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HEAVY METAL CONCENTRATIONS AND HEALTH RISK ASSESSMENTS IN COW SKIN (*PONMO*) FROM THREE ABATTOIRS ALONG EAST-WEST ROAD IN RIVERS STATE

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ABSTRACT

In this study, cowskin samples were purchased from three local abattoirs; Ishi-odu, Choba, and Rumuosi then sent to the laboratory to determine the levels of Lead (Pb), Cadmium (Cd), Chromium (Cr), Nickel (Ni), and Arsenic (As). The heavy metal levels in the sample were determined using an Atomic Absorption Spectrophotometer (AAS) following standard methods and procedures while the health risks of cowskin consumption were calculated using the US EPA risk models (Estimated daily intake, EDI; Target Hazard Quotient, THQ; Hazard Index, HI). The analytical results showed that Lead, Chromium, and Arsenic levels were above WHO-permissible limits with mean values of 0.141-0.171 mg/kg, 0.047-0.108 mg/kg, and 0.040-0.116 mg/kg respectively while the Cd and Ni levels were within WHO-permissible limits with mean values 0.01-0.005 mg/kg and 0.013-0.023 mg/kg. The ANOVA results showed that there was no statistical difference ($p<0.05$) in the mean values of Pb, Cr, and As among the three locations; in contrast, there are statistical differences ($p<0.05$) in the mean values of Cd and Ni among the three abattoirs. The computed EDI values were within tolerable daily intake limits while THQ and HI values were well below the benchmark value of 1.0 implying that there is no appreciable health risk from consuming cowskin sourced from the study areas. Nevertheless, the individual heavy metal levels in this study were of notable concentrations, it is optimal that cowskin consumers reduce their consumption frequencies to avoid the possibility of bioaccumulation and resultant toxicity from the total heavy metal burden.

Keywords: Cowskin, abattoir, heavy metal, health risk

INTRODUCTION

Nigeria's cow skin (*ponmo*) market has seen a vast increase in demand and consumption in recent years due to its prominence in preparing numerous Nigerian soups and delicacies such as, *peppered ponmo* native soup, okra soup, affang soup, egusi soup and ogbono soup, just to mention a few. Critics believe that cow skin has little to no nutritional value, but studies on its nutrient content disprove these claims. Bwirhonde *et al.* (2018) reported that in Bukavu city of the Republic of Congo, cow skin scrapings popularly called "*Nkulo*" are used for combating protein deficiency ailments e.g. kwashiorkor due to its high protein content. Ekenma *et al.* (2015) posit that due to the health-related problems associated with eating red meat, cow skin has become a substitute for red meat in Nigeria, increasing its demand. Nevertheless, before cow skin gets to its consumers, it experiences different environments which can be potential avenues for heavy metal exposure, from grazing fields to abattoirs, storage facilities, and even meat processing methods like skinning and dehairing. Cow skin dehairing methods for consumption vary in different countries and cultures (Saheed *et al.*, 2022) and in Nigeria, the scalding and singeing methods are prevalent despite the heavy criticism of the latter. The singeing process deposits PAH (polycyclic aromatic hydrocarbons) and traces of heavy metals on the cow skin due to the use of deleterious combustible materials for sustaining flames ranging from spent tires, scrapped shoes, plastics, et cetera. Usually, firewood is deemed safer for this purpose but even trees take up heavy metals through their roots and bioaccumulate them in the cells. The contaminated trees converted into firewood are capable of adulterating the cowskin with heavy metals. Due to environmental pollution associated with continued oil spillage specific to certain regions in Nigeria like Port Harcourt, cow skin contamination with heavy metals persists. Therefore, it is imperative to quantify the concentration levels of heavy metals in consumed cow skin and ascertain their toxicological safety. Additionally, this research also aimed to assess the health risks of cow skin consumption using several U.S. Environmental Protection Agency policy (US EPA) risk models such as Estimated Daily Intake, Target Hazard Quotient, and Hazard Index.

Cowskin is a common source of protein in Nigeria and other West African countries, and its consumption is popular among all socio-economic classes. However, due to the grazing habits of cowherds and processing methods, the skin may contain heavy metals, which can pose serious health risks to consumers. Heavy metals, such as lead and cadmium, are toxic to humans and can cause long-term health effects such as cancer, neurological disorders, and developmental abnormalities. By investigating the levels of heavy metals in cowskin, this study aims to identify potential health risks associated with its consumption and inform public health policies and the development of effective strategies to mitigate the risks associated with its consumption. The findings may also be useful in guiding the development of similar studies in other parts of Nigeria and West Africa.

MATERIALS AND METHOD

Study Area

The study was conducted in three abattoirs in Port Harcourt: Ishi-Odu with the coordinates 4.889810N and longitude 6.8888880E, Choba with the latitude of the coordinates 4.888350N and longitude 6.8985650E, and Rumuosi with the coordinates 4.8821810N and longitude 6.9415460E of South-South Nigeria located in Rivers State. The climate in this Port-Harcourt region is characterized by a tropical wet climate with lengthy and heavy rainy seasons and short-lived dry seasons (Tekenah et al., 2014). The Choba abattoir, situated at the bank of a receiving watercourse, and near the Choba Market, has existed for several decades with an average daily kill of 15-20 cows (personal communication) (Woke et al., 2014). The abattoir has facilities where farm animals are housed and water taps fixed around a built-in slab area to supply water in preparing the slaughter animals.

The Ishi-Odu abattoir is situated at the foot of the Choba bridge along East-West Road where cows are slaughtered and roasted every day for commercial purposes. According to a personally conducted questionnaire, veterinary doctors occasionally do routine checks to ensure that animal cruelty is not practised in the abattoir.

The Rumuosi abattoir is sited near an abandoned burrow pit, which harbours accumulated rainwater and a refuse dump (Numbere, 2021). There are housing facilities for cows that are slaughtered every day for commercial purposes and several sheds for butchers who vend meat to consumers and

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market vendors. The map of the study area is presented in figure 1 below;

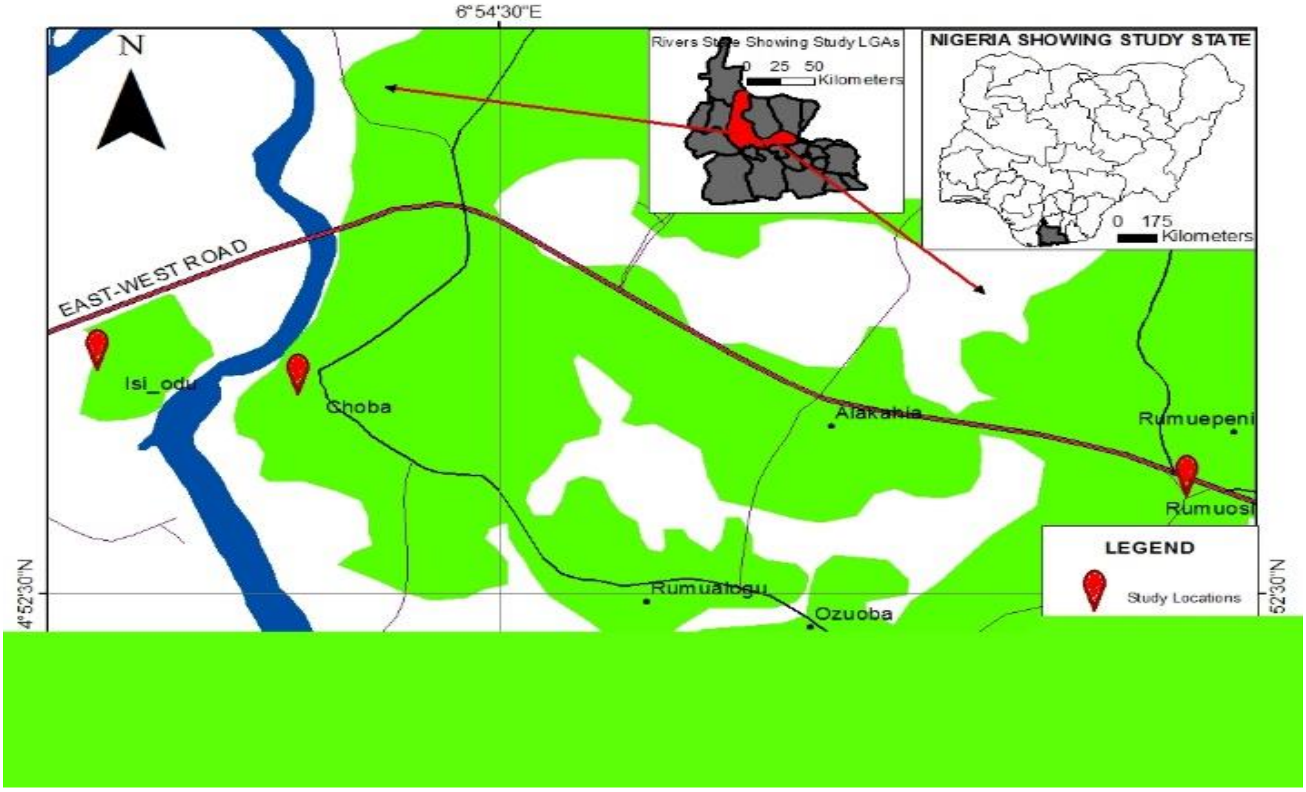

Figure 1: Map of the Study areas.

(Digitized by Ogoro, M. Department of Geography, University of Port-Harcourt)

Sample Collection

Cow skin samples were purchased weekly from three local abattoirs in Port Harcourt city, Nigeria. Two random butchers were chosen in each abattoir to remove bias. Each cow skin was assigned a sample code namely: CH, RU, and ISH for Choba, Rumuosi, and Ishi-Odu respectively. The cow skin samples were preserved in ice before the experiment.

Sample preparation and Acid digestion

The cowskin samples were placed into a porcelain evaporating dish and dried in an oven at 55˚C. The dried samples were then finely ground, sieved through a 20mm mesh sieve, and mixed thoroughly to achieve homogeneity. 0.5g of the ground cowskin samples was weighed and placed in a 125ml lager beaker, 100ml of distilled water, and 5ml of HNO_3 is also added to the beaker and thoroughly mixed. This mixture is then heated at 90˚C for 2 hours on a hot plate till the volume is reduced to 20ml ensuring that the sample does not boil.

Heavy Metal Analysis

The concentration of heavy metals was determined by Atomic Absorption Spectrophotometer (AAS) model: ASTM D 19718. The procedure includes these sequences; the digested cowskin sample was used for heavy metals analysis. The AAS system was powered on and an element cathode lamp was placed in the lamp holder. The system was allowed to warm up for about 30mins and wavelength was set to obtain maximum energy reading. Acetylene: Air ratio was ensured to be 1:8 i.e. 5psi: 40psi. The flow of air and acetylene was turned on; deionized water was ignited and aspirated for 5mins to warm up the system, and the deionized water was checked to see if it was still close to zero

(±0.005). To get a maximum absorbable reading, the burner height and position were adjusted, the nebulizer was adjusted to get a stable maximum signal and the wavelength was properly checked to also get a maximum signal of the analyte.

Quality Control

For each sample batch being processed, a method blank was carried throughout the entire sample preparation and analytical process; a smaller sample was taken through an entire procedure and re-analyzed for cases where the upper linear range of metal was exceeded to get good-quality results.

Statistical Analysis

The results of the heavy metal analysis were expressed as mean± standard deviation. The differences between the mean concentrations of the heavy metals in sampled cowskin were evaluated using the Analysis of Variance (ANOVA) tool of Microsoft Excel 2016. The software was also used to calculate the health risk assessment of cowskin consumption.

Health Risk Assessment

Estimated daily intake is the estimate by JECFA (Joint FAO/ WHO Expert Committee report on food additives) of the amount of a food additive, expressed on a body weight basis, that can be ingested daily over a lifetime without considerable health risk. The EDI of the Heavy Metals (HMs) in this study was calculated using the average concentrations of HMs in the cowskin samples studied and a daily average consumption rate of 0.0112 kg/person/day for cow skin was used for an adult with an average body weight of 65kg as reported by Asomugha et al. (2016); its values are measured in µg/g/day bw. EDI was calculated using the equation:

$$EDI = (C \times IR)/BW$$

Where C is the heavy metal concentration of selected cow skin samples; IR is the daily average intake of cow skin as stated by the FAO; BW is the body weight in kg.

The Target Hazard Quotient (THQ) for Pb, Cr, Cd, Ni, and As was calculated using the equation below;

$$THQ = \frac{Efr \times ED \times IR \times C}{RfDo \times BWaverage \times ATn(\mathrm{Efr} \times \mathrm{ED}).} \times 10^{-3}$$

EF is the exposure frequency 365 days/year, ED is the exposure duration, equivalent to the average life expectancy of a Nigerian 53years (Worldbank, 2020), RfDo is the reference dose and the applied RfDo for Pb, Cd, Cr, As, and Ni was 4.0×10^{-3}, 1.0×10^{-3}, 3.1×10^{-3}, 3.0×10^{-4}, 2×10^{-2} (see appendix 2) respectively measured in mg/kg/day. IR is the cow meat ingestion rate (kg/person/day) which is considered to be 0.0112 kg/person/day in Nigeria (FAO, 2017). C is the trace metal concentration in foodstuffs (mg/kg). BW average = average body weight 65kg and ATn is the average exposure time for non-carcinogens.

To determine the overall potential risk of adverse health effects posed by more than one metal, the individual THQs of heavy metals detected in the cowskin sample are summed to generate a Hazard Index (HI). When the HI value is ≥1, it signifies that there is a possibility of adverse health effects caused by heavy metals through the average dietary consumption of cowskin while values ≤1 depict very little to no non-carcinogenic health effects.

$$HI = \sum THQ_{Pb} + THQ_{Cd} + THQ_{Cr} + THQ_{Ni} + THQ_{As}$$

RESULTS

Heavy Metal Composition

The analysis of heavy metal levels in the purchased cow skin samples showed that Pb, Cd, Cr, As, and Ni were present in varied levels. The concentration of Pb in cowskin from Ishi-odu, Choba, and Rumuosi had values of 0.141mg/kg, 0.171mg/kg, and 0.141mg/kg respectively. The result of the Analysis of Variance showed no statistical difference ($p<0.05$) between the means of lead concentrations of cowskin purchased from the three abattoirs. The Cd concentration values in cowskin from Ishi-odu, Choba, and Rumuosi

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were recorded as 0.003mg/kg, 0.001mg/kg and 0.005mg/kg respectively. ANOVA results revealed a statistical ($p<0.05$) difference between the mean Cd concentrations in cowskin bought from the abattoirs.

The Cr levels in the cowskin sampled from the Ishi-odu, Choba, and Rumuosi had values of 0.047mg/kg, 0.108mg/kg and 0.093mg/kg respectively with no statistical ($p<0.05$) difference between the mean values. The heavy metal values of Ni were between 0.013 mg/kg and 0.023mg/kg and the results from the Analysis of Variance showed a statistical ($p<0.05$) difference between the mean Ni concentrations from each abattoir; the As concentrations of cowskin sampled from Choba had the lowest value of 0.040mg/kg while that of Ishi-odu and Rumuosi had values of 0.116 mg/kg and 0.076mg/kg respectively with no statistical ($p<0.05$) difference between the mean values. The heavy metal values are expressed in the table1 below;

Table 1: Heavy Metal concentrations (mg/kg) of purchased Cowskin from local abattoirs.

Heavy metals	Ishi-odu	Choba	Rumuosi	WHO/FAO
Lead (mg/kg)	0.141±0.00	0.171±0.00	0.141± 0.00	0.11
Cadmium (mg/kg)	0.003±0.00	0.01± 0.00	0.005± 0.00	0.2
Chromium (mg/kg)	0.047±0.00	0.108±0.00	0.093± 0.00	0.003
Nickel (mg/kg)	0.013±0.00	0.023±0.00	0.017± 0.00	0.02
Arsenic (mg/kg)	0.116±0.00	0.04± 0.00	0.076± 0.00	0.05

Results are expressed in mean± standard deviation.

Estimated Daily Intake (EDI)

The values for the Estimated Daily Intake of Pb, Cd, Cr, Ni, and As in cowskin gotten from the Ishi-Odu abattoir are as follows; 2.38615×10^{-5} µg/g/day bw, 5.07692×10^{-7} µg/g/day bw, 7.95385×10^{-6} µg/g/day bw, 2.2×10^{-6} µg/g/day bw, 1.96308×10^{-5} µg/g/day bw respectively and it is represented in figure 2 below;

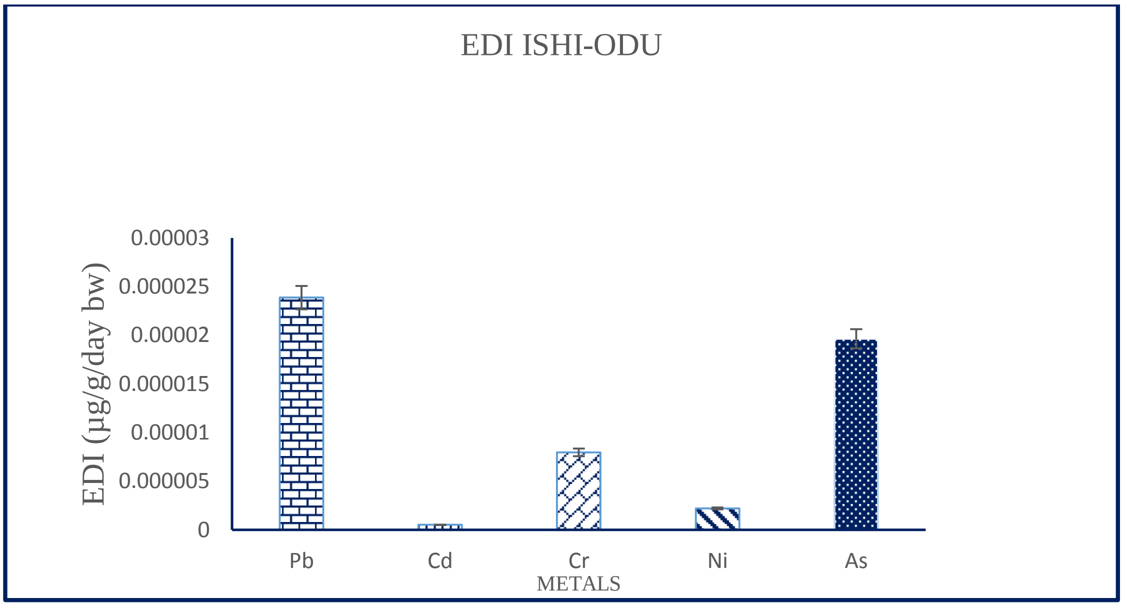

Figure 2: Estimated Daily Intake (EDI) of heavy metals purchased from Ishi-Odu abattoir.

The values for the Estimated Daily Intake of Pb, Cd, Cr, Ni, and As in cowskin gotten from the Choba abattoir are 2.89385×10^{-5} µg/g/day bw, 1.69231×10^{-7} µg/g/day bw, 1.82769×10^{-5}µg/g/day bw, 3.89231× 10^{-6} µg/g/day bw, 6.76923× 10^{-6} µg/g/day bw respectively. The values are represented in figure 3 below;

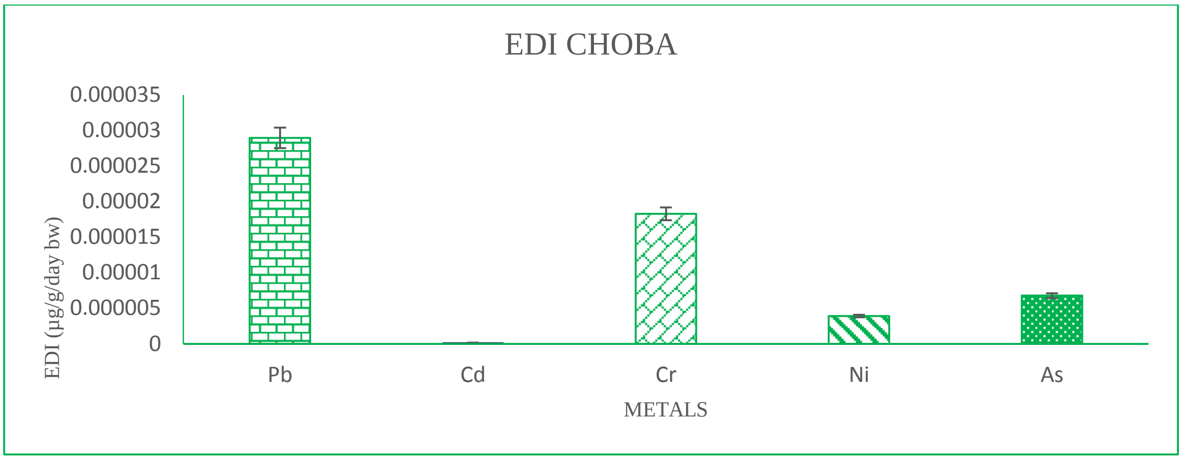

Figure 3: Estimated Daily Intake (EDI) of heavy metals purchased from Choba abattoir.

The EDI values of Pb, Cd, Cr, Ni, and As in cowskin gotten from the Rumuosi Abattoir include the following; 2.38615× 10^{-5} µg/g/day bw, 8.46154× 10^{-7} µg/g/day bw, 1.57385× 10^{-5} µg/g/day bw, 2.87692× 10^{-6} µg/g/day bw, 1.28615× 10^{-5} µg/g/day bw respectively and these values are represented in figure 4 below;

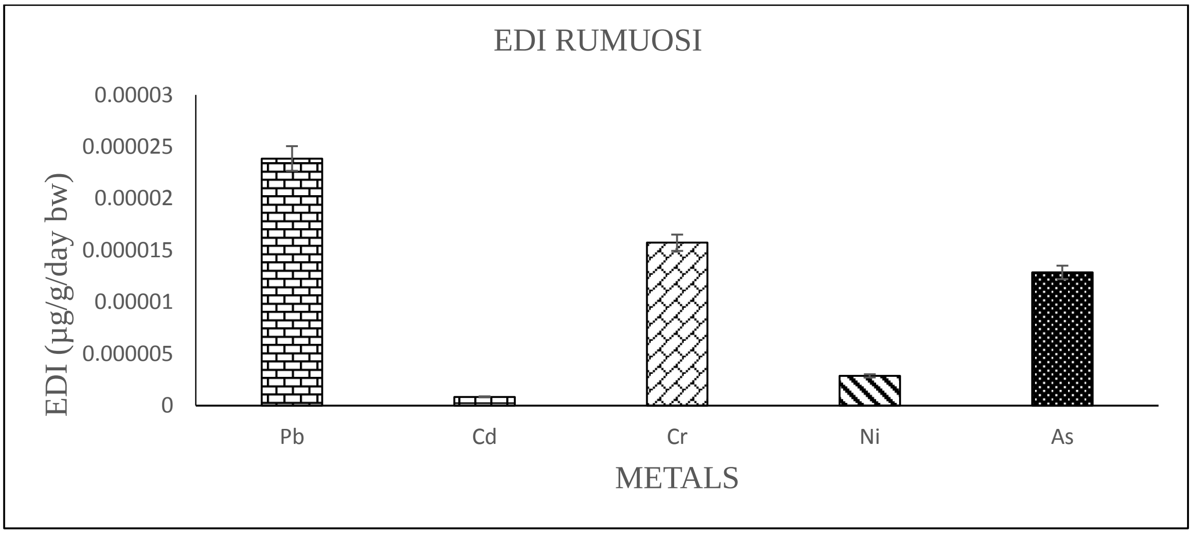

Figure 4: Estimated Daily Intake (EDI) of heavy metals purchased from Rumuosi abattoir.

Target Hazard Quotient (THQ)

The calculated Target Hazard Quotient values for Pb, Cd, Cr, Ni, and As were 6.07385× 10^{-6} 5.16923× 10^{-7}, 2.61241× 10^{-6}, 1.12× 10^{-7}, 7.21778× 10^{-5} respectively for cowskin purchased from the Ishi-Odu abattoir.

For cowskin bought from Choba abattoir, the calculated Target Hazard Quotient values for Pb, Cd, Cr, Ni, and As were 7.36615× 10^{-6}, 1.72308× 10^{-7}, 6.00298× 10^{-6}, 1.98154× 10^{-7}, 2.48889× 10^{-5} respectively.

The calculated THQ values of cowskin from Rumuosi Abattoir for Pb, Cd, Cr, Ni, and As were 6.07385× 10^{-6}, 8.61538× 10^{-7}, 5.16923× 10^{-6}, 1.46462× 10^{-7}, 4.72889× 10^{-5}. These values are represented in figure 5 below.

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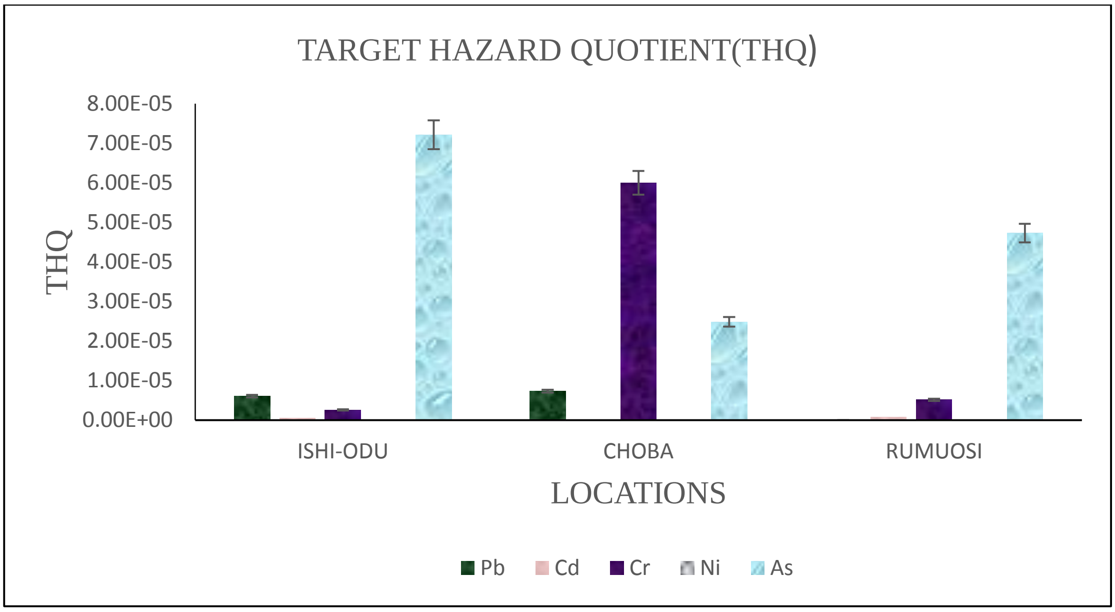

Figure 5: Target Hazard Quotient for exposure to heavy metals in several cowskin samples.

Hazard Index (HI)

The Hazard index values include 3.86285×10^{-5}, 5.954×10^{-5}, and 8.1493×10^{-5} for locations; Choba, Ishi-Odu, and Rumuosi respectively. This is represented in figure 6 below;

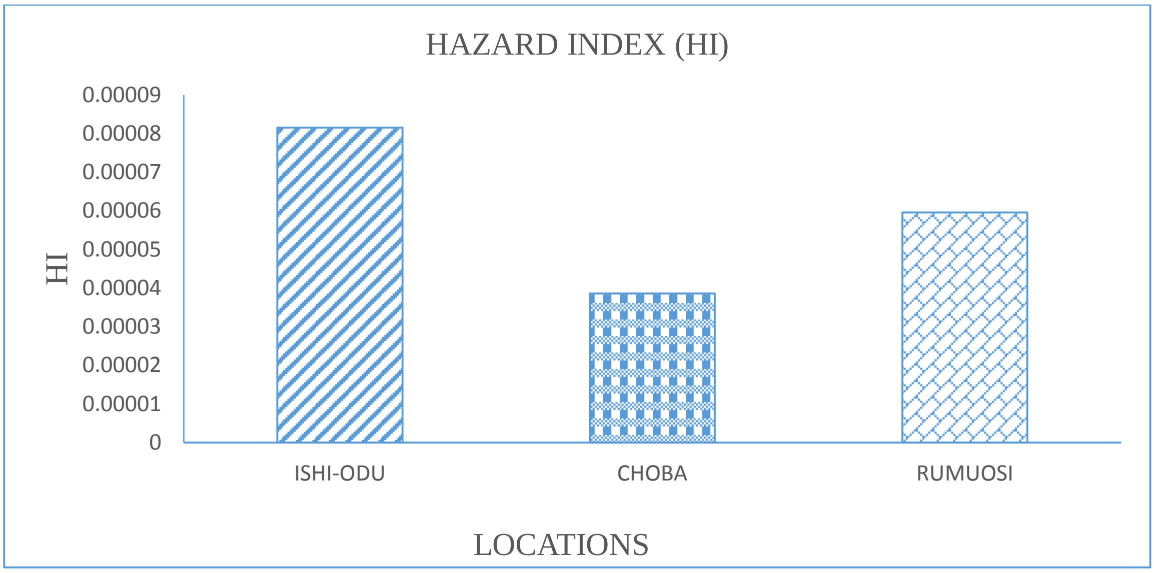

Figure 6: Hazard Index for total heavy metal concentrations.

DISCUSSION

Heavy metal (HM) concentrations in cowskin

The prevalence of HM contamination in the food industry has spearheaded numerous researches to ascertain the safety of the general public. Several factors contribute to the increased contamination of food with heavy metals, mostly from anthropogenic sources. This study assessed Pb, Cd, Cr, Ni, and As in cowskin from abattoirs in Rivers state; Ishi-Odu, Choba, and Rumuosi revealing that the samples accumulated varied heavy metal levels. The Pb levels in this study were above the WHO permissible limits of 0.11mg/kg which is in line with a study conducted in Abuja by (Hajara et al., 2022) reporting lead levels far above permissible levels with a value of 1.0973mg/kg. The presence of Pb in cowskin may be ascribed to the absorbed lead by plants and ingested contaminated pastures (Khan et al., 2015).

The lead values found in the cowskin sampled from the Ishi-Odu and Choba Abattoir had similar values of 0.141mg/kg which corresponds with a study conducted in Anambra state by Okafor et al. (2012) whose Pb values were reported to be 0.140mg/kg in cowskin. Lead has been shown many times to permanently reduce the cognitive capacity of children at extremely low levels of exposure (Golub, 2016).

Cadmium has no physiological function in humans; it accumulates in plants and animals with a long half-life of about 25–30 years. Genchi et al. (2020) and is capable of building up in the kidneys. The levels of cadmium were generally below detectable limits in this study contrasting with a study conducted in Rivers state by Ogbalu et al. (2008) which measured and reported higher Cd levels ranging from 0.22mg/kg to 0.75mg/kg. Another study by Sathyamoorthy et al. (2015) recorded above-permissible Cd levels in cattle skin sampled from livestock that graze in polluted areas while Okiei et al. (2009) also reported detectable Cd (0.10mg/kg- 0.38mg/kg) levels in cowskin which contrasts with the below detectable limits in the present study.

The Nickel levels in cowskin sampled in this study were below the stipulated WHO regulatory limit of 0.02 mg/kg levels except that of the Choba abattoir. The recorded Ni levels in cowskin from the Choba abattoir had a value of 0.023mg/kg which agrees with the study by Udo et al. (2021) whose Ni concentration level in cowskin was of the same value. Ekenma et al. (2015) also recorded higher Pb and Ni levels in sampled cowskin than in that of this study.

The As levels in the cowskin from Choba and Rumuosi abattoirs reported in this study were well-above permissible limits which agrees with Mensah et al. (2019) whose recorded As levels in scrap-tyre singed cowskin and firewood-singed cowskin were 0.82±0.076mg/kg and 0.38±0.076mg/kg exceeding the WHO regulatory limits. A study by Emeh (2019) conducted in Abia state analyzed heavy metals in tyre-combusted cowskin reporting Arsenic value of 0.005mg/kg which is within tolerable limits differing from the As values Abattoirs. Mandal (2017) stated that arsenic is farm animals' most common cause of inorganic chemical poisoning through contaminated drinking water, feedstuff, grasses, and vegetables. Consumption of these affected animals introduces arsenic toxicity to the human food chain.

Chromium pollution is a significant environmental threat whose excessive exposure results in serious health problems in humans, plants and animals (Prasad et al., 2021). The Cd and Cr values in cowskin sampled from the Ishi-Odu abattoir had similar values to a study conducted in Sokoto by Akawu et al. (2020). The chromium levels in this study were all detectable with values above WHO-permissible levels of 0.003mg/kg which is in contrast with a study conducted in Nasarawa state by Sabuwa et al. (2021) whose Cr levels in cowskin were non-detectable but significantly higher in other tissues of the cattle. The study reported that extensive grazing near industries contributes to the exposure of cattle to Cr and this enters the food chain causing several health problems for consumers.

Estimated Daily Intake (EDI)

The recorded EDI in all heavy metals evaluated in this study were below Tolerable daily intake limits with Pb having the highest level from all three abattoirs, this contrasts with Ihedioha et al. (2014) who carried out a health risk assessment in Enugu state reporting that the EDI (Estimated Daily Intake) of chromium from cow meat was high compared to established standards. The study advises a reduction in cowskin intake to avoid bioaccumulation toxicity. A study in Brazil by

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Leite et al. (2020) conducted a risk assessment and the calculated EDI was recorded to be below tolerable daily intake limits which agrees with this present study. The trend level in EDI in cowskin purchased from the Ishi-Odu abattoir is shown as Pb>As>Cr>Ni>Cd with values ranging from 2.38615× 10^{-5} µg/g/day bw to 5.07692× 10^{-7} µg/g/day bw. The EDI levels analyzed for the Choba abattoir arranged in ascending order is Cd<Ni<As<Cr<Pb. The lowest EDI level in the Rumuosi is that of Cd with a value of 8.46154× 10^{-7} µg/g/day bw.

Target Hazard Quotient (THQ)

The heavy metal concentrations recorded in this study were considerably high however using the Target Hazard Quotient risk model, there is no health risk associated with consuming cowskin sourced from these selected abattoirs since the sum of the THQ values of the selected heavy metals in this study were below 1.

Hazard Index (HI)

The values for the Hazard Index of the three locations include 3.86285× 10^{-5}, 5.954× 10^{-5}, and 8.1493× 10^{-5}. These values were less than 1.0 in each location implying that there is no considerable health risk from consuming the total burden of all heavy metals analyzed in the cowskin samples.

The study conclude that though statistical differences were found in the mean Cd, and Ni values of cowskin samples from the different abattoirs, no statistical differences were shown in the mean Pb, Cr, and As values of the various abattoirs. Further, concentrations of toxic heavy metals in the analyzed cowskin samples from the selected abattoirs in Port Harcourt abattoirs were above WHO permissible limits except Cd and Ni and this raises health concerns of its consumers. The calculated EDI values for all locations were within tolerable limits while the computed THQ and HI values were below the benchmark value of 1.0 which implies that there is no significant health risk associated with cowskin consumption from the study areas.

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