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Assessment of Heavy Metal Residues in Hides of animals Singed with Tyres, and Public Health Implications Associated with such Practice in Lokoja Metropolis.

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Abstract: The safety of food has been an issue of concern in developing countries like Nigeria where the processing method can pose some environmental health challenge. The use of scrap automobile tires to singe meat has been reported to possess some toxic materials that can pose health challenge to humans. Hence, this study was conducted to determine the concentration of heavy metals in meat singed with fire wood and scrap tires in Lokoja, Nigeria. Samples of cattle hides singed with firewood and scrap tires were collected from four (4) different abattoirs and analyzed for the concentration of Cu, Pb, Fe and Zn using Atomic Absorption Spectrophotometry. There was significant increase in the concentration of Cu, Zn and Pb of the cattle hides singed with firewood and scrap tires when compared to the unsinged. The concentration of heavy metals for firewood singed cattle hide is within recommended Maximum Permissible Levels (MPLs) of the European Commission Regulations while the concentration of scrap tires is above the recommended Maximum Permissible Levels (MPLs) of the European Commission Regulations for Cu, Zn and Fe. Though there was increase in the concentration of Fe it is within the recommended Maximum Permissible Levels. The presence of heavy metals concentration above the permissible levels in cattle hides singed with scrap tires makes it unsafe for human consumption hence safer method should be adopted by the abattoirs.

Key words: Heavy Metals, Hides of animals, Tyres, Public Health, Metal Residues.

I. Introduction

An environmental health objective for *Healthy People* 2020 is to "Reduce the global burden of disease due to poor water quality, sanitation, and insufficient hygiene" (U.S. Department of Health and Human Services, 2015). This particular health objective is an issue in various areas throughout developing countries and occurs primarily due to multiple environmental health influences from an individuals' social and physical environment. Additionally, characteristic negative environmental influences may disproportionately affect specific developing countries due to factors such as lack of (or limited) resources; lack of developed infrastructures such as political, economic, waste management and social infrastructures; along with influences of cultural practices. These characteristic issues include food safety, which has been a continuous battle due to lack of enforced regulations and proper resources or education (United States FDA, 2013). An example of food safety issues within developing areas can be witnessed in West African countries such as Ghana and Nigeria. In these areas as well as in other developing countries, one can typically purchase food items from street vendors and open markets (Duedu et al., 2014; Donkor, Kayang, Quaye & Akyeh, 2009). These street vendors often do not have appropriate water sources for proper hand washing or utensil cleaning. They also lack cold or hot storage devices to keep food at the correct temperatures to avoid bacteria growth. Additionally, these street vendors and food markets are often located in open uncovered and unsanitary environments; or the seller doesn't possess the knowledge of basic food safety rules/regulations necessary to prevent contamination (Duedu et al., 2014; Agyei-Baffour, Sekyere, & Addy 2013; Donkor et al., 2009). The foods that are sold in the markets are mostly supplied by local farmers who grow the vegetables and fruits themselves. The meat products sold in these markets are often supplied by the local butchers who often purchase it from the abattoirs/slaughterhouses located within the city (Agyei-Baffour et al., 2013; Frimpong et al., 2012).

Contamination of the food products in this type of environment can and does occur easily because the proper precautions are either not put into place or not enforced. Often times, due to lack of education on these issues or resources certain contaminants are introduced unnecessarily by human preparation or actions. For instance, the abattoirs, slaughterhouses, /or slaughter slabs are where meat (or animal carcasses) such as cow, goat, and sheep are slaughtered and stripped of its fur, transported to the market and sold for human consumption (Frimpong et al., 2012; Obiri-Danso, Hogarh, & Antwi-Agyei, 2008). While there are several unhygienic and unsanitary issues which need to be addressed at these facilities; one of the most important issues of toxicological and public health concern is the utilization of scrap automobile tires to singe the meat. In the slaughterhouses and slaughter slabs, the operators routinely burn scrap automobile tires as a source of fuel to remove the fur off the animal carcass (Obiri-Danso et al., 2008). The animal is completely charred, the black residue is washed off, and the animal is then prepared for transport to the markets. Some

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government funded facilities (usually referred to as abattoirs) use liquefied petroleum gas (LPG) to singe the meat; however, many unfunded facilities or operations that do not have the same resources utilize the scrap tires for the meat singeing process.

According to the U.S Environmental Protection Agency, scrap tires are ubiquitous nationally and internationally; the U.S. alone has approximately 275 million in stockpile (EPA, 2013a). One of the most common disposal methods of the tires is exporting them to foreign countries. In 2009, the amount of scrap tires exported from the U.S. was approximately 102,000 tons or 204 million pounds (RMA, 2013). While this appears to be a gracious gesture, some of those foreign countries are developing countries. These developing countries do not have the same infrastructures or regulations in place to properly handle the influx of the imported commodities (Ezebilo, 2013; Yiougo, Oyedotun, Some, & Da, 2013; Chang, Huang, & Liaw, 2010). Therefore, materials such as scrap tires become a part of an even larger problem within these countries and aid in perpetuating the cycle of certain environmental issues.

Due to the extremely limited solid waste management and disposal options, these tires are readily available in developing countries such as Nigeria. Also, these tires can even be found on the side of the streets free of charge or purchased very inexpensively. Additionally, tire-based flames are very efficient and effective as a source of fuel (EPA, 2013a). These characteristics, especially the cost-effectiveness, may obviously make the utilization of scrap tires a more preferred option compared to the alternatives, wood and liquefied petroleum gas (LPG) as fuel sources for meat processing. Thus, these factors along with other socio-cultural attributes ultimately lead to perpetuating the increase in utilization of scrap tires for singeing meat intended for human consumption.

1.1 Problem Statement

Eliminating practices that negatively affect human health within communities is a key component of public health. The EPA does not consider the scrap tires themselves to be hazardous, but it is the burning of these tires which emits noxious gases and have major adverse health effects (EPA, 2013a). Automobile tires are mainly comprised of chemicals such as synthetic and natural rubber, aromatic oils, silica, sulfur and sulfur compounds, phenolic resins, petroleum waxes, carbon black, fatty acids, steel wire, and other materials (RMA, 2011). Once these materials are ignited they emit chemicals such as carbon monoxide, sulfur oxides, nitrogen oxides, particulate matter – such as volatile organic compounds (e.g., benzene, toluene, xylene), dioxins/furans, polycyclic aromatic hydrocarbons (PAHs, e.g., benzo-a-pyrene), polychlorinated biphenyls (PCBs), 1,3-butadiene, and heavy/toxic metals/metalloids (e.g., arsenic, mercury, cadmium, chromium, etc.) (Reisman, 1998). When these tires are used for meat singeing, these emitted chemicals can adulterate the meat and hide; rendering the meat hazardous and unwholesome for human consumption (Obiri-Danso et al., 2008). Not only can human exposure to these chemicals occur through ingestion of contaminated meat, water, or vegetables grown in contaminated soil; it can also occur through inhalation (i.e., indoor and/or outdoor air polluted with the tire-fire smoke). These exposure scenarios can ultimately cause acute (short-term) and chronic (long-term) health risks to the community and pose occupational risks to the meat processing operators. Several reports have shown that these afore-mentioned chemicals have toxicological and public health implications. Examples of those implications include possible increased cancer rates, birth defects, along with various respiratory, cardiovascular, and neurological effects (EPA, 2014b; ATSDR, 2014a; Reisman, 1997). This study was therefore conducted to determine the concentrations of some heavy metals in the carcasses of animals singed with tyres at slaughter places in Lokoja metropolis, and to determine its health effect on consumers.

1.2 Study Objective.

The objective of this research is to;

1. To determine the concentrations of some heavy metals in the carcasses of animals singed with tyres at slaughter places within Lokoja metropolis.
2. Explore the community awareness and perceptions concerning the practice of utilizing scrap tires to singe meat.
3. To determine the factors which encourage or discourage the community's willingness or readiness to take action against the practice of using tires to singe meat.
4. To determine the perceived health threats of the use of automobile tires to singe meat.

1.4 Research Questions.

The research questions were developed based on the lack of (or extremely limited) information in the literature and the need to assess the community's awareness and perceptions concerning their health from the practice of using tires to singe meat:

1. How frequent do study participants consume singed meat?
2. Are participants aware of the most commonly used fuel source(s) for meat singeing?

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3. What are the perceived health threats among participants surrounding the use of automobile tires to singe meat?
4. What do participants, perceive as barriers to minimizing their exposure to meat singed with automobile tires?
5. What are the social norms among participants which influence the continued use of automobile tires to singe meat?

II. Literature Review

2.1.1 Utilization of Scrap Tyres in Singeing Meat Products

Traditionally the methods of singeing meat products have involved the use of firewood; however, firewood has become scarce in many African countries for several reasons (World Health Organization, 2013; Boucher et al., 2011). Some of the major reasons include population growth and urbanization. Although these phenomena can create positive economic results for individuals and communities, they also have unintended consequences - ranging from higher levels of poverty, increased infectious disease occurrence, social/political conflicts, infrastructural issues, food insecurity to ultimately straining the carrying capacity of that area and possibly leading to the depletion of its natural resources (Mojares, 2013).

The use of wood for the purposes of singeing meat in urban areas has become laborious and costly. People have therefore shifted from wood-fuel, when singeing meat, to the use of scrap tires which are readily available, easily accessible, inexpensive (sometimes free of charge), and an efficient source of fuel for "semi-commercial" open-air singeing/processing of meat.

Scrap tires have become common throughout the developing world, primarily because the excess tires in developed countries that are not reused, (Reschner, 2008). However, unlike developed countries many of these developing countries, such as Nigeria, do not have the same sophisticated waste management infrastructure in place. Some developing countries have little to no waste management in place or they are operated by private companies (Ezebilo, 2013; Yiougo et al., 2013; Chang, Huang, & Liaw, 2010). Often times, these private companies have minimal competition and therefore do not meet minimal waste management requirements and often deliver subpar services to the consumers; dumping the waste in any open space available without the proper pre-treatment or planning (Ezebilo, 2013; Yiougo et al., 2013; Chang et al., 2010). These waste management infrastructure issues contribute to the tires being easily accessible, very inexpensive to purchase and readily available.

2.1.2 Toxicological Implications of Chemicals Released via Scrap Tire Burning

The chemicals emitted from tire burning can be classified as toxicants, which are poisonous substances or by-products produced from anthropogenic activities (Casarett & Doull, 2008). Routes of exposure to these toxicants among humans and animals are inhalation, dermal or eye absorption and ingestion through air, soil, water, and food. Upon entry into humans, these chemicals are typically referred to as xenobiotics; which are defined as foreign chemical substances that enter the biological system (Fris, 2012; Casarett & Doull 2008; Baynes & Hodgson, 2004). There are innate biological defense mechanisms and membrane barriers found internally and externally that can block or reduce entry, along with controlling absorption and distribution of these toxicants throughout the body (Baynes & Hodgson, 2004). However, the effectiveness of these barriers depends primarily upon factors such as duration of exposure, route of entry, dosage, interactions with other chemicals (mixtures), molecular weight of the toxicant, ionization and an individual's physiological characteristics such as susceptibility/sensitivity (Fris, 2012; Casarett & Doull, 2008; Baynes & Hodgson, 2004). These factors dictate the xenobiotic action(s) in an organism and control the rate of absorption and distribution throughout the biological system. Once the xenobiotic enters the body, it begins a systemic process known as toxicokinetics which is the quantitative study of the time course of a toxicant from exposure, through distribution to various parts of the body via bloodstream or the lymphatic system, then biotransformation/metabolism and finally excretion. This process is commonly referred to as ADME, absorption, distribution, metabolism and excretion as shown in Figure 2.2 (Casarett & Doull, 2008; Baynes and Hodges, 2004).

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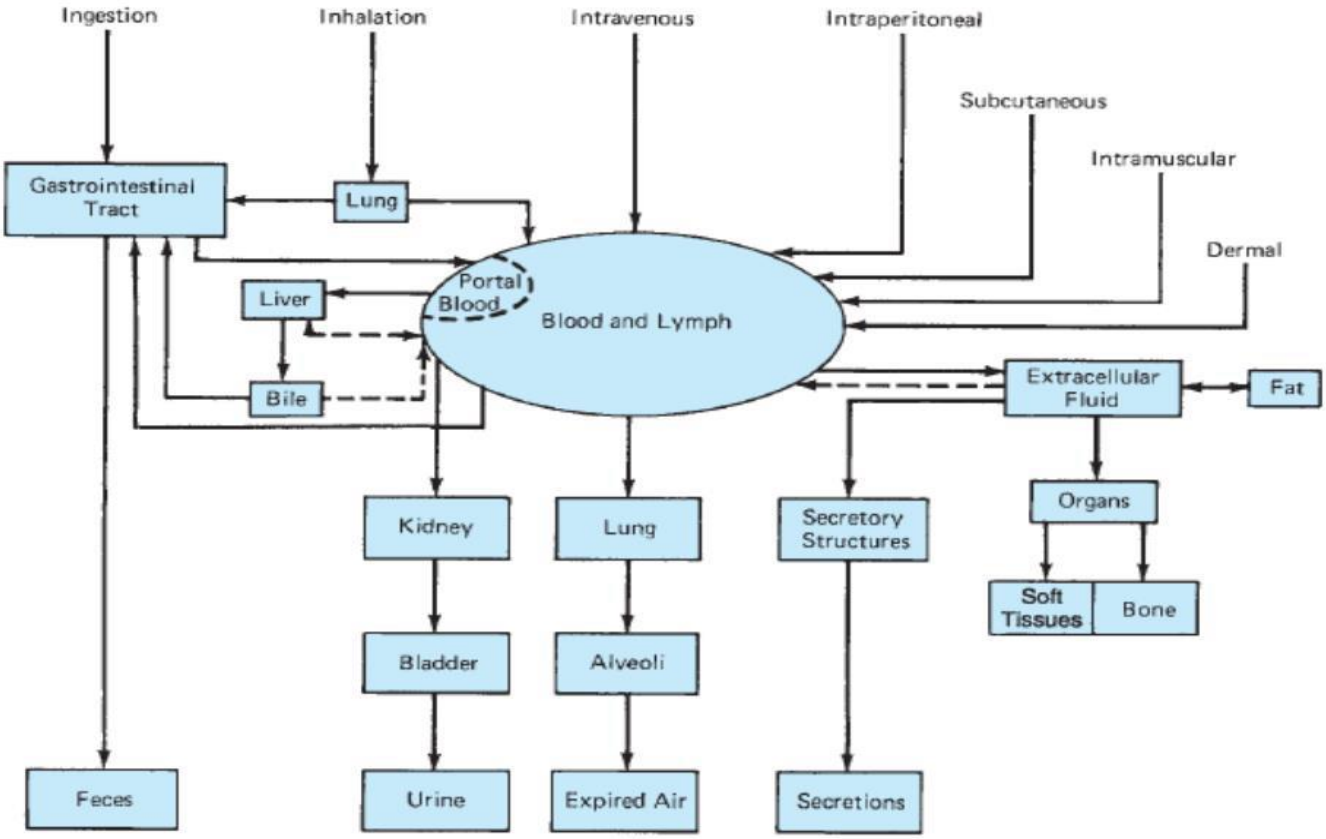

Figure 1: Disposition or fate of toxicants via ADME processes. Casarett, L. J., Klaassen, C. D., Amdur, M. O., & Doull, J. (2008). Casarett & Doull's Toxicology: The basic science of poisons. New York: McGraw-Hill.

Once a toxicant is absorbed into the body through the GI tract, the respiratory system or the skin, it is then distributed or transported to various biological tissues. Distribution occurs via the bloodstream or the lymphatic system (Casarett & Doull, 2008; Yu, 2005). Once distributed, a toxicant may be stored or metabolized. Storage sites include the liver, kidneys, lungs, adipose tissues, or the bones. For instance, the heavy metal lead (Pb) is stored in the bone tissues but concentrates and has an effect in soft tissues such as the brain (Casarett & Doull, 2008; Yu, 2005).

Once a toxicant has been distributed to various parts of the body it then undergoes biotransformation or metabolism. Metabolism is known as biotransformation because once this metabolic conversion occurs then a structural change takes place (Casarett & Doull, 2008; Yu, 2005). This process can take place in tissues or organs in the body such as the liver, kidneys, lungs and skin.

Multi-level Exposure Effects the process of using tires to singe meat affects the health of populations across several social-ecological levels. The practice largely takes place at abattoirs, slaughterhouses and slaughter slabs (and occasionally by private residents for personal use) (Obiri-Danso et al., 2008). These facilities employ several community members to complete the task of slaughtering and removing the hide from the carcass so the skin may be included as part of the meat. The singeing process involves burning of the tires that produce thick plumes of black smoke that potentially contaminate the meat and pollute the atmosphere. This chronic exposure to the chemicals emitted from the tires and the smoke inhalation pose an occupational hazard to the workers and communities/residents living in close proximity to the meat-singeing operation sites. Not only does this practice affect the workers/community/meat consuming public, and food quality; it also affects the environment where the singeing process is perpetuated - through pollution of water (via runoff), air (smoke, ash, particulate matter, etc.) soil and sediments.

2.1.3 Study area.

Lokoja is located between latitude 7^0 48' North and longitude 6^0 44' East (figure 1). Lokoja has a mean elevation of 41m (265ft) above mean sea level, (Ojo, 1985). Lokoja terrain is generally undulating with isolated residual hills or conical shaped sedimentary hills. Some of these hills such as the Mount Patti has appreciable local relief and are characterized by lateritic gravel, boulders and

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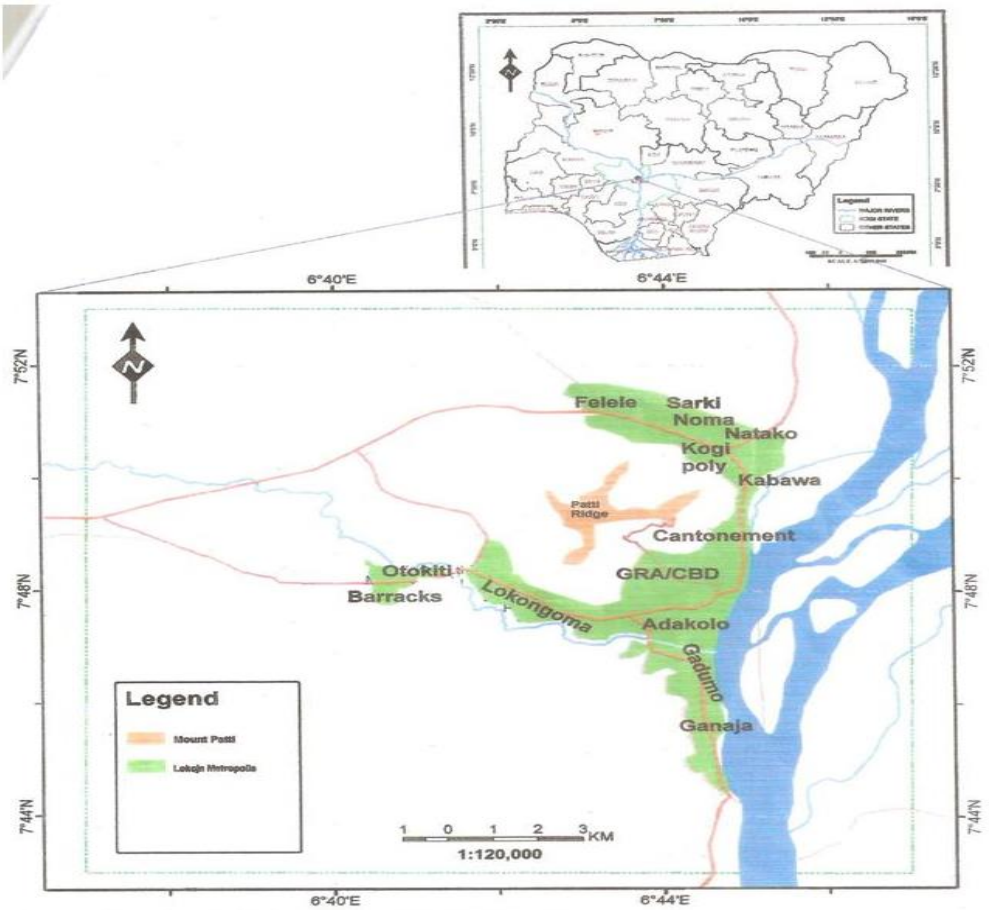
duricrust. The vegetation of the study area is of the tropical savanna and while the trees are used for timber and firewood, the grass components support grazing activities. Lokoja lies within the tropical climate with two marked seasons, the dry and wet seasons. The wet or rainy season last from March to October, and the dry season commences in November and continues till February. . Humidity is generally high throughout the year in Lokoja, because of its situation in the river valley. The monthly temperature range is very small. Lokoja has a mean temperature of 270 C (Ojo, 1985).

The major economic activities in the Lokoja area include trading, fishing, farming and mining. Fishing activities are carried out all year round along the major rivers (Benue and Niger Minerals mined in the study area include marble, limestone, iron ore granite, sand and gravel. Lokoja town has a large market which attracts thousands of traders and a large service sector. Lokoja depends to a large extent on Adankolo, Felele and Koton Karfi to supply its agricultural needs (Nigeria Information & Guide 2022).



Source: Department of Geography and Planning KSU

Fig. 1: Lokoja Metropolis (The Study Area)

III. Study Methodology

Freshly singed cattle hides would be obtained from some selected retail outlets on three retail markets; for the study. Out of this would be singed-treated with scrap tyres (T) while some would be singed-treated using firewood (F). The control for the study would be taken from the un-singed carcasses before the singing took place. Approximately 300g of each hide singed-treated and un-singed would be collected. The samples would be labelled, packed in the ice chest containing ice packs and then transported to the specialized Chemistry laboratory for chemical analyses. The samples would be washed with distilled water and oven dried to a constant weight at 100^{o}C for 24 hours. A meat grinder would be used to milling the dried samples and digested for analysis. Both the singed-treated and un-singed cattle hides' samples would be stored in a freezer at -20^{o}C before sample analysis.

An interviewer-administered questionnaire based on the specific objectives of the study was developed after a thorough literature review. It was pre-tested among butchers at a market in the study area and was further evaluated by experts in public health to ensure quality and content validity.

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3.1 Laboratory analysis of heavy metals.

The total lead (Pb), Copper (Cu), Iron (Fe) and Zinc (Zn) residues in the samples would be determined using the procedures of the Association of Official Analytical Chemists (AOAC, 1990).

3.2 Statistical Analysis

SPSS Version 20 and Graph Pad Prism 6 for the Graph analysis would be used for the statistical analysis. The probability level of significant differences (*p- value*) between sample means would be set at $p < 0.05$. Means of microbial contents would be compared with the US Centers of Disease Control & Prevention (CDC) Standards for Maximum Microbial Permissible Levels (MPLs) (CDC, 2014).

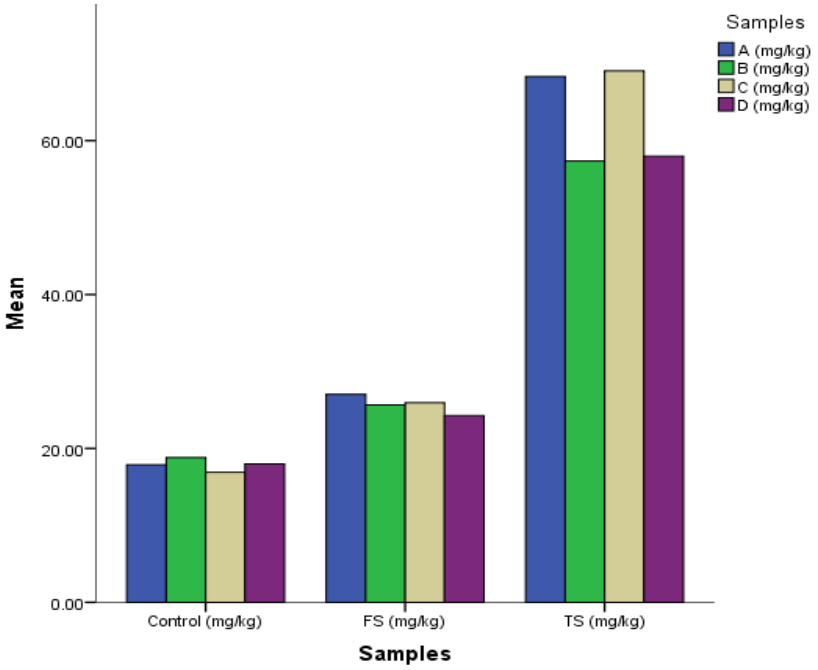
IV. Result and Discussion

The use of firewood and scrap tyres to singe cattle has been an existing practice in various abattoirs in Lokoja metropolis. Findings from this study indicated significant increase in the concentration of heavy metals determined from cattle hides A, B, C, and D when compared to the unsinged sample. Table 1 -4 shows the mean concentrations of Cu, Zn, Fe and Pb in cattle hides A, B, C and D. Figures 1-4 respectively represent the concentrations of Cu, Zn, Fe and Pb in the studied cattle hides. Though there was increase in the concentration of the firewood singed cattle hide, it is within recommended Maximum Permissible Levels (MPLs) of the European Commission Regulations (USDA, ECR, 2006) for Cu, Zn and Pb.

The concentrations of Cu, Zn and Pb in the cattle hide singed with scrap tyres were higher than the recommended Maximum Permissible Levels (MPLs) of the European Commission Regulations (USDA, 2006; ECR, 2006). These results are in agreement with the findings of Adam *et al.* (2013) and Mensah *et al*. (2019) who reported high levels of heavy metal residues in the hides of goats and cattle singed with tyres but in contrast to Ekenma *et al* (2015) who reported decrease in the level of Pb.

Table 1: Concentration of Zn in cattle hides

Heavy metal	Treatment	A (mg/kg)	B (mg/kg)	C (mg/kg)	D (mg/kg)
Zn	US/Control	17.88 ± 0.85	18.81± 0.26	16.89 ± 0.13	17.99 ± 0.07
	FS	27.02 ± 0.93	25.65 ± 0.46	25.95 ± 0.15	24.26 ± 0.22
	TS	68.34 ± 1.14	57.35 ± 0.58	69.08 ± 0.52	57.98 ± 0.18



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There was significant increase in the mean concentrations of Zn across the four samples when compared to the unsinged hide. According to Guvenc *et al* (2012) Zn is an essential micro-nutrient in human health and also very important for body functions but higher dose of Zn can lead to neurotoxicity, Alzheimer's disease or impaired lipid metabolism. Higher dose of Zn can also lead to irritation of the digestive tract causing nausea and vomiting (WHO, 1996).

Table 2: Concentration of Fe in cattle hides

Heavy metal	Treatment	A (mg/kg	B (mg/kg)	C (mg/kg)	D (mg/kg)
Fe	US/Control	10.47 ± 0.59	13.42 ± 1.74	8.83 ± 0.62	10.55 ± 0.45
	FS	19.02 ± 0.22	17.52 ± 0.64	20.39 ± 0.63	19.67 ± 0.58
	TS	36.55 ± 0.67	29.46 ± 0.99	32.36 ± 1.51	36.11 ± 0.38

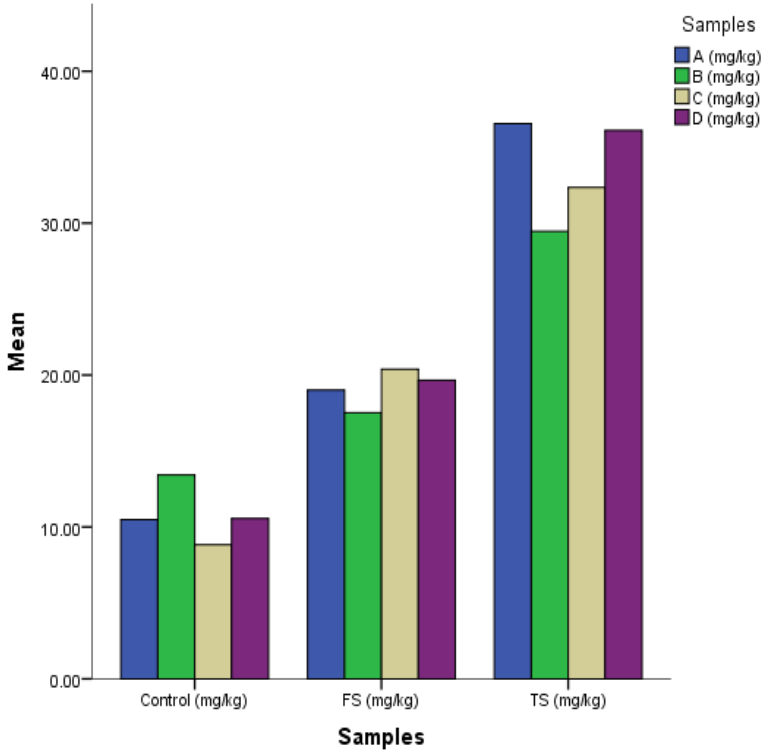

Figure 2 concentration of Fe in FS and TS in relation to the controls

Though there was significant increase in concentration of Fe, it is within the Maximum Permissible Levels (MPLs) of the European Commission Regulations (USDA, ECR, 2006). According to Abbaspour *et al* (2014), Fe is an essential element for all living organisms as it is important for a wide variety of metabolic processes, also involve in DNA synthesis, electron transport and oxygen transport.

Table 3: Concentration of Pb in cattle hides

Heavy metal	Treatment	A (mg/kg)	B (mg/kg)	C (mg/kg)	D (mg/kg)
Pb	Rb/Control	0.05 ± 0.02	0.08 ± 0.02	0.04 ± 0.02	0.08 ± 0.04
	FS	0.45 ± 0.14	0.31 ± 0.15	0.14 ± 0.06	0.39 ± 0.30
	TS	0.61 ± 0.04	0.45 ± 0.01	0.56 ± 0.04	0.45 ± 0.17

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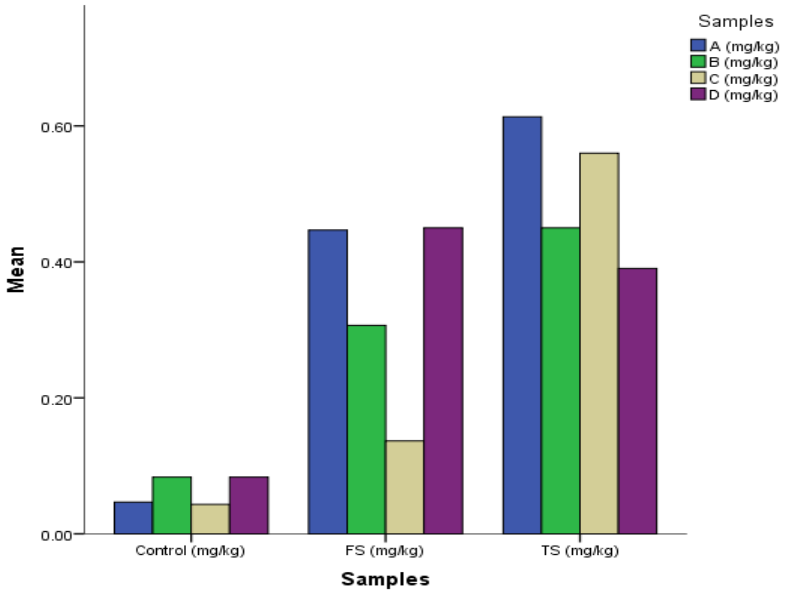

Figure 3 concentration of Pb in FS and TS in relation to the controls

There was significant increase in the mean concentrations of Pb across the four samples when compared to the unsinged hide. Exposure to Pb levels above safe limits has the potential to affect the neurological, reproductive, renal and hematological systems. Mensah *et al.* (2019) reported that excess Pb reduce the cognitive development and intellectual performance in children, increase blood pressure and cardiovascular disease in adults.

Table 4: Concentration of Cu in cattle hides

Heavy metal	Treatment	A (mg/kg)	B (mg/kg)	C (mg/kg)	D (mg/kg)
Cu	Pb/Control	10.95 ± 0.16	9.29 ± 0.66	10.01 ± 0.18	10.69 ± 0.29
	FS	17.55 ± 0.24	16.81 ± 0.21	17.55 ± 0.49	15.98 ± 0.39
	TS	22.32 ± 1.36	21.38 ± 0.95	21.81 ± 1.60	17.49 ± 3.89

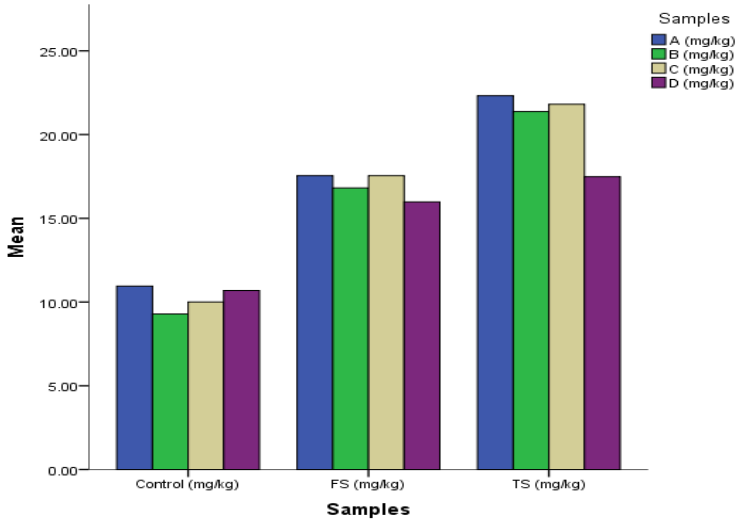

Figure 4 concentration of Cu in FS and TS in relation to the controls

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There was significant increase in the concentration of Cu. Accumulation of high levels of Cupper (Cu) in the liver and brain, result in Wilson's disease (Gautam and Irfan, 2011).

MPL- minimum permissible level

US – Unsinged

FS - Fire Singed

TS - Tyre Singed

Heavy metal	MPL mg/kg
Zn (Zinc)	50.00
Fe (Iron)	50.00
Pb (Lead)	0.10
Cu (Copper)	20.00

V. Conclusion

Singeing of animal hides with tyres, increases the heavy metal concentrations in the hides of the carcasses beyond acceptable limits. The study confirmed the use of tyres singeing hides. The overall level of knowledge on health effects of use of old tires on health and environment was poor. Various health problems were reported by butchers involved in singeing meats. Targeted education of butchers on the dangers to health and environment of these practices, intensified supervision of their activities and legislation and enforcement of the type of materials to be used in processing of hides for human consumption is also recommended. Boiling of these carcasses marginally reduces the heavy metal contents, but not below the safe limits. The scrapings of singed carcasses have very high heavy metal concentrations, and are potential sources of heavy metals in soils, surface water and in plants.

There is need for further studies to determine the effect of the recommended capacity building on knowledge and practices of butchers concerning meat singeing as well as the impact of their practices on their health and the environment.'

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