamination of food in a developing country like Bangladesh: An emerging threat to food safety. *Journal of Toxicology and Environmental Health Sciences*, 8(1), 1-5.

[22] Dubey, V. K., Mamta, A. & Archna, S. (2016). Determination of heavy metals in selected meat and meat products from meat market of Singrauli. *IOSR Journal of Applied Chemistry*, 9(11), 52-54.

[23] Flora, G., Gupta, D. & Tiwari, A. (2012). Toxicity of lead: a review with recent updates. *Interdisciplinary Toxicology*, 5(2), 47-58.

[24] Odoh. R., Yebpella, G. & Ugwuja. D. (2017). Assessment of some mineral contamination of meats singeing with scrap tyres and plastic wastes. *FTST*. 4(2), 869-874.

[25] Sanusi, A. Z., Yusuf, A., Jibir, M., Danmusa, A. M. & Ribah, M. I. (2016). Physico-Chemical Characteristics of Edible Hide (Ganda). *International Journal of Scientific & Engineering Research.* 7(4), 1392 – 1397.

[26] Ahmed, S. A., Banjoko, I. K., Ahmed, M. M., Isiaka, M. A. & Ifabiyi, J. O. (2022). Consumers' Perception, Nutritional and Mineral Composition of Processed Cowhide (Ponmo) as Affected by Different Processing Methods. *Al-Qadisiyah Journal for Agriculture Sciences.* 12(1), 65-69.

[27] Useh, M. U., Onwuazor, O. P., Orijajogun, J. O., Samuel, C. J., Uzama, D. & Dauda, M.S. (2016). Physicochemical Studies of Potable Water Resources within the Kubwa Vicinity of Bwari Area Council, Abuja. *J of Appl. Life Sc. Intl*, 8(4), 1-7.

[28] Useh, M. U., Uzama, D. & Etuk-Udo, G. (2022a). Effect of Dumpsite Leachate on Groundwater Quality in Mpape Community, Bwari Area Council, Abuja, Nigeria. *Nigerian Research Journal of Chemical Sciences.* 10 (1), 197 – 216.

[29] AOAC (2006). Official Methods of Analysis. 18th Edition, Association of Official Analytical Chemists, Washington DC, Method 935.14 and 992.24

[30] Useh, M. U., Uzama, D. & Obigwa, P. (2022b). Effects of Abattoir Activities in the Surrounding Soils within Abuja, Nigeria. *Communication in Physical Sciences*, 8(1): 58-74.

[31] USDA (2006). Specific maximum levels of contaminants in foods. (Jim Butterworth and Wu Bugang). Chinese peoples' Republic of FAIRS products. Foreign Agric services GAIN Report, Global GAIN Report No. CH6064.

[32] European Commission Regulation (ECR). (2006). No 1881/2006, Setting maximum levels for certain contaminants in foodstuff. Official *J. of the European Union*, L 364, 5-24.

[33] Cai, Q., Long, M., Lui, J., Zhu, M., Zhou, Q., Deng, Y., Li, Y. & Tain, Y. (2008). Correlation between heavy metal concentration in cattle tissues and rearing environment. *Chinese J. of Ecol*., 27(2), 202-207.