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Research Article

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

Napoleon Jackson Mensah[1], Samuel Antwi-Akomeah[2*], Servacious Akanlu[1], Bayaa Martin Bieranye Sixtus[3], and Sebiawu Etsey Godfred[3]

[1] Department of Science Laboratory Technology, Wa Polytechnic, Wa, Ghana
[2] Forensic Science Laboratory (FSL), Ghana Police Service, Accra, Ghana
[3] Department of Dispensing Technology, Wa Polytechnic, Wa, Ghana

Abstract:
The present study compared the residual levels of heavy metals in cattle hides obtained from the Wa Municipal abattoir (in the Upper West Region of Ghana) singed using scrap tyres and firewood as fuel sources. Heavy metals of interest included As, Cu, Fe, Pb and Cd. Residual levels of these metals were measured by Atomic Absorption Spectrophotometer AA 220. Scrap tyre singed hides in general recorded the highest concentrations of As, Cu, Fe, Pb and Cd than firewood singed hides and unsinged hides. Scrap tyre singed hides recorded significant increments in metal levels in the range of 312.50 - 811.11 %, 221.95 - 599.56 %, 236.21 - 366.57 %, 1408.82 - 1600.00 % and 1275.00 - 2875.00 % respectively for As, Cu, Fe, Pb and Cd. Firewood singed hides similarly recorded considerable increments in metal levels ranging from122.22 - 375.00 %, 202.44 - 280.63 %, 120.44 - 302.51 %, 1251.43 - 1361.73 % and 462.50 - 1837.50 % respectively for As, Cu, Fe, Pb and Cd. As, Pb and Cd maximum and minimum levels recorded for scrap tyre singed hides, firewood singed hides and unsinged hides all exceeded respective maximum permissible limits of 0.05 mg/kg, 0.1 mg/kg and 0.05 mg/kg. Cu and Fe maximum levels were below the respective maximum permissible thresholds of 20 mg/kg and 50 mg/kg. The present study essentially brought to bear the unwholesome state of cattle hides being consumed within the Wa Municipality of the Upper West Region of Ghana.

Keywords: Singeing; Scrap Tyre; Firewood; Cattle Hide; Heavy Metal Contaminants; Meat Quality; Wa Municipality

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*Correspondence to: Forensic Science Laboratory (FSL), Ghana Police Service, Accra, Ghana.

E-mail: sammious10@yahoo.com

1. Introduction

Processed cattle hide popularly referred to as *wele* in Ghana is served as a delicacy in several Ghanaian homes and many parts of Africa. In Southern-Western Nigeria for instance, it is popularly known as *ponmo* [1, 2]. Abattoirs and slaughterhouses are where animals such as sheep, goats and cattle are slaughtered and processed for subsequent transportation to the market where they are sold for human consumption [1]. As part of the processing, carcasses of these slaughtered animals are singed in an attempt to rid the carcasses of furs/hairs. In Ghana and several parts of Africa, singeing is highly preferred as it maintains the carcass hide for consumption and enhances the flavour of the meat [3]. Available singeing techniques include the use of fire fuelled by liquefied petroleum gas (LPG), vehicle scrap tyres and firewood to burn the furs/hairs [1]. Comparatively, there has been a surge in the use of scrap tyre as fuel source for the singeing of slaughtered animals in most abattoirs and slaughter houses in Ghana. Local butchers according to Obiri-Danso *et al*. [1] attribute their choice on the high cost and irregular supply of LPG coupled with the problem of firewood scarcity. In addition, these scrap tyres come in handy and at a relatively cheaper cost.

Singeing of slaughtered animals such as cattle, sheep and goat using scrap tyre as fuel source is also a common practice within the Wa Municipality of the Upper West Region of Ghana. The practice leaves much to be desired taking into account the fact that scrap tyre contains compounds such as furan, polyaromatic hydrocarbons (PAH), benzene and a host of heavy metals that are well known for their carcinogenic and other harmful/toxic attributes [4]. Thus singeing of slaughtered animals using scrap tyre typically may facilitate the introduction of toxic compounds and metals into the animal hide which in effect may compromise the hide quality and render it unwholesome for human consumption [5, 6].

Heavy metals are essentially metallic chemical elements that have a relatively high density and are toxic at high concentrations e.g. arsenic (As), lead (Pb), copper (Cu), chromium (Cr), cadmium (Cd), zinc (Zn), iron (Fe) and nickel (Ni). Metals such as Ni, Zn, Cu, Cr and Fe are trace elements/essential metals and play important roles in maintaining the normal metabolism of the human body via their role as co-factors. However, at higher concentrations, poisoning can occur. Metals such as Pb and Cd on the other hand are non-essential metals and are toxic, even in trace amounts [7]. The risk of heavy metal contamination of cattle hide singed using scrap tyre is thus an issue of concern in respect of food safety and consumer health taking into account the toxic nature of these metals even at relatively minute concentrations [5, 6]. Thus the consumption of such potentially contaminated meat products poses an enormous health risk [7] to the people of Wa.

The study compares the impact of firewood and scrap tyres as fuel sources for the singeing of cattle hides within the Wa Municipality of the Upper West Region of Ghana. The study seeks to contribute to the understanding of the dangers posed to human health by the use of either fuel sources for singeing of cattle and other ruminants within the Wa municipality. The study is also expected to stimulate further research in the subject area with focus on identifying safer alternative singeing practices.

2. Materials and Methods

2.1 Sampling Area

The study was conducted in Wa, the Regional capital of Upper West Region. The Wa Municipality shares administrative boundaries with, Nadowli District to the North, Wa East District to the East and South and Wa West District to the West and South. It lies within latitudes 1^{o}40'N to 2^{o}45'N and longitudes 9^{o}32' to 10^{o}20'W. It has a landmass area of approximately 234.74 square (Kilo) meters, which is about 6.4 % of the region. The indigenes are basically traders, crops and livestock farmers.

WA MUNICAIPAL MAP

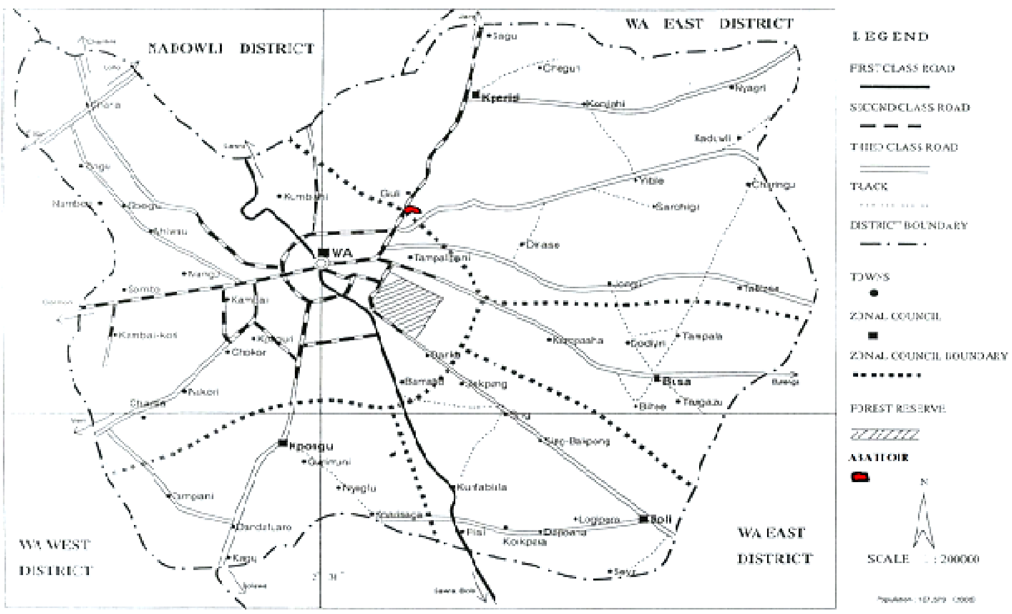

Figure 1 Wa Municipal Map Showing Sampling Location
Source: Wa Municipal Assembly, 2010

2.2 Sampling

Fifteen (15) cattle hide samples were obtained from the Wa Municipal abattoir in the Upper West Region of Ghana. Hide samples were obtained from five (5) different cows labelled A, B, C, D and E. The first set of five (5) hide samples taken from these cattle (a sample per cow) were singed using firewood as fuel source. The second group of five (5) were also singed using scrap tyre as fuel source. The third group of five (5) samples served as control samples and were not subjected to any form of singeing. About 10 g portions each of firewood singed hide (FSH), scrap tyre singed hide (STSH) and control hide was carefully cut and placed in an air tight bag. Samples were immediately transported to the Dispensary Chemistry Laboratory of Wa Polytechnic for sample preparation and acid digestion.

2.3 Sample Treatment

Each sample was thoroughly washed with distilled-deionised water and oven dried for 12 hours at 105^{o}C and pounded to powder using porcelain mortar and pestle with the aid of liquid nitrogen. The method of wet digestion was adopted [8]. 1g of the powdered hide sample was carefully weighed into 200 mL beaker and 10 mL of binary acid mixture HNO_3: HCI (1:1) was added to the sample. The flask was swirled gently for the content to mix thoroughly. The flask with the content was then placed onto a hotplate and heated until the production of fumes ceased. The flask was allowed to cool and after which it was further heated until the content appeared yellowish and the volume was about 3 mL. The content was made up with distilled water to 50 mL in a volumetric flask and filtered through Whatman 1 acid-washed filter paper into another 50 mL volumetric flask. The final digest was gently poured into a 60 mL clean container and preserved at 4^{o}C. The digests were transported to Environmental Quality Laboratory of Anglo Gold Ashanti-Obuasi for determination of the heavy metals using the atomic absorption spectrophotometer (AAS) model AA 220.

2.4 Analysis of Samples

The levels of the metals- lead (Pb), arsenic (As), copper (Cu), iron (Fe) and cadmium (Cd) in each digest were determined in triplicate using the AAS. Standards for AAS calibration were prepared using commercial stock metal standards of each metal. AAS was adjusted to read zero (0) for the blank solution.

2.5 Data Analysis

Concentrations of the metals were expressed as mean ± standard deviation (SD) with the use of Minitab (17) statistical software. Means among applied treatments were compared by one way analysis of variance (ANOVA). ANOVA computations were performed using Minitab (17) statistical software.

3. Results

Table 1 shows the concentrations of As, Cu, Fe Pb and Cd in cattle hides A, B, C, D and E. Table 2 represents the percentage increase in the levels of these metals in firewood singed hides (FSH) and scrap tyre singed hides (STSH). Figures 2, 3, 4, 5 and 6 respectively represent the concentrations of As, Cu, Fe Pb and Cd in the studied cattle hides.

Table 1 Concentrations of As, Cu, Fe, Pb and Cd in Cattle Hides

Metal	Treatment	Cattle Hide Samples (Mean concentrations in mg/kg dry weight ± SD)				
		A	B	C	D	E
As	Control	0.09 ± 0.010	0.08 ± 0.008	0.09 ± 0.003	0.09 ± 0.003	0.08 ± 0.005
	FSH	0.28 ± 0.076	0.20 ± 0.050	0.20 ± 0.050	0.30 ± 0.050	0.38 ± 0.076
	STSH	0.47 ± 0.076	0.33 ± 0.058	0.63 ± 0.076	0.82 ± 0.076	0.43 ± 0.104
Cu	Control	2.01 ± 0.076	2.05 ± 0.045	2.22 ± 0.104	2.62 ± 0.076	2.28 ± 0.076
	FSH	6.60 ± 0.132	6.20 ± 0.100	8.45 ± 0.100	8.85 ± 0.100	8.27 ± 0.153
	STSH	6.82 ± 0.029	6.60 ± 0.312	8.65 ± 0.100	10.32 ± 0.126	15.95 ± 0.180
Fe	Control	3.59 ± 0.104	3.62 ± 0.029	3.48 ± 0.076	3.55 ± 0.100	3.58 ± 0.074
	FSH	14.45 ± 0.100	7.98 ± 0.104	11.08 ± 0.126	9.48 ± 0.896	13.30 ± 0.087
	STSH	16.75 ± 0.150	15.65 ± 0.100	11.70 ± 0.150	12.28 ± 0.126	15.83 ± 0.126
Pb	Control	0.34 ± 0.029	0.35 ± 0.006	0.34 ± 0.035	0.34 ± 0.000	0.34 ± 0.035
	FSH	4.70 ± 0.150	4.73 ± 0.076	4.97 ± 0.072	4.87 ± 0.076	4.75 ± 0.050
	STSH	5.49 ± 0.441	5.55 ± 0.328	5.26 ± 0.079	5.13 ± 0.064	5.78 ± 0.200
Cd	Control	0.08 ± 0.006	0.08 ± 0.006	0.07 ± 0.000	0.07 ± 0.006	0.08 ± 0.006
	FSH	0.53 ± 0.025	0.45 ± 0.025	0.85 ± 0.020	1.22 ± 0.030	1.55 ± 0.025
	STSH	1.10 ± 0.015	1.26 ± 0.012	1.54 ± 0.031	1.87 ± 0.025	2.38 ± 0.137

Table 2 Percentage Increase in Heavy Metal Residues of FSH and STSH Relative to Controls

Metals	Increment in Heavy Metal Residue Levels	
	FSH (%)	STSH (%)
As	122.22 - 375.00	312.50 - 811.11
Cu	202.44 - 280.63	221.95 - 599.56
Fe	120.44 - 302.51	236.21 - 366.57
Pb	1251.43 - 1361.73	1408.82 - 1600.00
Cd	462.50 - 1837.50	1275.00 - 2875.00

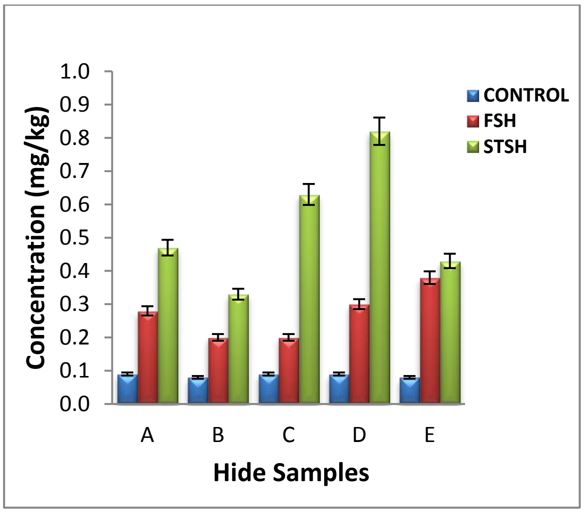

Figure 2 As levels in FSH and STSH in relation to the controls

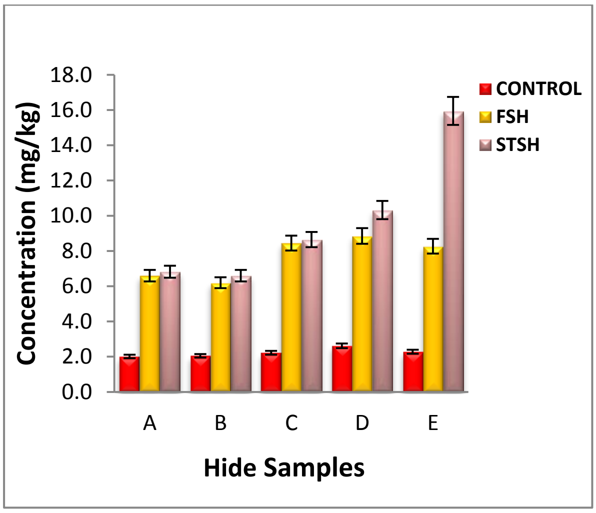

Figure 3 Cu levels in FSH and STSH in relation to the controls

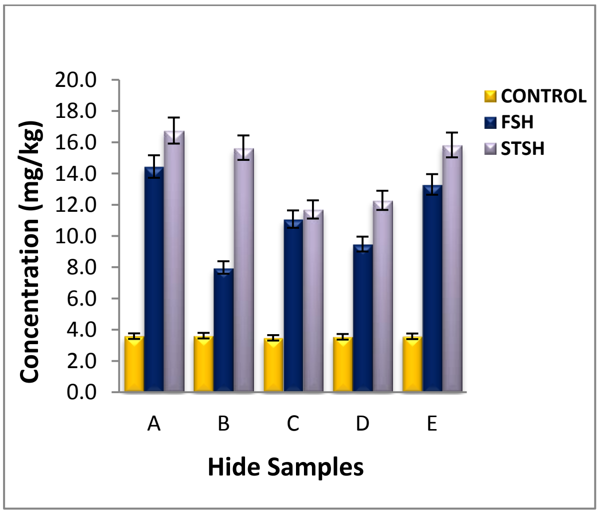

Figure 4 Fe levels in FSH and STSH in relation to the controls

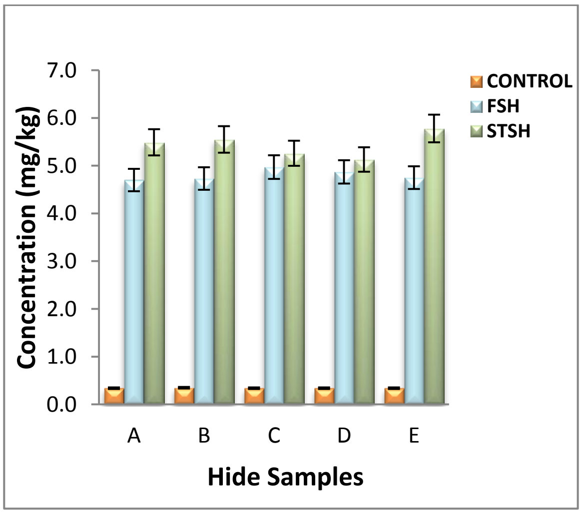

Figure 5 Pb levels in FSH and STSH in relation to the controls

One way ANOVA analysis revealed significant differences in mean concentrations among treatments ($p < 0.05$) for all metals analysed across all samples examined. Tukey simultaneous tests for differences of means showed significant differences in mean concentrations for FSH and STSH pairs for all metals analysed across all samples examined ($p < 0.05$) except for As in the case of sample E and Cu in the case of samples B and C ($p > 0.05$).

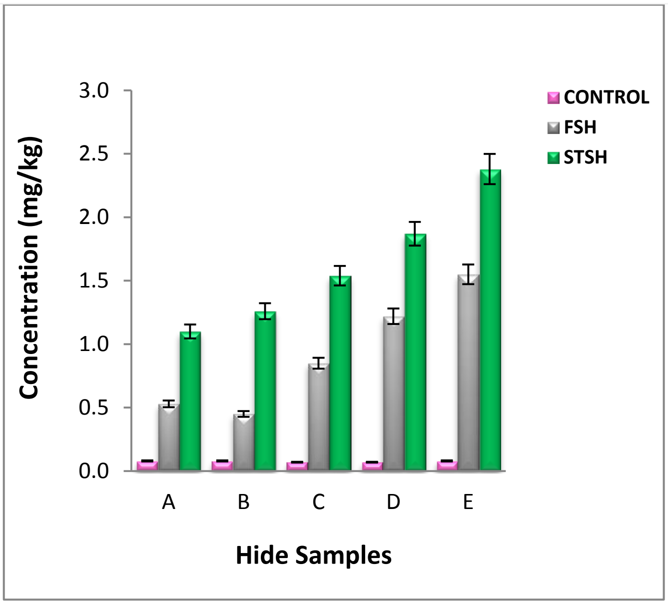

Figure 6 Cd Levels in FSH and STSH in relation to the Control

4. Discussion

Firewood has been used in the singeing of slaughtered ruminants such as cattle in various abattoirs across Ghana. The use of scrap tyres as an alternative fuel source to singe slaughtered animals has also over the years also received grand patronage in several slaughter houses across Ghana. Comparative analysis of cattle hides singed using these two methods revealed considerable levels of metals including As, Cu, Fe, Pb and Cd in the present study. Scrap tyre singed hides (STSH) recorded the highest levels of As, Cu, Fe Pb and Cd compared to firewood singed hides (FSH) (Table 1) and the controls (unsinged hides).The order of metals levels with reference to applied treatments was thus STSH > FSH > control. STSH recorded maximum As, Cu, Fe, Pb and Cd levels of 0.82 ± 0.076 mg/kg, 15.95 ± 0.180 mg/kg, 16.75 ± 0.150 mg/kg, 5.78 ± 0.200 mg/kg and 2.38 ± 0.137 mg/kg respectively. Minimum As, Cu, Fe, Pb and Cd levels recorded were respectively 0.33 ± 0.058 mg/kg, 6.60 ± 0.312 mg/kg, 11.70 ± 0.150 mg/kg, 5.13 ± 0.064 mg/kg and 1.10 ± 0.015 mg/kg respectively. As, Cu, Fe, Pb and Cd levels in STSH compared to the controls appreciated by 312.50 - 811.11 %, 221.95 - 599.56 %, 236.21 - 366.57 %, 1408.82 - 1600.00 % and 1275.00 - 2875.00 % respectively. In a similar study by Obiri-Danso *et al*. [1], scrap tyre singed cattle hides recorded increases in the concentrations of all metals analysed except for Pb which recorded a decrease in concentration. Ekenma *et al*. [5] also reported of increased levels for all metals analysed in scrap tyre singed cattle hides except for Pb and Cd that saw decreases in levels. Thus while the concentration of some metals increased in these studies others decreased. In contrast to the above studies, the present study recorded increases in the concentrations of all metals analysed including Pb and Cd (which recorded decreases in the previous studies).

Maximum As, Cu, Fe, Pb and Cd levels realised in the case of FSH were respectively 0.38 ± 0.076 mg/kg, 8.85 ± 0.100 mg/kg 14.45 ± 0.100 mg/kg, 4.97 ± 0.072 mg/kg and 1.55 ± 0.025 mg/kg. The corresponding minimum levels of these metals in FSH were 0.20 ± 0.050 mg/kg, 6.20 ± 0.100 mg/kg, 7.98 ± 0.104 mg/kg, 4.70 ± 0.150 mg/kg and 0.45 ± 0.025 mg/kg. Similar to STSH, As, Cu, Fe, Pb and Cd levels in FSH compared to the controls saw increases of 122.22 - 375.00 %, 202.44 - 280.63 %, 120.44 - 302.51%, 1251.43 - 1361.73 % and 462.50 - 1837.50 % respectively. Increments in metal levels attained for FSH in the present study are in agreement with the findings of Okafor *et al*. [9] who also recorded increases in the concentrations of all metals analysed when firewood (bamboo) was used as fuel source in the singeing of cattle hides. Two of such metals analysed in the present study include Pb and Cu.

Per the results of the present study, both singeing techniques invariably ensured the introduction/deposition of significant levels of As, Cu, Fe, Pb and Cd into all cattle hides analysed in relation to the controls. This phenomenon was imminent as the burning/combustion of scrap tyres and wood are associated with the emission of toxic contaminants such as particulates amidst heavy metals such as Cd, Pb, As, Zn, etc. [10, 11].

Unsinged cattle hides (controls) in themselves contained considerable levels of As, Cu, Fe, Pb and Cd (Table 1). Maximum As, Cu, Fe, Pb and Cd levels realised for unsinged cattle hides were 0.09 ± 0.003 mg/kg, 2.62 ± 0.076 mg/kg, 3.62 ± 0.029 mg/kg, 0.35 ± 0.029 mg/kg and 0.08 ± 0.006 mg/kg respectively. The corresponding minimum levels were also 0.08 ± 0.005 mg/kg, 2.01 ± 0.076 mg/kg, 3.48 ± 0.076 mg/kg, 0.34 ± 0.000 mg/kg and 0.07 ± 0.000 mg/kg. Obiri-Danso *et al*. [1] recorded substantial levels of heavy metals in unsinged cattle and goat hides and attributed the observation to the possible exposure of animals to heavy metals within the local environment. The scenario may not be different in the case of the present study as the free range system of cattle/animal rearing is a very common practice within the Wa Municipality. Thus cattle could potentially come into contact with heavy metals within the environment in the course of scavenging for fodder from open waste dump sites, drinking water from polluted water bodies and drains as well as via atmospheric depositions from the open burning of solid waste and automobile fumes. There exists a strong correlation between heavy metals concentration in cattle tissues with that in soil, feed, and drinking water according to Qiu *et al*. [12].

As, Pb and Cd maximum and minimum levels recorded for STSH, FSH and the controls all exceeded respective maximum permissible limits of 0.05 mg/kg [13], 0.1 mg/kg [14] and 0.05 mg/kg [14]. Thus As, Pb and Cd levels in STSH, FSH and their respective controls were all above safe limits and present potential health risk on consumption of these hides. Several cases of human disease, disorders, malfunction and malformation of organs due to As, Pb and Cd toxicities have been reported [15]. As is a known carcinogen and can cause cancer of the skin, lungs, liver and bladder. Low level exposure can cause decreased production of red and white blood cells, abnormal heart rhythm, damage to blood vessels etc. Ingestion of very high levels can possibly result in death. Long-term low level exposure can cause a darkening of the skin among others [16]. Exposure to Pb levels above safe limits also has the potential to affect the neurological, reproductive, renal and haematological systems [17]. Excess Pb has also been shown to reduce the cognitive development and intellectual performance in children and increase blood pressure and cardiovascular disease incidence in adults [18]. Similarly Cd levels above safe limits are primarily toxic to the kidney, especially to proximal tubular cells. Bone demineralization is affected by Cd toxicity directly by bone damage and indirectly as results of renal dysfunction [17]. Cd has been reported to have no known bio-importance in human biochemistry and physiology and consumption even at very low concentrations can be toxic [19, 20].

However, for Cu, maximum and minimum levels realised for STSH, FSH and their corresponding controls in each instance were below the maximum permissible threshold of 20 mg/kg [14]. Similarly, the maximum and minimum levels of Fe realised for STSH, FSH and their respective controls in each instance were also below the maximum permissible threshold of 50 mg/kg [14]. Thus Cu and Fe levels in STSH, FSH and the controls essentially present no public health threat on consumption. Although Cu is an essential element in trace amounts, it can be toxic when it exceeds the maximum permissible limit. Copper is responsible for hyperactivity in autistic children [21].

5. Conclusion

The study established both scrap tyre singeing and firewood singeing to invariably contribute to significant levels of heavy metals in cattle hides analysed. For the metals analysed, while Cu and Fe levels were below their respective maximum permissible limits, the levels of As, Pb and Cd realised exceeded their respective maximum permissible limits. Thus the levels of As, Pb and Cd realised in singed cattle hides analysed essentially raises health concerns over the wholesomeness of singed cattle hides sold and consumed within the Wa Municipality of the Upper West Region of Ghana. The presence of these metals in concentrations above their permissible thresholds invariably renders these hides unfit for human consumption.

The levels of As, Cu, Fe, Pb and Cd in unsinged cattle hides though way lower than that recorded for both singeing techniques, also raises questions on the wholesomeness of unsinged cattle hides in themselves. As it stands, baseline levels of these heavy metals in cattle from different farms within the municipality could be way higher than what the present findings depict. Moreover, the issue of cross-contamination cannot be entirely overlooked as a possible contributing factor to the contamination of the unsinged hides as the phenomenon may be very much prevalent in our abattoirs.

There is need to educate and regulate the activities of abattoirs to adhere to safer and best practices. The traditional method of processing animal hides using hot water may be a better alternative to both firewood and scrap tyre singeing. The free range system of animal rearing should be critically looked at with focus on regulating/limiting the free outdoor movement of animals in an attempt to limit their exposure to heavy metal contaminants within the environment. It is also incumbent for periodic monitoring of the levels of heavy metals within the local environment in order to establish baseline levels of these metals.

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Conflicts of Interest

The authors declare no conflict of interest.

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