Determination of Zinc Concentration and Nutritional Value of Cow Hide (Ponmo) Sold in different parts of the Federal Capital Territory, Nigeria

ABSTRACT

Investigation of heavy metals (Zinc) concentration and nutritional value of cow hides (ponmo) consumed in AMAC (Abuja Municipal and Kuje Area Councils was carried out between November 2021 and January 2022. Samples were randomly collected from both Area Councils and prepared for Analysis using Nitric acid digestion and Atomic Absorption Spectrometer (AAS). The mean concentration of Zinc (Zn) in AMAC were 0.88 ± 0.35mg/kg and 2.04 ± 0.57mg/kg in Kuje Area Council respectively. Results showed that the concentration of Zinc (Zn) in cow hide (Ponmo) from AMAC was two times as high as cow hide (Ponmo) from Kuje Area Council. The mean concentration of Zinc (Zn) in cow hide in both Area Councils were two times as high as the Food and Agricultural Organization Standard unit for Zinc(Zn), which is 0.03mg/kg -1.0mg/kg. However, potential accumulation may depend on the frequency of consumption or exposure. In contrast to many studies the samples had alot of nutritional value. Proximate analysis showed that the ponmo samples for Kuje had 54% proteinand 34.68% carbohydrate, moisture 5.3%, crude lipid 2.3%, ash 2.7%, fibre 0.82% while ponmo samples for AMAC had 51.4% protein, 36% carbohydrate, 5% moisture, crude lipid 4.3%, ash 2.1% and fibre 1.1% which suggests that Ponmo has some level of nutrient especially rich in protein and carbohydrate and low in fibre content. Cowhides from AMAC and Kuje Area Councils contain significant amount of zinc, which exceeded the standard limit and could pose a potential health risk to consumers depending on the frequency of consumption. Hence the need for monitoring of this metal concentration to avoid excessive bioaccumulation that could be harmful to health. This study also showed that cowhides is rich in some nutrients especially protein and carbohydrates and can be a substitute for meat protein.

KEYWORDS: Cowhide, Zinc, Proximate, Nutritional value, Concentration

INTRODUCTION

Food and drink are shown to expose humans to hazardous metals at a higher rate than air (Adimula *et al.,* 2019). Since metals and mixtures containing these metals are normal parts of the world's outside and different biotas, they can be found in food and drinking water (Beckett *et al.,* 2007).

As a result of industrial and human activity, environmental pollution has become a widespread and dangerous problem (Agbogidi, 2014). Many weighty metals' biochemical and geographical cycles have been adjusted because of human action (Athar, 2001).

Weighty metals are depicted as metallic components with a thickness that is higher than that of water (Ferguson, 1990). Heavy metals are grouped together based on the notion that heaviness and toxicity are linked, which include metalloids like arsenic, that can be harmful even at small levels of exposure (Duffus, 2002).

Heavy metals are dangerous metals with a density five times that of water, and they are harmful to all living things (Karmran*et al.,* 2013). They enter the human body in a variety of methods, including ingestion, absorption, andso on (Karmran*et al.,* 2013). They become dangerous when their accumulation rate exceeds their outflow rate; they develop in the body over the long haul and are harmful (Karmran*et al*., 2013).

Copper, zinc, and iron are minor components that are expected for the solid working of the human body. Too high quantities, on the other hand, can cause toxicity (Ahmed *et al.,* 2012; Hezbullah*et al.* ,2016).

Hides in various parts of Africa, cow flesh known as 'ponmo' in South-Western Nigeria and 'wele' in Southern Ghana is eaten as a delicacy (Okiei*et al.*, 2009). Hair is customarily removed from hides by tenderizing them in hot water and then shaving them with a razor blade to produce the 'ponmo' finish. Metal shavings from the shavers used to remove the hair may be present in hides acquired through this ancient processing procedure of boiling in water (Okiei*et al.*, 2009).

Dehaired cowhide meat is commonly known as ponmo in the southwestern area of Nigeria (Dada *et al.*, 2018). Ponmo is a type of cowhide that has been dehaired and processed to resemble meat (Dada *et al.*, 2018). There are two types: white ponmo and brown ponmo. The names 'white ponmo' and 'brown ponmo' are impressions of their separate tones in the wake of dehairing and handling (Dada *et al.*, 2018).

In Nigeria, cowhides, in some cases known as ponmo or kanda, have turned into a famous substitute for red meat, bringing about expanded interest (Kalu *et al.*, 2015). To accommodate this demand, abattoir employees rush through the process of singeing the skins, using a variety of ingredients to fuel the fire (Kalu *et al.*, 2015). Unfortunately, these substances leach hazardous metals into the hides, which can lead to serious health problems, causing harm to its customers (Kalu *et al.*, 2015).

Different techniques, for example, scorching off the hair on fire took care of by different substances like as wood blended in with spent motor oil, plastics blended in with junk, or tires, have been presented and embraced by a few meat processors in the earlier ten years (Okiei*et al.*, 2009). These materials include hazardous compounds that can contaminate the skins and make them unsafe to eat. To obtain the completed product, ponmo, the burnt hides are scraped to remove ash and then cooked in water for roughly an hour (Okiei *et al.*, 2009).

Even though zinc is a fundamental minor component for all types of life, its significance in human nourishment and general wellbeing has as of late been recognized (Bhowmik *et al.*, 2010). A lack of zinc has been identified by several experts as a major public health concern, particularly in poor nations (Bhowmik *et al.*, 2010; Emani *et al.*, 2023).

Zinc is a fundamental minor element that is expected for the metabolic movement of 300 of the body's compounds, as well as cell division and DNA and protein union (Bhowmik *et al.*, 2010). Protein, carbohydrate, fat, and alcohol metabolism are all aided by these enzymes (Bhowmik *et al.,* 2010). Zinc is likewise important for tissue development, mending, taste sharpness, connective tissue development and upkeep, resistant framework work, prostaglandin age, bone mineralization, suitable thyroid capacity, blood thickening, mental working, pre-birth development, and sperm creation, in addition to other things (Bhowmik *et al.,* 2010).

Meat is a delicacy commonly consumed food all around the world, Preferences for different types of meat, as well as methods for dehairing slain animals and processing dehaired meat for eating, vary by country and culture (Dada *et al.,* 2018). In Nigeria and many other regions of Africa, eating dehaired cow skin is a typical practice in addition to regular diet of red meat (Dada *et al.,* 2018). Despite the fact that governments, concerned organizations, and people have launched campaigns against the habit, which poses a risk to consumers' health and harms the leather industry,this keeps on being the situation (Dada *et al.,* 2018).

Metals like cobalt (Co), copper (Cu), chromium (Cr), iron (Fe), magnesium (Mg), and manganese (Mn) have been connected to malignant growth, molybdenum (Mo), nickel (Ni), selenium (Se), and zinc (Zn) are for the most part fundamental components required for an assortment of biochemical and physiological cycles (WHO, 1996). A lack of certain micronutrients leads to a number of deficiency illnesses or syndromes (WHO, 1996).

Cadmium, mercury, lead, titanium, arsenic, bismuth, and antimony are examples of non-essential metals that are poisonous even in tiny levels and are not required by biological systems (Tyagi and Mehra, 1992). All metals are toxic at larger doses, whether essential or non-essential, and their toxicity has been related to chronic disorders such as renal failure, liver cirrhosis, brain syndrome, itai-itai, and many more (Salem *et al.*, 2000).

Natural methods for removing heavy metals from the environment are lacking. As a result, heavy metals are found naturally in the earth's crust. In all ecosystems, crust is present in variable amounts. Human activities, however, have severely disrupted the biogeochemical cycle and heavy metal equilibrium in diverse ecosystems. Environmental contamination became widespread in the nineteenth century as mining, industrialization, and mechanized agriculture expanded, and it has only grown since then (Morsholy *et al.*, 2022).

Animal and meat products provide sustenance to humans due to their large reserve of micronutrients (Lukáčová *et al.,* 2014,). Meat is essential for body building, repairs, antibody generation, and overall health (**Ubwa*et al.*, 2017; Salim *et al.*, 2023).** Heavy metal pollution, on the other hand, can put meat and animal products at risk. Because of their toxicity and bioaccumulation, heavy metals are considered a major health risk, well as bio magnification's role in food chains (Baykov*et al.,* 1996).

People are generally presented to weighty metals through their eating routine. Even at low concentrations, it impacts food safety and poses health concerns to humans (Santhi *et al.,* 2008). The cause and effect of metals in animal flesh and blood appears to be of international interest, and many institutions involved look to be overwhelmed (WHO, 1996).

Heavy metals are one of the most serious environmental issues, posing a threat to animal and human health due to bioaccumulation of heavy metals through the food chain (Aschner, 2002), and the resulting effect on brain cells. Heavy metals are thus bio-accumulated, bio-absorbed, bio-magnified, and finally assimilated through the food chain, Health dangers may be posed by humans (Agah *et al.,* 2009).

Previous studies have been carried out to ascertain the different levels and concentration of heavy metals such as copper, iron and manganese but the justification of this study is that it specifically targets the assessment of Zinc in Hides (ponmo).

(Kalu *et al.,* 2015). Carried out an investigation which showed that the skin of cattles butchered in Nsukka abattoir aggregated shifting degrees of weighty metals. The metals found in high focuses included Cd, Cu, Fe, Ni and Pb in unsinged stows away. The high centralization of weighty metals recorded in the unsinged stows away might be credited to the presence of weighty metals in the neighborhood climate which the creature could undoubtedly have interacted with through searching in open waste or deny dumps, free range grazing, drinking water from polluted streams, drains and exposure to atmospheric depositions especially from automobile fumes and open burning of solid waste (ObiriDanso *et al*., 2008). The Area Councils studied were exposed to similar modes of contamination of meat product.

The study of concentration of Heavy metals (Zinc) and nutritional value of cow hides is important to understand the threats of heavy metals in cow hides and how it affects human health after intake. It will also help to understand how hides are contaminated and how contamination can be reduced to ensure safety for human consumption.

METHODOLOGY

Study Area

This study was conducted in Biology laboratory of the Department of biological science University of Abuja main campus Airport Road, Federal Capital Territory, Abuja. The ponmo for the test was collected from Kuje abattoir and Abuja Municipal Area Council (AMAC) abattoir. Kuje is a community in the Federal Capital Territory of Nigeria, it has an area of 1,043 km3 and a populace of 157,770 at the 2006 registration. Kuje is about 40km southwest of Abuja, located at latitude of 8^{o}52’56’’N and longitude 0f 7^{o}13’13’’E. Abuja metropolitan Area Council (AMAC) is the biggest and the most evolved of the six region communities in FCT. The majority of the developed of the Federal Capital City (FCC). Figure 1 shows that the FCC has five principal areas, to be specific Asokoro, Maitama, Garki, Wuse, and Central Area and other recently evolved locale Apo, Gaduwa, Gudu, Lokugoma, Kaura, Durumi, Katampe, Gwarimpa, different regions like Kagini, Karsana, Karmo, and so on, has shown late formative development in the FCC. Figure 1 gives the limit area of the review regions. Abuja Municipal Area is situated between scope 80,401 and 90,201 north of the equator and longitude 60,401 and 70,401 east of the Greenwich meridian. The Abuja, FCT has a land mass of roughly 8000sq km of which the FCC involves around 250sq km with populace late enumeration at 778,567 for Abuja Municipal Area Council.

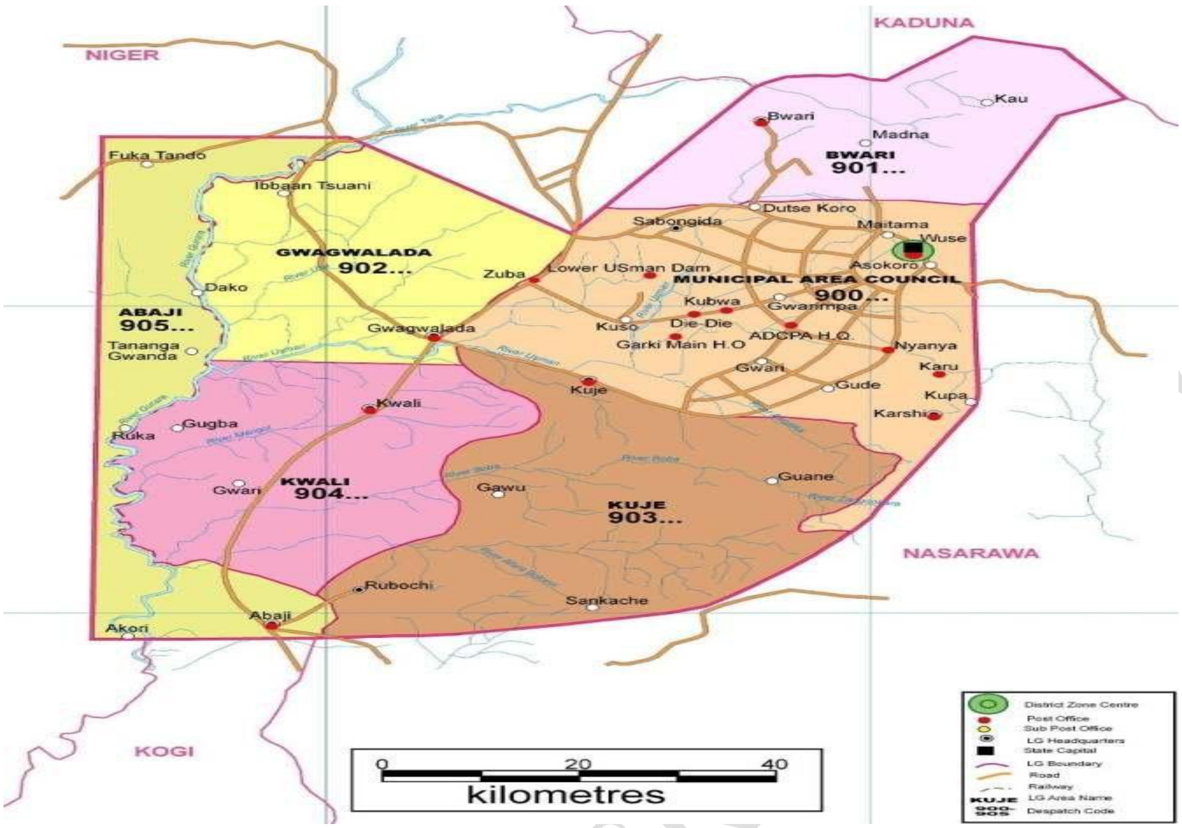

Figure 1: Map of Abuja (Source: www.Wikipedia.com, 2021)

Sample Collection

Finished cowhides products ‘‘ponmo’’ were collected for the study, ten (10) samples were collected from each area council Kuje and AMAC council. The ponmo samples were put into a pre cleaned transparent plastic plate and covered with its lid and placed into an ice chest and transported to the University of Abuja, biology laboratory in Preparation for analysis.

Sample Preparation

The samples were collected and prepared as described by okiei (2009). The ponmo was obtained randomly from the abattoir in Kuje and AMAC area councils FCT, Abuja. The Cowhide (ponmo) Samples were placed in a well cleaned transparent plastic plate and labeled properly and taken to the lab. The samples were then properly rinsed off to get rid of debris. They were weighed individually and then oven dried in an oven at $100^{O}C$ for 48hours and grinded into powder, sieved and kept in airtight clip sealed bags for digestion.

Digestion of Cowhides Samples

Samples were digested as described by okiei (2009). Wet digestion method was used and carried out in triplicate for each sample by weighing 1.0g of the powdered sample on an electric balance. The weighed sample was digested with 20ml of nitric acid (HNO_3) in a 50ml conical flask and heated with a hot plate for 10-20minute. After completing the digestion, the residue was allowed to cool and filtered into a 50ml volumetric flask. Distilled water was added to it to fill up to the mark. The filtrate was transferred into pre cleaned sample bottles and labeled appropriately for further Analysis with the Atomic Adsorption Spectrophotometer (AAS) - Thermos Fisher Scientific Model ICE 3000

Quality Control

Reagent blanks, duplicate samples and Certified Reference Material were incorporated into the batch for analysis to check for contamination, estimate analytical precision and bias respectively.

Metal Determination Procedure Using Atomic Absorption Spectrometer (AAS)

The major underlined principle of Atomic Absorption Spectrometer (AAS) is that the ground state atoms are capable of absorbing radiant energy of their own specific resonance wavelength when passed through a solution containing the atoms in question, then part of the light will be absorbed. The extent of absorption is proportional to the number of ground state atoms present in the flame. Zinc (Zn) content was determined using the Atomic Absorption Spectrometer (AAS) with a digital readout system. The instrument was fitted with specific lamp of Zinc (Zn) metal. The instrumentwere calibrated using manually prepared standard solution on Zinc (Zn) metal as well as a drift blank. The solutions were diluted for desired concentration to calibrate the instrument. Quality control measures were taken to assess contamination and reliability of data.

Proximate Analysis

The proximate analysis was carried out as described Akwetey *et al.* (2013):

Moisture content: the moisture and dry matter contents were justified by the difference in weight between wet and dried tissue which represented the weight of water and dry matter in the body tissue and was expressed as percentages.

Protein content: The protein contents were determined by calculating nitrogen amount using micro-Kjeldahl method described by Persson et al., 2008. The percentage of nitrogen was converted to crude protein by multiplying the nitrogen content by a factor of 6.25.

Lipid assay content: The total lipid contents were estimated using modified Bligh and Dyer method. Cleaned fat extracting beakers were placed in drying oven for one hour at 100 °C. After that the beaker was removed and placed in a desiccator to cool and was weighed. The weighed (1g) and finely ground sample was placed in an asbestos thimble and placed it in the Soxhlet apparatus. Added 310ml of acetone into the fat extraction beaker which was dried and weighed earlier and fix the beaker to the Soxhlet. After that the beaker was heated to 45 hours (heating point 55 °C) while cool water was running through the apparatus. After the extraction was completed, thimble and fat extracted beaker were removed from the apparatus and the beaker was kept in a vacuum oven (80 °C) until dried to a constant weight. After that the beaker was kept in a desiccator to cool and was weighed accurately.

The ash content: The ash content was determined by using the method described by Pomeranz and Meloan (1994). Ash contents of the samples were determined by incinerating the weighed test material (1gm of dry weight in a Muffle furnace at 600 ºC for a period of 4 hours). The residues were weighed and the percentages were calculated. Triplicates were maintained for each experiment. Dry matter, ash, crude fat, and crude protein content were measured according to the AOAC.

Statistical Analysis

Data were analyzed using the statistical software SPSS version 25 for windows. Independent T-test was used to compare the metal concentration between the varieties of ponmo and the two Area councils. The Kolmogorov Smornov test was used to determine whether the data was normally distributed.

RESULTS

The result of Mean concentration in mg/kg of Zinc (Zn) in cow hide (Ponmo) collected from Kuje and AMAC Abattoirs are shown in Table 1. Table 1 shows that the Mean concentration of Zinc in ponmo in KujeArea Council was 0.88 ± 0.35mg/kg which is within the range of the permissible limit of the Food and Agriculture Organization (FAO)(0.3 - 1.0mg/kg) while the Mean concentration of Zinc in ponmo in AMAC is 2.04 ± 0.57mg/kg was above the FAO limit.

Table 1: Comparison of Zinc(Zn) Concentration in Cow Hides (ponmo) from Kuje and AMAC with FAO limits.

Area councils	Zinc mg/kg (Mean±SEM)
Kuje	0.88 ± 0.35
AMAC	2.04 ± 0.57
FAO	0.3-1.0 (FAO, 2011).

Key:

SEM= Standard error of the mean

FAO= Food and Agriculture Organization (FAO, 2011).

Mean and SEM are in 2 decimal places.

Figure 2 below shows the comparison of the zinc concentration of cowhides (ponmo) from both AMAC and kuje area councils. The Figure showed that the Cowhide (ponmo) from AMAC contains a higher Concentration of Zinc (Zn) than the Cowhides(Ponmo) from Kuje Area Council.

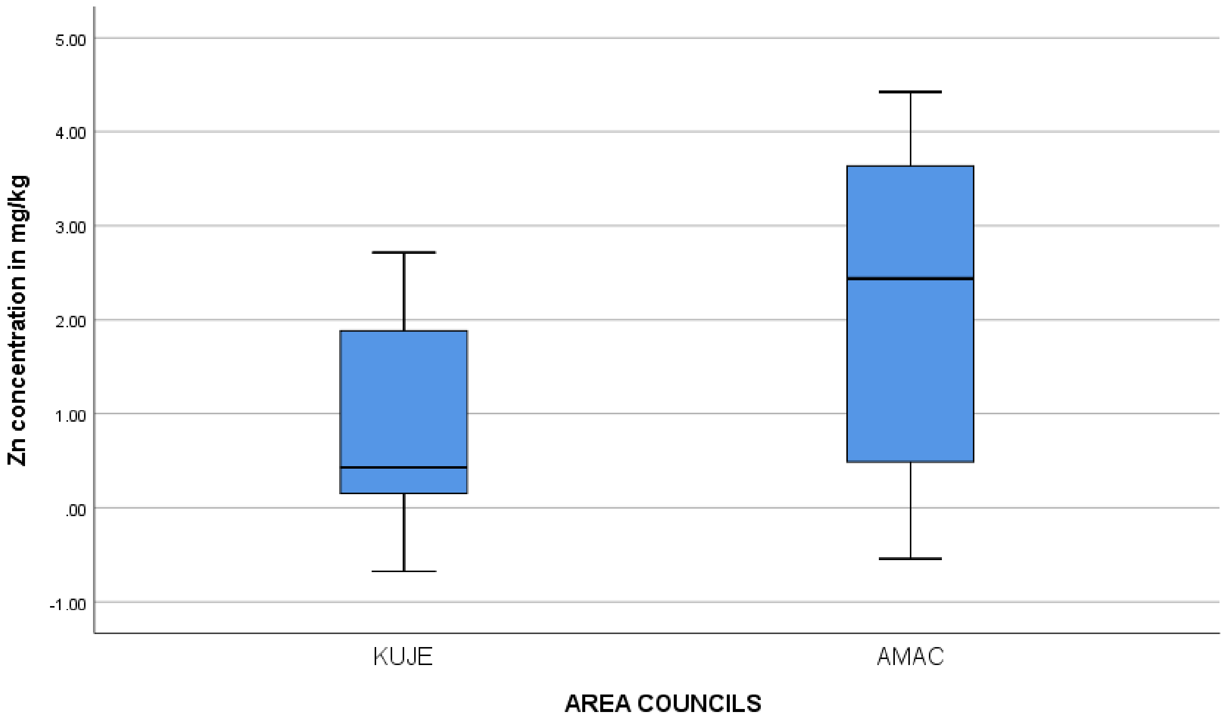

Figure 2: Comparison of Zinc (Zn) in Cow Hides in kuje and AMAC

Error Bar represents 2 Standard Errors on the mean

PROXIMATE ANALYSIS OF COWHIDES (PONMO)

Proximate examination shown in Table 2 showed that Six (6) nutrients were present in the cow hides (ponmo) from Kuje and AMAC Abbatoirs. They are Protein, Carbohydrate,Fibre, Moisture, Ash and Crude lipids. Protein and carbohydrate were the most abundant with 54% and 35% in kuje respectively. This was followed by moisture (53%). Ash and Crude lipid were 2.7% and 2.3% respectively, while fibre was the least of the supplements having 0.82% of the complete supplements in the ponmo.

Nutrients concentrations were in this order: Protein > Carbohydrate > Moisture > Ash > Crude Lipid >Fibre in Cowhide (Ponmo) from Kuje Area council.

Cowhide from AMAC also had Protein and Carbohydrate as the most abundant with 51.4% and 36% respectively. The moisture content was 5.0%, then Crude Lipid, Ash and Fibre were 4.3%, 2.1%, 1.1% respectively.

Similarly, nutrients concentrations were in this order: Protein > Carbohydrate > Moisture > Crude Lipid > Ash >Fibre.

Table 2: The nutritional analyses of the cow hide (Ponmo)

S/N	Nutritional parameter	Kuje area council (%)	AMAC area council (%)
1	Protein	54.23	51.43
2	Fibre	0.82	1.12
3	Moisture	5.25	5
4	Ash	2.7	2.01
5	Crude Lipid	2.32	4.31
6	Carbohydrate	34.68	36.13

Protein > Carbohydrate > Moisture > Ash > Crude Lipid >Fibre in Cowhide (Ponmo) from Kuje Area council.

Protein > Carbohydrate > Moisture > Crude Lipid > Ash >Fibre in Cow hide (Ponmo) from AMAC.

DISCUSSION

The result of this study showed that Zn and some nutrients were found in cowhide (Ponmo). The mean concentration of Zinc in Cowhide in Kuje and AMAC region Area Councils were 0.88 ± 0.35 and 2.04 ± 0.57 as opposed to another report Essumang *et al.*, 2007 with risen concentration of 245.80 mg.kg-1 of zinc in scorched stows away handled with vehicle broken down tyres, which suggests the concentration of zinc in cowhide could be influenced by the mode of preparation.

A review from (Obin-Danso *et al.,* 2008) in Ghana reported Zinc concentration of 17.71 ±3.48 mg.kg-1 for un-seared conceals which expanded impressively to 204. 49 ± 36.68 mg.kg-1 after they were scorched. The undeniable contrast in the concentration of Zinc in this study and that of Obiri-Danso *et al.,* (2008) might be because of the scorching system utilized in the examinations as the conceals were put straightforwardly on metal stripes from consumed tyres.

Zinc like all other heavy metals may pose a health risk when its concentration is higher than the permissible limit. The higher concentration of zinc in AMAC showed that it is a good source of zinc and other nutrients studied. However, its zinc concentration exceeded the standard limit, which might pose a health threat if frequently consumed. The extent of health risk depends on the frequency of consumption and other factors such as other sources of zinc.

Likewise, this study showed that Cowhide (Ponmo) in AMAC and Kuje contain a greater amount of protein and carbohydrates with 54% and 35% respectfully unlike the investigation of (Akwetey *et al.,* 2013) where the aftereffects of the wholesome examinations of the Cowhides showed extremely high Crude protein with moderate upsides of ether concentrate and debris acquired.

Protein content of 58.86% from the investigation of (Satarug *et al.*, 2011) is similar to the protein content in this outcome (54%). Conversely, the rough lipid content for the cowhide in this study is 2.3% and is lower by 5% when compared with the outcome detailed by (Satarug*et al.*, 2011).

It is generally believed that cowhides are low in nutrients such as protein but high in fibre content. This study contradicts this belief as high protein content was recorded and low fibre content with the fibre content constituting the least of all the nutrients. This discovery favoured the consumption of cowhides as delicacies and supplement for meat protein in many Nigerian diets.

Zinc and nutrient concentrations differ between the two Area Councils. This might have been as result of so many factors, which include the following: sources of cowhide, mode of preparation, site specific characteristics e.t.c.

However, this difference was not statistically significant. This suggests that ponmo from these areas generally have similar nutrient and Zn concentration.

Qualitative observations on site showed that roasting of cowhides with plastics and tyres may potentially contaminate cowhides with other potentially toxic metals.

CONCLUSION

This study found that cowhides (ponmo) contain zinc and other important nutrients that could supplement human and animal dietary requirements for this nutrient. However, it is important to ensure that these nutrient concentrations do not exceed the recommended limit. From the results, the cowhides in AMAC and Kuje Area Councils are richer in supplements like carbohydrates and proteins and had relatively less fibre.

From this study it is recommended that:

i. The use of tyres and plastics for burning the cowhides should be stopped by the abattoir workers in order to avoid exposing the Cow hides to contamination by heavy metals

ii. Resellers should be aware of the possible openness to heavy metals in cow hides from abattoirs and their effects on human health and should ensure thorough cleaning of cowhides before selling to consumers.

iii. Consumers should ensure to wash and cook the cow hides properly before consumption.

iv. Public Authorities should make regulations that stops or reduces the burning of cow hides with tyres, which significantly build heavy metals in them and the general public should be enlightened on the dangers of accumulation in the body.

REFERENCES

Adimula V. O., Ilupejo O., Onianwa P. C., Ayom G. E., Alafara B. A. (2019). Assessment of heavy metals in foods and adult dietary intake estimates. *African Journal of Science Technology Innovation and Development*.DOI: 10.1080/20421338.2018.1556455

Agah, AL; Mepba, HD; Ekpo, MB (2009). Heavy metal contaminants and processing effects on the composition, storage stability and fatty acid profiles of five common commercially available fish species in Oron Local Government, Nigeria. *Food Chemicals.* 97:490-497.

Agbogidi, O. M. (2014). Trace metal profile of some fruits in Kokori and Abraka Market, Delta State, Nigeria. *International Journal of Scholarly Research Gate,* 2(1).

Ahmed A. T. A., Mandal S., Chowdhury D. A., Tareq A. R. M. , Rahman M. M. (2012). Bioaccumulation of some heavy metals in Ayre Fish (SperataAor Hamilton, 1822), sediment and water of Dhaleshwari River in dry season. *Bangladesh Journal of Zoology* 40(1):147-153

Akwetey, Worlah& WY, &Eremong, & CD, &Donkoh, Armstrong. (2013). Chemical and nutrient composition of cattle hide ("welle" using different processing methods. *Journal of Animal Science Advances.* 3. 176-180. 10.5455/jasa.20130430123444.

Aschner, M (2002). Neurotoxic mechanism of fishbonemethylmetry. *EnviromentalToxic Pharmacology*. 12:101-102.

Athar M., Vohora S. B. (2001). Heavy Metals and Environment. New Delhi: *New Age International* (P) Limited; 2.

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(1-4): 155- 159.

Beckett W. S., Nordberg G. F., Clarkson T. W. (2007). “Routes of Exposure, Dose, and Metabolism of Metals.” Handbook on the Toxicology of Metals, edited by G. F. Nordberg, B. A. Fowler, M. Nordberg, and L. T. Friberg. Copenhagen: *Academy Press Inc*. 35-39

Bhowmik D, Chiranjib KP, Kumar KPS (2010) A potential medicinal importance of zinc in human health and chronic disease. *International Journal Pharmaceutical Biomedical Science*1(1):05–11

Boreiko C. J. (2009). Lead (Metal). *Encyclopedia of Electrochemical Power Sources.*

Dada E. O., Osilagun H. O., Njoku L. K. (2018). Physicochemical and Genotoxic Evaluations of Singed Cowhide Meat (Ponmo) Wastewater. *Article in Journal of Health and Pollution* .DOI: 10.5696/2156-9614-8.20.181207.

Duffus J. H. (2002). Heavy metals-a meaningless term?.*Pure Applied Chemistry* 2002;74(5):793–807.

Emami M. H., Saberi F., Mohammadzadeh S., Abdolvand A.F.M., Dehkordi S.A.E., Mohammadzadeh S., Maghool . (2023).A Review of Heavy Metals Accumulation in Red Meat and Meat Products in the Middle East, Journal of Food Protection,86(3): 100048, https://doi.org/10.1016/j.jfp.2023.100048

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.

Food and Agriculture Organization (FAO) (2011). Manual of the slaughter of small ruminants in developing countries: Section on slaughtering practices and techniques. *FAO Animal Production and Health Paper* 49.

Fergusson J. E., (1990). The Heavy Elements: Chemistry, Environmental Impact and Health Effects. *Oxford: Pergamon Press.*

Hezbullah, M., Sultana, S., Chakraborty, S., and Patwary, Md. (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. 1-5. 10.589.

Kalu E., Nwanta J., Anaga 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. 9-17. 10.5897.

Kamran S., Ali S., Hameed S., Afzal S., Samar F., Muhammad B. S., Bharwana S. A, Hafiz M. T. (2013). Heavy Metals Contamination and what are the Impacts on Living Organisms. *Greener Journal of Environmental Management and Public Safety*.Vol. 2 (4), pp. 172-179

Lukáčová, A., Golian, J., Massanyi, P. &Formicki, G. (2014). Lead concentration in meat and meat product of Different Origin. *Potravinarstvo Slovak Scientific Journal for Food Industry*, 8 (1): 43-47.

Morshdy, M. A. l Bayomi, A. E. , M. E Khalifa, R., M. Salah, S. , M. El-Dien, W. , Darwish, W., & Fikry A. Mahmoud, A. (2022). Heavy Metal Content in Chicken Meat Products: A Health Risk Assessment Study. *Journal of Advanced Veterinary Research*, *12*(4): 451-455.https://www.advetresearch.com/index.php/AVR/article/view/1061

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* Vol. 2 (8). pp. 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 Biochemical Research*; 3(10):332–339.

Person, J.A., Wennerholm, M. and O'Halloran, S. (2008). *Handbook for Kjeldahl Digetion; FOSS, Hilleroed, Denmark.* Pp12.

Pomeranz, Y. and Meloan, C.E. (1994). *Food analysis*. *Food science text series.* Pp287.

Salem H. M., Eweida E. A., Farag A. (2000). Heavy metals in drinking water and their environmental impact on human health. *The International Conference for Environmental Hazard Mitigation (ICEHM); Cairo University, Egypt.* Pp. 542–556.

Salim S.A., Sarraf ov N., Dana Z.,Hashami Z.,Afrah A., Sadeghi E., Bashiry M.(2023). A comprehensive image of environmental toxic heavy metals in red meat: A global systematic review and meta-analysis and risk assessment study, Science of The Total Environment, 889164100, https://doi.org/10.1016/j.scitotenv.2023.164100.

Satarug S., Garrett S. H., Sens M. A., Sens D. A. (2011). Cadmium, environmental exposure, and health outcomes. *Ciência&SaúdeColetiva;* 16(5):2587–2602.

Santhi D., Balakrishnan V., Kalaikannan A., Radhakrishnan K. T.(2008). Presence of heavy metals in pork products in Chennai (India). *American Journal of Food and Technology*. 3(3): 192-199.

Tyagi, O. D. and Mehra, M.: (1992). Environmental Chemistry. *Anmol Publications, New Dehli;* pp.109–288.

Ubwa, S. T., Ejiga. R., Okoye, P-A. C. &Amua, Q. M. (2017). Assessment of heavy metals in the blood and some selected entrails of cattle, goat, pig slaughtered at Wurukum Abattoir, Makurdi-Nigeria. *Advances in analytical chemistry,* 7(1):7-12. doi:10.5923/j.aac. 20.70701.02.

WHO.(1996). World Health Organization. Switzerland: Geneva; *Trace Elements in Human Nutrition and Health.*

Wikipedia. (2021). *Lead.* https://en.m.wikipedia.org/wiki/Lead