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Assessment of Heavy Metals in Slaughtered Cattle and Goats in Gwagwalada, Abuja, Nigeria

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ABSTRACT
Environmental pollution with concomitant contamination of foods of plant and animal origin, particularly by heavy metals, continues to be of great concern in many parts of the world, especially in developing countries. These heavy metals—whether naturally occurring or synthetic—are ubiquitous. Humans encounter them via water, air, plants, and animals, as they enter the body through inhalation, contact, and ingestion, ultimately accumulating in various tissues and organs with deleterious health outcomes. This study assessed the blood and tissue levels of cadmium (Cd), chromium (Cr), cobalt (Co), lead (Pb), and arsenic (As) in cattle and goats slaughtered at the Gwagwalada abattoir, Abuja, Nigeria, using atomic absorption spectrophotometry. The findings revealed elevated levels of these metals in various tissues, often exceeding FAO/WHO safety limits, indicating potential public health risks. More regular evaluation of meat and meat products for heavy metals should be undertaken and safety limits should be enforced to protect public health.

INTRODUCTION

Environmental contamination by heavy metals is a growing public health issue globally, especially in developing countries where environmental regulations and food safety practices mat be less stringent. Heavy metals such as cadmium (Cd), chromium (Cr), cobalt (Co), lead (Pb), and arsenic (As) are of particular concern due to their toxic, persistent, and bioaccumulative nature. These metals may enter the food chain through soil, water, plants, and feed, eventually accumulating in the tissues of food-producing animals (Ali et al., 2021).

Meat from cattle and goats is an important source of high-quality protein and essential micro-nutrients for many Nigerian households, contributing substantially to dietary intake of macro- and micro-nutrients in both urban and rural populations. However, red meat and edible offal may also be a route of human exposure to heavy metals

Environmental and anthropogenic sources that lead to elevated heavy-metal loads in livestock include industrial emissions, mining, traffic and roadside dust, irrigation or drinking water contaminated with metals, use of contaminated fertilizers or agrochemicals, and grazing on polluted land or near dumpsites and mining areas. Animals may accumulate metals via ingestion of contaminated forage and soil, drinking contaminated water, or through contaminated feed and supplements. These metals subsequently distribute differently among tissues, commonly concentrating in liver and kidney more than in muscle. Such pathways have been documented across Africa and are especially well reported in Nigerian abattoir-based studies (Domingo, 2025; Emurotu et al., 2024).

Numerous studies across Nigeria and neighboring African countries have documented detectable levels of toxic metals in muscle and offal of slaughtered livestock, with a

recurring pattern of higher concentrations in organs (liver, kidney) than in muscle tissue. For example, studies in Enugu, Ibadan, Lagos, and Kaduna have reported measurable Pb and Cd in edible tissues, with occasional cases of concentrations exceeding national or international guidance values for certain elements; similar patterns have been found in Uganda and Ghana (Ihedioha & Okoye, 2013; Taiwo et al., 2018; Kasozi et al., 2021).

Other studies in Nigeria, have documented the presence of heavy metals in tissues of slaughtered livestock. For instance, Akinyeye et al. (2021) reported elevated blood lead levels in cattle and goats slaughtered at abattoirs in Zaria, exceeding WHO permissible limits. In Jimeta, Yola, Milam et al. (2020) found relatively low levels of Cd, Pb, and other heavy metals in cattle tissues, within international safety limits. However, Ezeonyejiaku et al. (2021) observed high levels of Pb and As in goat carcasses in Enugu, indicating significant public health concerns.

Globally, the contamination of red meat by toxic metals remains a widespread problem. A recent meta-analysis by Pourret et al. (2023) revealed that levels of Cd and Pb in red meat samples frequently exceed FAO/WHO safety thresholds, especially in Africa and Asia. Such findings underscore the need for localized monitoring of heavy metal residues in abattoirs, particularly in urban centers like Abuja.

In the Federal Capital Territory, including Gwagwalada, there are relatively fewer published abattoir-based studies compared with other Nigerian regions. Given local patterns of livestock movement, open grazing, proximity to urban activities, and the frequent consumption of organs by local populations, an abattoir-based assessment of Pb, Cd, Cr, and Ni in cattle and goat tissues in Gwagwalada will fill an important data gap. The resulting data can inform local risk assessments, guide meat inspection policy, and suggest pragmatic measures for reducing livestock exposure (Emurotu et al., 2024; Taiwo et al., 2018).

MATERIALS AND METHODS

Tissue and blood samples were collected from freshly slaughtered cattle and goats at the Gwagwalada abattoir. Each sample (3 g) was homogenized and digested with 20 cm^3 of concentrated nitric acid (HNO_3) in a 250 cm^3 conical flask at 110°C for 3 hours. After evaporation to near dryness, the residue was diluted with 20 cm^3 of 2% nitric acid, filtered, and made up to 100 cm^3 with deionized water. Heavy metal concentrations were determined using a Thermo Scientific iCE 3000 Atomic Absorption Spectrophotometer (AAS). Results were expressed as mean ± standard error of mean (SEM).

Data Analysis

The data generated were analysed using GraphPad version 9.7.1 and the results obtained were expressed as the mean concentration of heavy metals.

RESULTS AND DISCUSSION

Results

The present study revealed the presence of all the heavy metal evaluated in all the blood and organs of cattle and goats slaughtered at the Gwagwalada abattoir with the exception of Cr was not detected in the liver and kidney of cattle (Tables 1 and 2)

Cr was the metal with the highest mean concentration in goats (49.24mg/kg in the kidney). The metal with the highest concentration in slaughtered cattle was Pb(13. 48mg/kg) and this was found in the kidney(Table 2).

The mean concentration of Cd ranged from 0.6 mg/kg in goat blood to 3.91 mg/kg in cattle kidney. Co had a mean concentration ranging from 1.62mg/kg in goat blood to 9.77mg/kg in cattle kidney. Cr showed a mean concentration ranging from 0.35mg/kg in cattle blood to 49.24mg/kg in goat kidney and As was accumulated least in the kidney of cattle and mostly accumulated in goat liver (Tables 1 and 2)

The relative organ/tissue concentrations of Cd,Co, Pb, Cr and As in the blood, intestine, kidney, liver and muscle in goats and cattle collected at slaughter at the Gwagwalada abattoir bench-marked against their respective FAO/WHO permissible limits, are depicted in Tables 3-7.

Table 1: Mean and standard error of mean concentration (mg/kg) of Cadmium, Cobalt, Lead, Chromium and Arsenic in blood, intestine, kidney, liver and muscle of goat slaughtered at Gwagwalada abattoir

Heavy Metals	Blood	Intestine	Kidney	Liver	Muscle
Cd	0.626±0.12	1.339±0.637	0.829±0.184	1.091±0.259	0.985±0.221
Co	1.622±0.479	4.625±1.379	2.715±0.652	3.379±1.119	4.408±1.023
Pb	2.928±1.172	4.231±1.777	4.696±1.261	4.309±1.751	10.282±2.771
Cr	23.890±8.698	42.517±13.207	49.242±20.321	31.136±13.596	33.293±13.427
As	1.214±0.286	1.521±0.454	1.156±0.370	6.135±2.681	1.781±0.594

Table 2: Mean and standard error of mean concentration (mg/kg) of Cadmium, Cobalt, Lead, Chromium and Arsenic in blood, intestine, kidney, liver and muscle of cattle slaughtered at Gwagwalada abattoir

Heavy Metals	Blood	Intestine	Kidney	Liver	Muscle
Cd	1.197±0.064	3.029±0.544	3.914±1.001	2.754±0.494	2.639±0.669
Co	1.862±0.293	7.655±1.438	9.779±3.043	4.279±0.933	5.581±1.180
Pb	3.505±1.212	12.029±4.741	13.485±8.888	11.468±8.726	7.634±5.192
Cr	0.350±0.247	0.545±0.543	0.000±0.000	0.000±0.000	0.910±0.910
As	1.289±0.079	3.179±1.320	0.650±0.317	1.903±0.417	1.764±0.396

Table 3: Mean and standard error of mean concentration (mg/kg) of Cadmium, Cobalt, Lead, Chromium and Arsenic in blood of cattle and goat slaughtered at Gwagwalada abattoir and the FAO/WHO standards

Heavy Metals	Blood		
	GG	GC	FAO/WHO
Cd	0.626±0.12	1.197±0.064	0.5
Co	1.622±0.479	1.862±0.293	0.5
Pb	2.928±1.172	3.505±1.212	0.5
Cr	23.890±8.698	0.350±0.247	1.0
As	1.214±0.286	1.289±0.079	1.0

GG- Gwagwalada Goat, GC- Gwagwalada Cattle

Table 4: Mean and standard error of mean concentration (mg/kg) of Cadmium, Cobalt, Lead, Chromium and Arsenic in intestine of cattle and goat slaughtered at Gwagwalada abattoir and the FAO/WHO standards

Heavy Metals	Intestine		
	GG	GC	FAO/WHO
Cd	1.339±0.637	3.029±0.544	1.0
Co	4.625±1.379	7.655±1.438	0.5
Pb	4.231±1.777	12.029±4.741	0.5
Cr	42.517±13.207	0.545±0.543	1.0
As	1.521±0.454	3.179±1.320	1.0

GG- Gwagwalada Goat, GC- Gwagwalada Cattle

Table 5: Mean and standard error of mean concentration (mg/kg) of Cadmium, Cobalt, Lead, Chromium and Arsenic in kidney of cattle and goat slaughtered at Gwagwalada abattoir and the FAO/WHO standards

Heavy Metals	Kidney		
	GG	GC	FAO/WHO
Cd	0.829±0.184	3.914±1.001	1.0
Co	2.715±0.652	9.779±3.043	0.5
Pb	4.696±1.261	13.485±8.888	0.5
Cr	49.242±20.321	0.000±0.000	1.0
As	1.156±0.370	0.650±0.317	1.0

GG- Gwagwalada Goat, GC- Gwagwalada Cattle

Table 6: Mean and standard error of mean concentration (mg/kg) of Cadmium, Cobalt, Lead, Chromium and Arsenic in liver of cattle and goat slaughtered at Gwagwalada abattoir and the FAO/WHO standards

Heavy Metals	Liver		
	GG	GC	FAO/WHO
Cd	1.091±0.259	2.754±0.494	0.5
Co	3.379±1.119	4.279±0.933	0.5
Pb	4.309±1.751	11.468±8.726	0.5
Cr	31.136±13.596	0.000±0.000	1.0
As	6.135±2.681	1.903±0.417	1.0

GG- Gwagwalada Goat, GC- Gwagwalada Cattle

Table 7: Mean and standard error of mean concentration (mg/kg) of Cadmium, Cobalt, Lead, Chromium and Arsenic in muscle of cattle and goat slaughtered at Gwagwalada abattoir and the FAO/WHO standards

Heavy Metals	Muscle		
	GG	GC	FAO/WHO
Cd	0.985±0.221	2.639±0.669	0.5
Co	4.408±1.023	5.581±1.180	0.5
Pb	10.282±2.771	7.634±5.192	0.1
Cr	33.293±13.427	0.910±0.910	1.0
As	1.781±0.594	1.764±0.396	1.0

GG- Gwagwalada Goat, GC- Gwagwalada Cattle

Discussion

The results of this study demonstrate concerning levels of heavy metal contamination in both cattle and goat tissues. Cadmium, lead, and chromium were consistently above FAO/WHO permissible limits in several tissue types, indicating a high risk of bio-accumulation and public exposure through meat consumption.

Our findings are consistent with those of Akinyeye et al. (2021), who reported blood lead concentrations between 1.90 and 4.83 ppm in goats and cattle from Zaria abattoirs. High levels of Pb and As in goat carcasses were also found in Enugu (Ezeonyejiaku et al., 2021), while Salihu et al. (2024) reported hazardous concentrations in Lokoja.

In contrast, Milam et al. (2020) in Yola and Musa et al. (2020) in Nasarawa observed relatively lower and safer metal levels in animal tissues. These differences likely stem from regional disparities in industrial activity, environmental quality, and abattoir practices.

Environmental sources may contribute significantly. Ajayi et al. (2023) documented high metal loads in soils and water near abattoirs in Ibadan. Furthermore, hide singeing with scrap tyres, as reported by Aliyu et al. (2022), is a direct source of contamination.

These patterns mirror global trends. Pourret et al. (2023) confirmed that meat in Africa and Asia often exceeds permissible heavy metal limits, affirming the global relevance of our findings.

CONCLUSION

This study provides compelling evidence of significant heavy metal contamination in the blood and tissues of cattle and goats slaughtered at the Gwagwalada abattoir in Abuja. Concentrations of cadmium, lead, and chromium in particular were found to exceed FAO/WHO safety limits in most sampled tissues. These results suggest that the consumption of meat and offal from animals slaughtered at this abattoir may pose serious health risks to the local population. The study highlights a critical gap in food safety oversight and raises concern about environmental contamination, feed quality, and abattoir practices in the Gwagwalada area. When compared with other studies across Nigeria and internationally, the data suggest a broader pattern of localized contamination, which if left unaddressed, could contribute to chronic health burdens in the population through prolonged dietary exposure.

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