International Journal of Agriculture and Environmental Research

ISSN: 2455-6939

Volume: 11, Issue: 04 "July-August 2025"

HUMAN HEALTH RISK ASSESSMENT OF LEAD (Pb) AND NICKEL (Ni) IN EDIBLE COWHIDE FROM LOKOJA, KOGI STATE, NIGERIA

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DOI: https://doi.org/10.51193/IJAER.2025.11413

Received: 14 Jul. 2025 / Accepted: 22 Jul. 2025 / Published: 23 Jul. 2025

ABSTRACT

Processed cowhide is a widely consumed meat source in Nigeria due to its availability and affordability compared to other beef parts. However, its common processing methods, often involving car tyres and refined petroleum products such as premium motor spirit and kerosene, raise significant public health concerns due to potential contamination with toxic heavy metals. This study evaluated the health risks associated with lead (Pb) and nickel (Ni) in edible cowhide sold across major markets in Lokoja metropolis, Kogi State, Nigeria. Heavy metal concentrations were analyzed using Atomic Absorption Spectrophotometry (AAS), and health risk assessments were conducted using Estimated Daily Intake (EDI), Target Hazard Quotient (THQ), and Hazard Index (HI), following USEPA guidelines. Results from 30 cowhide samples showed Pb and Ni concentrations ranging from 0.91 to 1.29 mg/kg and 26.42 to 27.48 mg/kg, respectively, both significantly above FAO/WHO permissible limits. EDI values revealed highest exposure levels in children, followed by adult women and men. THQ values were also highest among children, particularly in Old Market, reaching 0.46 for Pb and 1.72 for Ni. Hazard Index values for combined exposure exceeded the safe limit of 1 in all child groups (1.98–2.18), indicating potential non-carcinogenic health risks, while adult values remained below 1. Carcinogenic risk (CR) values from Pb exposure fell within the acceptable range (10^{-6}–10^{-4}), but were highest in children (up to 1.37×10^{-5}). These findings suggest that regular consumption of cowhide, especially among children, may pose both non-carcinogenic and low-level carcinogenic risks. Improved processing methods, public health education, and routine safety monitoring are recommended to reduce exposure and safeguard consumer health.

Keywords: Cowhide (*Ponmo*), Health risk, Lead and Nickel, Lokoja Nigeria

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INTRODUCTION

Meat is a major source of animal proteins, minerals and vitamins (Geiker *et al.,* 2021). Humans consume all parts of animal products, such as the meat, milk and egg, globally. Due to the harsh economy in most developing countries, majority of the populace resort to purchase and consume less costly animal parts which are otherwise use as industrial raw materials. One of such animal parts commonly used in the industries to produce different leather products (Izuchi *et al.,* 2016) like furniture, cloth, bags, belts and shoes, among others is cowhide (animal skin) (Curtidos Menacho, 2022). Cowhides have been used as source of meat in some parts of African countries, including Nigeria (Keta *et al.,* 2020; Bosede and Omokaro, 2022). To get the edible cowhide, the live cattle is slaughtered and the hide is carefully detached using a sharp knife. In Nigeria, the hide is placed on burning fire generated by mixture of fire wood, used car tyers, kerosene/petrol in order to manually remove the hairs attached with ease. The smoky flavoured, dark hides devoid of hairs are then scraped clean, washed with water before they are retailed alongside the reaming fresh cow meat at various open markets across Nigeria. Due to their relatively lower cost over the richer parts of cow products (meat), many consumers prefer to purchase the processed cowhide, commonly referred to as *ponmon*, for preparing different local delicacies in several Nigerian communities. The '*Ponmo'* is boiled or smoked at home, spiced and eaten directly or added to other local delicacies before consumption (Akwetey *et al*., 2013). Majority of Nigerians and even food sellers continue to patronize cowhide sellers without recourse to their health effects.

Although, cowhides chemically are composed of proteins and carbohydrates, in recent times, several studies have demonstrated that cowhides are potential accumulators of heavy metals (Ayanda et al., 2021; Perillo *et al.,* 2021; Yakubu *et al.,* 2022; Ogunlade-Anibasa and Ogwuiche, 2023). Currently, significant public health concerns have been raised on the incessant consumption of cowhide meat as a result of the questionable processing techniques that are applied. The effluent from cowhide preparation was found to contain harmful chemicals which induced significant chromosomal abnormally and cell division in *Allium cepa* (onion) (Dada *et al.,* 2018). This indicates that regular consumers of poorly processed cowhide are exposed to genetoxicity among other health hazards. There are calls by dieticians and other health officers on the general public to reduce or discontinue the consumption of cowhides (*ponmo*) due to their higher health risk associated with it. One of the major concerns associated with cowhide is the possible of harmful microbes (Magdalene *et al*., 2024) and metals (Yakubu *et al.,* 2022; Ogunlade-Anibasa and Ogwuiche, 2023) leaching into the inner cowhide layers during processing with mixture fire wood and tires and waste materials added to fuel the cowhide de-hairing process. Theses harmful substances accumulate in inner layers of the processed cowhide and pose serious health risk to regular consumers.

Heavy metals contaminations are of particular interest in food because of the their propensity to settle and accumulate in tissues of animals leading to numerous health effects such as neurological disorder, kidney damage, and carcinogenicity in exposed individuals. Among the different heavy metals of public health concerns, lead (Pb) and nickel (Ni) stand out due to their high toxicity and frequent occurrence in animal-derived and associated food products (Afzal and Mahreen, 2024; Hussain *et al.,* 2024). Nickel (Ni) is widespread in the environment being applied as raw material for metallurgy, electroplating, battery from where they contaminate food, soil and water. Human exposure to high levels of Ni, via food/water, causes serious oxidative stress and malfunctioning of the mitochondria in cells leading to higher risks of dermatitis, asthma/respiratory disorder, cardiovascular disease, lung fibrosis, and cancers (Genchi *et al.,* 2020; Dinu *et al.,* 2021). Similarly, Pb is very common toxic and persistent heavy metals widespread in different environmental sources such as soil, water, food, air, industrial and petrochemical products (Wani *et al.,* 2015). Lots of health issues have been reported in exposed individuals and are more serious in infants and children, who are more vulnerable. Intense behavioral issues, learning impairment, lower IQ, and developmental disorders are the major issues associated with children that exposed to Pb (Wani *et al.,* 2015). There are reported higher risks of cancers, high blood preseure, low counts of red blood cells, kidney dysfunction, central nervous system impairments and infertility in exposed individuals due to the disruption of the smooth functioning of the pathways used for the production heme and calcium-dependent neurological activities (Wani *et al.,* 2015; Kataba *et al.,* 2023; Vagnoni *et al.,* 2024). These heavy metals normally gain entrance in food during unsafe processing, thereby making their presence in edible food a source of worry for the public, hence warranting constant investigations for consumer safety. In Lokoja, Kogi State, North Central, Nigeria, processed cowhide is a very common source of animal protein in both homes and various commercial food joints. Its relatively low cost and cultural preference have made it a staple part of many diets in the region. However, due to the crude nature in which cowhides are processed and retailed, consumers are seldom unaware of how the product was processed or what toxic substances may be present. There is limited information on the extent of heavy metal contamination of cowhide reatiled and consumed humans dwelling in Lokoja. Hence, it raises some concerns about food safety and the potential health risks associated with frequent exposure to edible cowhide (*ponmo*) in the region. Therefore, the objectives of this study were to assess the concentrations of lead and nickel in edible cowhide sold in Lokoja, Kogi State, and to evaluate the potential human health risks associated with its consumption using standard risk assessment models.

MATERIALS AND METHODS

Study Area

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This study was conducted in Lokoja, the capital of Kogi State in North Central Nigeria. Lokoja is located where the River Niger and River Benue meet, making it an important historical and commercial city. It lies between latitude 7°45′N and 7°51′N and longitude 6°44′E and 6°46′E. The city shares borders with Ajaokuta to the east, Koton-Karfe to the west, and Kabba to the north. The climate is tropical, with a rainy season from April to October and a dry season from November to March. Temperatures range from 26°C to 34°C, and annual rainfall averages between 1,100 mm and 1,500 mm. Humidity is high during the rainy season and drops during the dry Harmattan months. Lokoja is a busy trade center with vibrant markets and active street food sales, including high consumption of cowhide (ponmo). Lokoja was chosen for this study due to its high consumption of cowhide and the lack of data on its safety in the area.

Sampling

A total of 30 cowhide (ponmo) samples were collected from five major markets in Lokoja, Kogi State: Old Market, Ganaja, Felele, Adankolo, and Kpata. Six samples were taken from each market, selected based on high sales and regular availability. Sampling took place over two weeks in February 2025 during the dry season. The samples were bought directly from vendors and each sample (about 250–300 g) was wrapped in sterile foil, labeled by market, and packed in clean bags inside an ice-cooled container (4°C). They were transported within two hours to the laboratory for analysis.

Sample Preparation and Laboratory Analysis

Sample Preparation: The cowhide samples were first rinsed with distilled water to remove any surface dirt or loose particles. After washing, they were air-dried on clean trays at room temperature. Once completely dry, the samples were cut into smaller bits and blended using a clean stainless steel laboratory blender to produce a fine, uniform powder. About 2.0 grams of each powdered sample was then measured using an electronic balance and transferred into a clean, dry 100 mL glass beaker for further digestion

Wet Acid Digestion: Sample digestion was carried out using the standard wet acid method based on AOAC guidelines (2005). Each powdered cowhide sample received 10 mL of concentrated nitric acid (HNO_3) and 2 mL of perchloric acid ($HClO_4$) in a clean glass beaker. The beakers were covered with watch glasses and left at room temperature for about 30 minutes to allow any reactive gases to escape. After this pre-digestion step, the samples were heated on a hot plate at 150°C for about one hour, until the solution became clear and the volume reduced to roughly one-third. Once digestion was complete, the beakers were removed from the heat and allowed to cool. The digested solutions were then filtered through Whatman No. 42 filter paper into clean 50 mL volumetric flasks. Each filtrate was topped up to the 50 mL mark with deionized water and transferred into

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acid-washed plastic bottles for storage until analysis. Accuracy was ensured by analyzing acid-only blanks and certified reference materials alongside the actual samples.

Atomic Absorption Spectrophotometry (AAS) Analysis: The levels of Lead (Pb) and Nickel (Ni) in the digested cowhide samples were measured using an Atomic Absorption Spectrophotometer (AAS), model Buck Scientific 210VGP. Before analyzing the samples, the instrument was calibrated with standard solutions of known concentrations of Pb and Ni. These standards were prepared in a series of increasing concentrations: 1, 2, 4, 6, 8, and 10 mg/L. During analysis, each digested sample was introduced into the AAS flame, and the absorbance of each metal was measured at its specific wavelength—283.3 nm for Lead and 232.0 nm for Nickel. To ensure accuracy, each sample was analyzed three times, and the average value was used. The final concentrations were reported in milligrams per kilogram (mg/kg) of dry cowhide tissue. Inorder to maintain quality control and data reliability, instrumental blanks, calibration checks, and duplicate samples were analyzed after every ten samples. The detection limits of the instrument were 0.01 mg/kg for Lead and 0.02 mg/kg for Nickel, ensuring sensitivity in detecting even low levels of these metals.

Non-Carcinogenic Health Risk Assessment Models

This study used three standard non-cancer risk models: Estimated Daily Intake (EDI), Target Hazard Quotient (THQ), and Hazard Index (HI) to evaluate the health risks associated with heavy metals in cowhide. These models are based on guidelines from the United States Environmental Protection Agency (USEPA, 2011) and are widely accepted in environmental health studies.

Estimated Daily Intake (EDI): The EDI helps to determine how much of a heavy metal a person might take in each day through food, based on their body weight. The calculations were carried out for three different consumer groups to better represent real-life exposure levels using equation 1. These included children (average body weight of 20 kg), adult women (average body weight of 65 kg), and adult men (average body weight of 70 kg). This approach made it possible to estimate the level of metal exposure for each group and identify those who might be more at risk.

$$\textbf{EDI} = (C \times IR) / BW \qquad \text{(Equation 1)}$$

Where:

C is the average concentration of the metal in cowhide (in mg/kg),

IR is the ingestion rate of cowhide, set at 0.01909 kg/day (equivalent to 19.09 grams per day),

BW is the average body weight of the consumer (in kg).

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Target Hazard Quotient (THQ): The THQ is used to estimate the risk of non-cancer health effects from long-term exposure to a single metal. It was calculated using the United States EPA risk evaluation model formula (Equation 2). THQ value less than one suggests no serious health risk, while a value equal to or greater than one indicates possible concern from long-term exposure. THQ was calculated separately for children, adult women, and adult men to reflect differences in body weight and sensitivity.

$$\mathbf{THQ = (EFr \times ED \times Cr \times Mc) / (RfD \times Bwt \times AT)}, \text{ (Equation 2)}$$

Where:

EFr = Exposure frequency (**365 days/year)**

ED = Exposure duration (**70 years)**

Cr = Average daily intake of cowhide (0.01909 **mg/person/day)**

Mc = Mean concentration of metal in cowhide **(mg/kg)**

RfD = Oral reference dose (**0.0035 mg/kg/day** for **Pb; 0.02 mg/kg/day** for **Ni)**

Bwt = Average body weight (**C**hildren: 20kg; Adult women: 65kg; Adult men: 70kg)

AT = Averaging time = **25,550 days** (70 years × 365 days/year)

Hazard Index (HI): The HI is used to assess the combined risk from exposure to both metals. It is the sum of the THQ values for lead and nickel (Equation 3). An HI value below one means the overall risk is low, while a value of one or more points to a potential non-carcinogenic health risk. Like THQ, HI was also calculated for the three consumer groups to give a clearer picture of risk across age and gender.

$$\mathbf{HI = THQ_{Pb} + THQ_{Ni}} \qquad \textbf{(Equation 3)}$$

Where:

HI = Hazard Index

THQ_{Pb} = Target Hazard Quotient for Lead

THQ_{Ni} = Target Hazard Quotient for Nickel

Carcinogenic Health Risk Assessment Models

The potential cancer risk from consuming cowhide contaminated with heavy metals was estimated using the Cancer Risk (CR) model. This model calculates the chance of developing cancer over a lifetime through dietary exposure. The cancer risk was determined by multiplying the Estimated

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Daily Intake (EDI) of the metal by its Slope Factor (SF) (Equation 4), which indicates the cancer-causing potential. In this study, only Lead (Pb) was assessed because Nickel (Ni) does not have a defined oral slope factor under USEPA guidelines. The slope factor used for Lead was 0.0085 mg/kg/day. The CR values obtained were then compared with the acceptable risk range of 1 in 1,000,000 to 1 in 10,000. Any value above this range may indicate a possible public health concern.

$$\mathbf{CR = EDI \times SF} \qquad \textbf{(Equation 4)}$$

Where:

CR is the Cancer Risk,

EDI is the Estimated Daily Intake of the metal (mg/kg/day),

SF is the Slope Factor $(mg/kg/day)^{-1}$, which reflects the cancer-causing potential of the metal.

RESULTS

Heavy metal analysis

The mean concentration of Lead (Pb) was highest in cowhide samples from Old Market (1.29 mg/kg) and lowest in Kpata Market (0.91 mg/kg) (Table 1) Similarly, Nickel (Ni) concentrations were highest in Old Market (27.48 mg/kg) and lowest in Kpata Market (26.42 mg/kg). All observed concentrations of Pb and Ni across the markets exceeded the FAO/WHO permissible limits of 0.10 mg/kg for Pb and 0.50 mg/kg for Ni. Statistically significant differences ($p < 0.05$) were observed among the markets for both metals.

Table 1: Mean Concentrations of Lead (Pb) and Nickel (Ni) in Cowhide Samples from Different Markets in Lokoja (mg/kg)

Market	Pb (mg/kg)	Ni (mg/kg)
Old Market	1.29 ± 0.03^{a}	27.48 ± 0.10^{a}
Ganaja Market	1.14 ± 0.02^{b}	27.21 ± 0.08^{b}
Felele Market	1.06 ± 0.02^{c}	26.95 ± 0.07^{c}
Adankolo Market	0.97 ± 0.01^{c}	26.78 ± 0.05^{c}
Kpata Market	0.91 ± 0.01^{d}	26.42 ± 0.04^{d}
FAO/WHO Limit	0.10	0.50

**Values are presented as Mean ± Standard Deviation (n = 6 per market). Different superscript letters (^{a}–^{d}) indicate significant differences at $p < 0.05$ using ANOVA followed by Tukey's post hoc test.*

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Estimated Daily Intake (EDI) Analysis

Children recorded the highest estimated daily intake (EDI) of lead (Pb) and nickel (Ni) across all five markets in Lokoja (Table 2). The highest Pb intake was 0.001231 mg/kg/day in children from Old Market, and the lowest was 0.000248 mg/kg/day in adult men from Kpata Market. For Ni, the highest EDI was 0.026230 mg/kg/day in children from Old Market, and the lowest was 0.007205 mg/kg/day in adult men from Kpata Market. In all markets, children had the highest EDI values, followed by adult women, and then adult men.

Table 2: Estimated Daily Intake (EDI) of Pb and Ni (mg/kg/day) in Cowhide Samples from Different Markets in Lokoja

Market	Consumer Group	EDI (mg/kg/day)	
		Pb	Ni
Old Market	Child (24 kg)	0.001231	0.026230
	Adult Woman (55 kg)	0.000379	0.008071
	Adult Man (65 kg)	0.000352	0.007494
Ganaja Market	Child (24 kg)	0.001088	0.025972
	Adult Woman (55 kg)	0.000335	0.007991
	Adult Man (65 kg)	0.000311	0.007421
Felele Market	Child (24 kg)	0.001012	0.025724
	Adult Woman (55 kg)	0.000311	0.007915
	Adult Man (65 kg)	0.000289	0.007350
Adankolo Mkt	Child (24 kg)	0.000926	0.025562
	Adult Woman (55 kg)	0.000285	0.007865
	Adult Man (65 kg)	0.000265	0.007303
Kpata Market	Child (24 kg)	0.000869	0.025218
	Adult Woman (55 kg)	0.000267	0.007759
	Adult Man (65 kg)	0.000248	0.007205

Target Hazard Quotient (THQ) Analysis

The highest THQ values for both lead and nickel were found in children who ate cowhide from Old Market, with 0.35 for lead and 1.31 for nickel. The lowest (Table 3) THQ values were seen in adult men from Kpata Market, with 0.07 for lead and 0.36 for nickel. Generally, children had higher THQ levels than adult women, while adult men had the lowest for both metals.

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Table 3: Target Hazard Quotient (THQ) for Pb and Ni in Cowhide Samples from Different Markets in Lokoja

Market	THQ					
	Children (20kg)		Adult Woman (65kg)		Adult Man (70kg)	
	Pb	Ni	Pb	Ni	Pb	Ni
Old Market	0.35	1.31	0.11	0.40	0.10	0.37
Ganaja Market	0.31	1.30	0.10	0.40	0.09	0.37
Felele Market	0.29	1.29	0.09	0.40	0.08	0.37
Adankolo Market	0.26	1.28	0.08	0.39	0.08	0.37
Kpata Market	0.25	1.26	0.08	0.39	0.07	0.36

Hazard Index (HI) Analysis

Children who consumed cowhide from Old Market had the highest combined hazard index (HI) of 1.66, followed by adult women, while adult men had the lowest.]. This was followed by children from Ganaja (1.61), Felele (1.58), Adankolo (1.54), and Kpata Market (1.51). Among adult women, HI values ranged from 0.51 in Old Market to 0.46 in Kpata Market. Adult men recorded the lowest HI values, from 0.48 in Old Market to 0.43 in Kpata Market. Across all locations, children had the highest HI,

Table 4: Hazard Index (HI) from Combined Pb and Ni Exposure in Cowhide Samples from Different Markets in Lokoja

Market	HI		
	Children (20 kg)	Adult Women (65 kg)	Adult Men (70 kg)
Old Market	1.66	0.51	0.48
Ganaja Market	1.61	0.50	0.46
Felele Market	1.58	0.48	0.45
Adankolo Market	1.54	0.47	0.44
Kpata Market	1.51	0.46	0.43

Carcinogenic Risk (CR) Analysis

Among all the markets surveyed, children who consumed cowhide from Old Market recorded the highest lead-related cancer risk at 1.05×10^{-5}. They were followed by children from Ganaja (9.25×10^{-6}), Felele (8.60×10^{-6}), Adankolo (7.87×10^{-6}), and Kpata Market (7.39×10^{-6}). For adult women, the CR values ranged from 3.22×10^{-6} at Old Market to 2.27×10^{-6} at Kpata. The adult men had the lowest levels across all sites, ranging from 2.99×10^{-6} at Old Market to 2.11×10^{-6} at Kpata Market.

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Table 5: Carcinogenic Risk (CR) of Pb Based on Lifetime Exposure to Cowhide Samples from Different Markets in Lokoja

Market	Consumer Group	EDI (mg/kg/day)	CR = EDI × 0.0085
Old Market	Children (20 kg)	0.001231	1.05×10^{-5}
	Adult Women (65 kg)	0.000379	3.22×10^{-6}
	Adult Men (70 kg)	0.000352	2.99×10^{-6}
Ganaja Market	Children (20 kg)	0.001088	9.25×10^{-6}
	Adult Women (65 kg)	0.000335	2.85×10^{-6}
	Adult Men (70 kg)	0.000311	2.64×10^{-6}
Felele Market	Children (20 kg)	0.001012	8.60×10^{-6}
	Adult Women (65 kg)	0.000311	2.64×10^{-6}
	Adult Men (70 kg)	0.000289	2.46×10^{-6}
Adankolo Mkt	Children (20 kg)	0.000926	7.87×10^{-6}
	Adult Women (65 kg)	0.000285	2.42×10^{-6}
	Adult Men (70 kg)	0.000265	2.25×10^{-6}
Kpata Market	Children (20 kg)	0.000869	7.39×10^{-6}
	Adult Women (65 kg)	0.000267	2.27×10^{-6}
	Adult Men (70 kg)	0.000248	2.11×10^{-6}

DISCUSSION

Cowhide, commonly consumed as a delicacy in many Nigerian communities, is often processed using traditional methods that may introduce harmful substances, including heavy metals. Some heavy metals are the common contaminants associated with such practices, especially when materials like used vehicle tires, plastics, engine oil and kerosene are burned during processing. Frequent exposure via consumption of contaminated cowhide (*ponmo*) may pose serious health risks, particularly to vulnerable groups such as children. This study assessed the levels of Pb and Ni in cowhide from various markets in Lokoja and evaluated the potential health risks associated with their intake. The findings from the metal analysis showed that both lead (Pb) and nickel (Ni) concentrations in the cowhide samples were far above the safety limits set by FAO/WHO. This could be linked to heavy metal contaminations, likely caused by poor processing methods that involve burning with harmful substances such as used tires, plastics, and other waste materials. As a result, individuals who regularly consume such cowhide may be exposed to toxic heavy metals over time. These results align with the observations of Yakubu *et al*. (2022), who also found high levels of Pb and Ni in cowhide obtained from markets in Abuja. In a similar study, Ogunlade-Anibasa and Ogwuiche (2023) linked elevated metal levels in hides to open-flame processing with uncontrolled materials, stressing the health risks of such unregulated practices. On the other hand, the metal concentrations found in this present research were significantly higher than those reported by Ayanda *et al*. (2021) in Ogun State, where Pb and Ni levels were relatively low. This variation might be due to differences in regional pollution levels, fuel sources used during processing, and how strictly food hygiene regulations are enforced. The public health risks associated with these contaminants are serious. According to Wani *et al*. (2015), lead is a dangerous neurotoxin that can damage the nervous system, particularly in children, and may also affect kidney function and fertility in adults. Genchi *et al*. (2020) also noted that long-term exposure to nickel can trigger breathing problems, skin reactions like dermatitis, and oxidative stress due to mitochondrial damage, all of which are linked to cancer and other chronic diseases.

The estimated daily intake (EDI) revealed that the children had the highest value of both lead (Pb) and nickel (Ni) across all five markets studied in Lokoja. This trend probably reflects the increased health vulnerability of children, largely due to their smaller body size and higher intake of food relative to body weight. A similar pattern was reported by Genchi *et al.* (2020), who explained that children are more prone to the harmful effects of heavy metals, especially nickel, which can affect lung function and developmental processes. The findings are in agreement with the work of Kataba *et al.* (2023), who reported elevated lead exposure in younger age groups in contaminated environments. They linked this exposure to immune disturbances and changes in cytokine levels. In the same vein, Wani *et al.* (2015) reported that even minimal lead intake in children could result in neurological damage, learning difficulties, and stunted growth, all of which underline the risk highlighted in the present study. Across all markets, adult women had higher EDI values than adult men. This difference may be due to physiological factors such as body fat distribution and iron metabolism. A similar observation was made by Ayanda *et al*. (2021), who reported gender-based variations in exposure among adults consuming cowhide in Ogun State. However, in comparison, the EDI values from the current study are much higher, indicating a greater level of contamination in Lokoja. This variation further emphasizes the importance of site-specific assessments when evaluating food safety risks. In particular, the notably high nickel intake in children from the Old Market supoorts the findings of Edet *et al*. (2024), who reported substantial nickel residues in goat meat processed with discarded tyres in Calabar. Their study also linked such exposure to potential cancer risks, reinforcing concerns about unsafe processing methods such as tyre burning, which appear to be contributing significantly to heavy metal contamination in food products.

THQ analysis revealed that children remain the most at risk of non-cancer health effects from Pb and Ni exposure through cowhide consumption. The highest THQ values were recorded in children consuming cowhide from Old Market, with a Pb THQ of 0.35 and a Ni THQ of 1.31. These figures indicate a significant potential for health impacts, especially from Ni, where values above 1.0 suggest a substantial risk of chronic toxicity. This agrees with the findings of Genchi *et al.* (2020), who reported that long-term Ni exposure can trigger oxidative stress, respiratory disorders, and

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allergic skin reactions. The higher risk in children compared to adults could be attributed to the fact that children's smaller body size, higher food consumption per unit of body weight, and still-developing organs make them more vulnerable. Wani *et al.* (2015) emphasized that exposure to Pb during early life can severely affect neurological development, cause behavioural disturbances, and impair growth. In all market locations, THQ values for children were higher than those for adult women, while adult men recorded the lowest values for both metals. This pattern probably reflects the influence of body weight and physiological factors on individual susceptibility to contaminants. However, the lowest THQ values observed in adult men from Kpata Market are still notable because even though they fall below the critical threshold, they point to a cumulative risk that could increase over time. The current THQ values for Ni in children are similar to those reported by Edet *et al*. (2024), who found that goat meat processed with burning tyres and plastics in Calabar also resulted in Ni THQ values above 1. Their study confirmed that the use of such hazardous materials during hide processing significantly contributes to metal contamination in meat products. These findings reiterate the probability that poor processing practices in Lokoja, especially open singeing using unregulated waste, are key contributors to the high THQ values seen here. On the other hand, Ayanda *et al.* (2021) reported much lower THQ values for both Pb and Ni in cowhide samples from Ogun State, where values for all population groups remained safely below 1. This difference could be attributed to the variations in local environmental pollution, fuel sources used during processing, or better regulatory practices. Zakariyau *et al*. (2025) also supported the submission that burning tyres and plastics during processing markedly increases toxic residues in hides. This could be a possible reason for the elevated heavy metal risk levels observed in this study.

Analysis of the findings from hazard index also showed that children recorded the highest combined exposure to both lead (Pb) and nickel (Ni) through cowhide consumption across all sampled markets in Lokoja. These values were above the safety HI index threshold of 1, which suggests potential non-carcinogenic health risks due to the cumulative effects of multiple heavy metals. This finding is in concordance with earlier observations from THQ analysis and underscores the greater susceptibility of children to environmental toxins, largely due to their lower body weight and developing organ systems. Among adult consumers, women recorded moderate HI values, while adult men had the lowest indices in general. The progressive decline in HI from children to adult men reflects the influence of body size and metabolic differences on toxic metal absorption, as previously noted by Genchi *et al.* (2020). It also supports the assumption that while all population groups face some level of exposure, children are the most affected and should be prioritized in public health interventions. These results agree with findings reported by Hussain *et al*. (2024), who documented that combined exposure to heavy metals significantly amplifies systemic toxicity, especially among young populations. The high cumulative risk seen in this study is also consistent with Edet *et al.* (2024), who reported similarly elevated hazard index values in

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goat meat processed with tyres and waste materials in Calabar. Dada *et al*. (2023) found higher levels of contaminants in cowhide compared to fresh beef, especially in settings with poor hygiene practices and unregulated processing. This study further supports earlier findings on the contribution of hazardous processing methods and unhygienic practices to increased contaminant levels in edible animal products. This finding in this study are in disagreement with those of Ayanda *et al.* (2021), whose study in Ogun State reported HI values below 1, indicating a lower level of risk. This variation could be due to regional differences in processing methods, market sanitation, or proximity to industrial pollutants. In Lokoja, the frequent use of tyres and plastics in cowhide preparation may be a key factor driving up exposure levels, as also suggested by Ihedioha *et al.* (2014), who found that meat consumption was a major route of nickel intake in several Nigerian cities.

The results of children carcinogenic risk (CR) assessment revealed they face a higher lifetime cancer risk from Pb exposure through cowhide consumption compared to adults. The highest CR value of 1.05×10^{-5} was recorded in children consuming cowhide from Old Market, was above the United States Environmental Protection Agency's (USEPA) acceptable threshold of 1.0×10^{-6}. This suggests a notable cancer risk and of public health significance. The CR values decreased progressively from children to adult women and were lowest among adult men across all sites. This trend highlights how children’s lower body weight and higher food intake relative to size increase their vulnerability to the cancer-causing effects of heavy metals. This pattern agrees with the findings of Ihedioha *et al.* (2014), who reported elevated cancer risks from Pb in meat consumed in urban areas of Nigeria. The findings also buttresses the study by Edet *et al*. (2024), which linked increased lifetime cancer risk in consumers of goat meat processed with tyres and waste materials to elevated lead levels and carcinogenic substances, such as polycyclic aromatic hydrocarbons (PAHs). Dada *et al.* (2023) similarly pointed out that the safety of cowhide products is strongly determined by market conditions and proximity to industrial pollutants. This suggest that methods by which cowhide is processed and the level of pollution around the market greatly affect how harmful it can be to people’s health. Despite the valuable findings, this study had some limitations. First, it focused only on two heavy metals (lead and nickel), while other potentially harmful metals and compounds such as cadmium, mercury, or PAHs were not analyzed. Also, the cowhide samples were limited to five markets in Lokoja, which may not represent contamination levels in other parts of Nigeria. In addition, the health risk models used assumed average body weights and daily intake rates, which may vary among individuals. Lastly, the study did not account for long-term dietary habits or cumulative exposure from other food sources, which could influence the actual health risks. Further studies are recommended to include a wider range of contaminants, expand sample locations across different regions, and adopt a more comprehensive risk model that factors in long-term dietary habits and total exposure from multiple sources.

ISSN: 2455-6939

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CONCLUSION

This study has revealed that cowhide meat sold in major markets across Lokoja contains elevated levels of heavy metals, particularly Pb and Ni, posing both non-carcinogenic and carcinogenic health risks to consumers. Children were identified as the most vulnerable group, likely due to their lower body weight and higher intake relative to body mass. Hazard Index (HI) and Carcinogenic Risk (CR) values in this group exceeded recommended safety thresholds. The use of hazardous materials such as tyres, engine oil, and plastics during processing appears to be a major contributing factor to the contamination. These findings highlight an urgent need for public health interventions, including stricter regulations on cowhide processing methods, regular monitoring of food contaminants, and public education on the associated health risks. Taking these steps is essential to ensure food safety and protect the health of all population groups, especially children.

REFERENCES

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

[2]. Ayanda, O., Ajayi, T., and Bilewu, O. (2021). Analysis of some heavy metals in cow skin (ponmo) sold at major markets in Ado-Odo/Ota LGA, Ogun State, Nigeria. *Tropical Journal of Natural Product Research, 5*(6): 1006–1009. https://doi.org/10.26538/tjnpr/v5i6.3

[3]. Ayanda, O., Ajayi, T., and Bilewu, O. (2021). Analysis of some heavy metals in cow skin (ponmo) sold at major markets in Ado-Odo/Ota LGA, Ogun State, Nigeria. *Tropical Journal of Natural Product Research, 5*(6): 1006–1009. https://doi.org/10.26538/tjnpr/v5i6.3.

[4]. Bosede, A. A., and Omokaro, O. (2022). Microbiological quality of roasted cowhide meat (‘ponmo’) processed and sold in some abattoirs in Bayelsa and Rivers States. *Acta Scientific Microbiology, 5*(7): 64–70. https://doi.org/10.31080/ASMI.2022.05.1098.

[5]. Curtidos Menacho. (2022). *Cowhide, one of the best options*. Curtidos Menacho Blog. https://www.curtidosmenacho.com/blog/news/cowhide-one-of-the-best-options.

[6]. Dada, E. O., Adediwura, T. M., and Yusuf, A. T. (2023). Relative nutritional and contaminant status of cowhide meat and fresh cow meat. *Aswan University Journal of Environmental Studies (AUJES): 4*(2): 61–73. https://doi.org/10.21608/aujes.2023.183868.1115

[7]. Dada, E. O., Osilagun, H. O., and Njoku, K. L. (2018). Physicochemical and genotoxic evaluations of singed cowhide meat (ponmo) wastewater. *Journal of Health and Pollution, 8*(20): 181207. https://doi.org/10.5696/2156-9614-8.20.181207.

[8]. Dinu, C., Gheorghe, S., Tenea, A. G., Stoica, C., Vasile, G.-G., Popescu, R. L., Serban, E.

A., and Pascu, L. F. (2021). Toxic metals (As, Cd, Ni, Pb) impact in the most common medicinal plant (*Mentha piperita*). *International Journal of Environmental Research and Public Health, 18*(8): 3904. https://doi.org/10.3390/ijerph18083904.

[9]. Edet, U., Joseph, A., Bebia, G., Mbim, E., Ubi, B., Archibong, C., Ugwu, J., Umoafia, N., Akindele, A. F. I., Edet, A., Obsike, G., Udoeyop, F., and Nwaokorie, F. (2024). Health risk of heavy metals and PAHs contaminants in goat meat de-haired with waste tyres and plastic in Calabar, Nigeria. *Journal of Food Composition and Analysis*, *131*, 106216. https://doi.org/10.1016/j.jfca.2024.106216

[10]. Geiker, N. R. W., Bertram, H. C., Mejborn, H., Dragsted, L. O., Kristensen, L., Carrascal, J. R., Bügel, S., and Astrup, A. (2021). Meat and human health—Current knowledge and research gaps. *Foods, 10*(7): 1556. https://doi.org/10.3390/foods10071556

[11]. Genchi, G., Carocci, A., Lauria, G., Sinicropi, M. S., and Catalano, A. (2020). Nickel: Human health and environmental toxicology. *International Journal of Environmental Research and Public Health, 17*(3): 679. https://doi.org/10.3390/ijerph17030679.

[12]. Hussain, M. I., Khan, Z. I., Ahmad, K., Naeem, M., Ali, M. A., Elshikh, M. S., Zaman, Q. U., Iqbal, K., Muscolo, A., and Yang, H.-H. (2024). Toxicity and bioassimilation of lead and nickel in farm ruminants fed on diversified forage crops grown on contaminated soil. *Ecotoxicology and Environmental Safety*, *283*, 116812. https://doi.org/10.1016/j.ecoenv.2024.116812.

[13]. Ihedioha, J. N., Okoye, C. O. B., and Onyechi, U. A. (2014). Health risk assessment of zinc, chromium, and nickel from cow meat consumption in an urban Nigerian population. *International Journal of Occupational and Environmental Health, 20*(4): 281–288. https://doi.org/10.1179/2049396714Y.0000000075

[14]. Izuchi, Y., Takashima, T., and Hatano, N. (2016). Rapid and accurate identification of animal species in natural leather goods by liquid chromatography/mass spectrometry. *Mass Spectrometry (Tokyo): 5*(1): A0046. https://doi.org/10.5702/massspectrometry.A0046.

[15]. Kataba, A., Yohannes, Y. B., Nakata, H., Yabe, J., Toyomaki, H., Muzandu, K., Zyambo, G., Ikenaka, Y., Choongo, K., Ishizuka, M., and Nakayama, S. M. M. (2023). Association between chronic environmental lead (Pb) exposure and cytokines in males and females of reproductive age from Kabwe, Zambia. *International Journal of Environmental Research and Public Health, 20*(8): 5596. https://doi.org/10.3390/ijerph20085596.

[16]. Keta, J. N., Mubarak, A., Peter, R. J., Keta, M. N., and Joseph, G. G. (2020). Bacteria contamination of market vended *ponmo* (processed cow hide) in Birnin Kebbi, Kebbi State. *Equity Journal of Science and Technology*, *7*(1): 41–45. https://www.equijost.com

[17]. Magdalene, T. N., Ogbene, O. S., and Etele, A. J. (2024). Microbiological examination of ready-to-eat cow hide (ponmo) sold by street vendors in Makurdi, Benue State, Nigeria. *Science World Journal*, *19*(3): Article 8. https://dx.doi.org/10.4314/swj.v19i3.8

ISSN: 2455-6939

Volume: 11, Issue: 04 "July-August 2025"

[18]. Ogunlade-Anibasa, G. O., and Ogwuiche, P. O. (2023). *Determination of zinc concentration and nutritional value of cow hide (ponmo) sold in different parts of the Federal Capital Territory, Nigeria*. *Journal of Advances in Biology and Biotechnology, 26*(9): 1–10. https://doi.org/10.9734/JABB/2023/v26i9652.

[19]. Perillo, L., Arfuso, F., Piccione, G., Dara, S., Tropia, E., Cascone, G., Licitra, F., and Monteverde, V. (2021). Quantification of some heavy metals in hair of dairy cows housed in different areas from Sicily as a bioindicator of environmental exposure—A preliminary study. *Animals (Basel): 11*(8): 2268. https://doi.org/10.3390/ani11082268.

[20]. Vagnoni, G., Bortolotti, E., Checchi, S., Saieva, C., Berti, G., Doccioli, C., and Caini, S. (2024). Lead (Pb) in biological samples in association with cancer risk and mortality: A systematic literature review. *Cancer Epidemiology, 92*, 102630. https://doi.org/10.1016/j.canep.2024.102630.

[21]. Wani, A. L., Ara, A., and Usmani, J. A. (2015). Lead toxicity: A review. *Interdisciplinary Toxicology, 8*(2): 55–64. https://doi.org/10.1515/intox-2015-0009.

[22]. Yakubu, H., Funke, A. W., Olawale, S. A., and Ibukun, E. E. (2022). Assessment of heavy metals in processed cow skins consumed in two Area Councils of the FCT-Abuja. *Journal of Agriculture and Aquaculture, 4*(2). https://doi.org/10.47760/cognizance.2022.v02i09.003.

[23]. Zakariyau, U., Bello, M., Musa, A., Gidado, S., Umar, A., Sanni, N., and Abdullahi, A. (2025, February 4). Dioxin levels in cattle hide processed using different fuel sources for human consumption in Sokoto Central Abattoir, Sokoto State, Nigeria. *Journal of Interventional Epidemiology and Public Health, 8*(Suppl 12): 4. https://doi.org/10.37432/jieph.supp.2025.8.1.12.4

