Heavy Metals Analysis in Selected Tissues and Organs of Slaughtered Cattles from Old Timber Market Abattoir, Gombe, Gombe State, Nigeria

Abstract

Heavy metal contamination in livestock poses significant risks to both animal and human health. This study evaluated the concentration of heavy metals in selected tissues and organs of slaughtered cattle in the vicinity of the new Abattoir in Gombe State. A total of 5 samples each were collected from various anatomical regions; the head, heart and liver of the slaughtered cattle and were analyzed for Cr, Cd and Pb. The samples were weighed and digested using a mixture of HCl and HNO_3. The elemental analysis of the digested samples was carried out using Atomic Absorption Spectrophotometer (AAS). The concentration (ppm) trend of heavy metals in the samples detected in the liver region was Cr > Pb > Cd whose mean concentrations were 0.41, 0.08 and 0.03 ppm respectively, Cr > Cd > Pb was observed in the heart region with sample concentrations 0.34, 0.02 and 0.01 ppm respectively, Cr > Cd > Pb was observed in the head region with sample concentrations 0.99, 0.03 and 0.01 ppm respectively. The results revealed that the area of study whose slaughtered cattle was subjected to assessment was not contaminated to a high extent when compared to the permissible limits set by the WHO and FAO.

Keywords: Heavy metals, cattle, organs, tissues, contamination

1 Introduction

Livestock play a very important role in global agriculture and specifically in Nigeria contributing about 12.7% of the total agricultural Gross Domestic Product [1]. Meat from slaughtered cattle at various abattoirs constitutes the largest source of animal protein for Nigerian populace [2]. Due to increased industrial and mining activities around livestock farms in most regions of the country, there have been a lot of reported cases of poisoning as a result of heavy metal contamination of food and food products [3]. These activities have led to metal dispersion in the environment and, consequently, impaired health of the population by the ingestion of edible meat contaminated by harmful elements [4]. A number of serious health problems can develop as a result of excessive uptake of dietary heavy metals [5].

A toxic heavy metal is any relatively dense metal or metalloid that is noted for its potential toxicity [6]. Some heavy metals are otherwise regarded as essential elements, they are needed by the body in trace amount, and they accomplish important role in biological systems, however these essential metals can also produce toxic effects at high concentrations. They include metals such as iron, copper, zinc, and manganese [7]. Toxic heavy metals on the other hand are hazardous in nature even in trace amount; they are completely excluded in food for human consumption [2].

Furthermore, the consumption of heavy metal-contaminated food can seriously deplete some essential nutrients in the body causing a decrease in immunological defenses, intra-uterine growth retardation, impaired psycho-social behaviours, disabilities associated with malnutrition and a high prevalence of upper gastrointestinal cancer [8], [9]. Anthropogenic activities such as mining, use of inorganic agricultural products, unselective dumping of waste on land and water contribute to the existence of toxic metals in the ecosystem [10].

Heavy metals toxicosis in animals occurs when livestock ingest contaminated forage and water or inhalation of contaminated air from their surroundings [11]. This ultimately bio-accumulate in the tissues and organs such as liver, kidney, which are consumed by humans as a source of animal protein [8]. For the purpose of this investigation, lead (Pb), chromium (Cr) and Cadmium (Cd) were taken into consideration due to their prevalence in livestock as reported by Okareh and Oladipo [12]; Sabuwa and Nafarnda [7].
The findings from this study will help to assess the levels of heavy metals in the tissues and organs of slaughtered cattle, providing valuable data on the potential health risks associated with consuming contaminated meat. This information is crucial for policymakers, the food industry, and consumers to make informed decisions regarding meat consumption and food safety regulations.

2 Materials and method

2.1 Materials

All glassware employed were washed with Omo detergent (Unilever, Lagos, Nigeria), well rinsed with deionized water and sterilized at 100°C for 10 min before been used. 65 % AR HNO_3, Chem-LAB; Hydrochloric acid 37 % ACS Reagent Grade, SSGW 100 Degree laboratory Hot plate (SSE-HP), Watch glass, Erlenmeyer flasks and beakers, measuring cylinder. The samples consist of blood samples derived from the liver, heart and head tissues of slaughtered cattle.

2.2 Method

2.2.1 Sample collection

A total of 15 samples were collected from slaughtered cattle during the period of study. These samples comprise each of liver, heart, and head tissue from 5 different slaughtered cattle. About 5 g of samples is collected, labeled, and stored separately in clean polythene bags and transported in an ice pack containing ice where they are refrigerated at a temperature of 2℃ to 8℃ [13].

2.2.2 Sample digestion

The frozen samples were allowed to defrost, the liver, kidney and skin tissues of these slaughtered cattle are collected for heavy metal analysis. 1.0 g each of the collected slaughtered cattle organs and tissues are oven dried at 80 ℃ for 2 hours, made into powder by approximately weighing 2.0 g each of the samples and ashed in a furnace at 550 ℃ for 90 minutes, this is then followed by digesting with concentrated nitric acid and hydrochloric acid in the ratio 3:1. The resulting solution was allowed time to cool and thereafter filtered into a 50 ml flask into which distilled water was added to make up to mark [14].

2.2.3 Instrumentation

An atomic absorption spectrometer (AAS), Shimadzu AA-6800 Japan model, was employed to determine the heavy metals concentrations (Cr, Pb and Cd) which was analyzed at the National Research Institute for Chemical Technology (NARICT), Zaria, Kaduna State, Nigeria.

3 Results and discussion

3.1 Results

The heavy metal concentration for the slaughtered cattle samples (C_1, C_2, C_3 and C_x) for a given selected tissues and organs is shown in Table 1 below.

Table 1 Heavy metals concentration in the liver of slaughtered cattle

S/n	Sample	Pb (ppm)	Cr (ppm)	Cd (ppm)
1	C_1	0.02	0.67	Nd
2	C_2	0.02	0.15	0.02
3	C_3	0.03	Nd	0.04
4	C_x	0.01	0.83	0.04

Table 2 Heavy metals concentration in the heart region of slaughtered cattle.

S/n	Sample	Pb (ppm)	Cr (ppm)	Cd (ppm)

1	C_1	0.01	0.65	0.03
2	C_2	Nd	0.33	0.02
3	C_3	0.02	0.33	Nd
4	C_x	0.02	0.12	0.04

Table 3 Heavy metals concentration in the head region of slaughtered cattle.

S/n	Sample	Pb (ppm)	Cr (ppm)	Cd (ppm)
1	C_1	0.01	0.87	0.03
2	C_2	0.01	1.18	0.04
3	C_3	0.01	0.52	0.04
4	C_x	0.01	1.40	0.02

Where:

C_x is a composite sample derived from two different cows.

C_1 is cow sample 1.

C_2 is cow sample 2.

C_3 is cow sample 3.

Nd = Not detected.

3.2 Discussion

3.2.1 Heavy metals concentration in the liver of slaughtered cattle

It can be seen from Table 1 that the concentration of lead in the samples C_1,C_2,C_3 C_x were found to be very low (0.02 0.02, 0.03 and 0.01 ppm respectively) when compared with findings by Bala et al., [15], whose mean concentration of lead in liver sample was 1.89 ppm, this research revealed that the concentration of lead in the liver is however, higher when compared to research findings by Okareh and Oladipo, [12] whose mean concentration was found to be 0.001 ppm in Akinyele central abattoir in Ibadan and was within the permissible limits of lead concentration in liver of 0.50 ppm stipulated by the Food and Agricultural Organization and World Health Organization [16]. The trace amount of Pb in these samples could be attributed to possible contamination of water sources, these cattle may have drunk from water contaminated with Pb , such as nearby industrial sites or natural sources with high Pb levels.
Table 1 also revealed that the concentration of chromium in sample C_3 was not detected while, for C_1, C_2, and C_x samples, 0.67 0.15 and 0.83 ppm were recorded, these observed values were however lower when compared to the Food and Agricultural Organization and World Health Organization [16] whose permissible limits for chromium is 1.00 ppm and to the findings by Sabuwa et al. [7] whose mean concentration of Cr in the liver of slaughtered cattle was 4.05 ppm. Thus, there was no degree of contamination risk in the samples. However, the observed concentration value was lower when compared to research findings by Okareh and Oladipo, [12] whose concentration in liver was recorded to be 1.28 ppm. Whereas, the findings by Fathy et al., [3] revealed lower concentration levels of chromium in liver at 0.022 ppm. It has been shown that the liver tends to bioaccumulate heavy metals more than any anatomical sites [17], [18] and the investigation by Tchounwou et al. [19] revealed that Cr could get into soil, air or water from a range of anthropogenic and natural sources which ultimately gets into the anatomical sites of these cattle. The concentration of Cadmium was undetected in sample C_1 however (Table 1), samples C_2, C_3 and C_x concentrations were

found to be low (0.02, 0.04, 0.04 ppm) when compared to the concentration of chromium and investigation by Okareh and Oladipo, [12] whose mean concentration levels was found to be as high as 5.24 ppm which indicated a greater contamination threat in the liver samples from the Akinyele Central Abattoir vicinity in Ibadan. The contamination level for cadmium in the samples investigated in this study were however found to lie within the permissible limits stipulated by the Food and Agricultural Organization and World Health Organization [16] as 0.5 ppm.

A trend of Cr > Pb > Cd was established for the concentration of heavy metals in the liver samples whose mean concentrations were 0.41, 0.08 and 0.03 ppm respectively.

3.2.2 Heavy metals concentration in the heart of slaughtered cattle

The result displayed in Table 2 revealed that the concentration of Pb in sample C_2 was not detected, while samples C_1, C_3 C_x had concentrations of 0.01, 0.02 and 0.02 ppm from this investigation. The presence of these trace amounts could be attributed to lead from agricultural activities, such as the use of pesticides, which may have entered the environment and been ingested by the cattle. These observed values were however lower when compared to research findings by Daniel *et al*., [20] whose Pb concentrations in the heart of slaughtered cattle were in the mean concentrations of 1.67±2.89 (Owena, Osun State), 4.33±2.52 (Akure, Ondo State) and 1.17±0.63 (Ado-Ekiti, Ekiti State). However, the values obtained from this study are within the FAO and WHO [16] permissible limits for lead in heart as 0.50 ppm was stipulated.

The concentration level of chromium in all the samples were found to be higher (0.65, 0.33, 0.33 and 0.12 ppm) than that of Pb. These observed values were however within the stipulated limits set by the FAO and WHO, [16] whose permissible limits for chromium is 1.00 ppm. The total number of chromium residues detected in all the tissues sampled are generally high when compared to the findings of Fathy et al., [3] who reported lower residual levels of chromium in muscle, liver, and kidney of 0.011 ppm, 0.022 ppm and 0.025 ppm concentrations respectively. The presence of Cr could be attributed to its natural occurrence as an element in the soil, water, plants, so cattle may have ingested it through their feed or environment.

The concentration level of cadmium in the samples as observed from Table 2, C_1, C_2, C_x were 0.03, 0.2 and 0.4 ppm respectively while, sample C_3 was not detected. The 0.4 ppm maximum cadmium value detected in this study was higher when compared to the concentration obtained by Nwude et al., [21] whose samples of blood from cows in Awka, Southern Nigeria was 0.2 ppm as minimum Cd concentration. The concentration of Cd in this study was however, within the 0.5 ppm permissible limit set by FAO and WHO [16] for Cow tissues.

A trend of Cr > Cd > Pb was established for the concentration of heavy metals in the liver samples whose mean concentrations were 1.43, 0.02 and 0.01 ppm respectively.

3.2.3 Heavy metals concentration in the head of slaughtered cattle

The concentration level of lead in all the samples in the head region was lower (0.01 ppm for all samples) when compared to the findings by Ogabiela *et al*, [22] whose investigation revealed a lead concentration of 0.79 ppm from a polluted environment, it can be attributed however, that the observed low lead concentrations were due to their ruminal system of digestion which can reduce the heavy metals absorption. It was also observed that the concentration of lead in the head tissues obtained from this study fell within the permissible limit stipulated by the Food and Agriculture Organization and World Health Organization [16] been 0.50 ppm.

The concentration level of chromium for the samples C_1, C_2, C_3 and C_x were (0.87, 1.18, 0.52 and 1.40 ppm) were lower when compared to findings by Sabuwa *et al*., [7] who reported mean concentrations of 1.01, 4.01 and 1.12 ppm respectively in the kidney, liver, and muscle of slaughtered cattle in Northern agricultural zone of Nasarawa state, Nigeria. The obtained values for Cr in this investigation, however, was found to be higher when compared with findings by Fathy *et al*., [3] who reported very low concentration of 0.010, 0.022 and 0.025 ppm respectively in the muscles, liver, and kidney of slaughtered cattle. The observed Cr prevalence in the head tissues could be attributed to possible water or soil contamination which inevitably found its way to the head tissues.

It has also been shown by Nwaichi [23] that exposure to compounds containing Cr in a vicinity can cause renal failure, cancer and even allergy of the respiratory tract. Chromium has also been tagged as carcinogenic by some regulatory units [7].

The concentration level of cadmium was found to be low for samples C_1, C_2, C_3 and C_x (0.03, 0.04, 0.04 and 0.02 ppm respectively) when compared to the concentration of chromium from this study. The prevalence of cadmium could be attributed to possible contamination of feed that has been exposed to heavy metals or through contaminated soils upon

which these feeds were grown. The contamination level for cadmium in the samples investigated in this study were however found to lie within the permissible limits stipulated by the FAO and WHO [16] of 0.5 ppm.
The investigation by Mahmoudi et al [24] confirmed that Cd had reduced accumulation ability in ruminants' tissues when compared with livers. A trend of Cr > Pb > Cd was established for the concentration of heavy metals in the liver samples whose mean concentrations are 0.41, 0.08 and 0.03 ppm respectively.

4 Conclusion

From this investigation, it was established that the levels of heavy metals concentrations were within the permissible limits set by the WHO and FAO except for two samples whose Cr concentrations were slightly higher than the stipulated standards set by the FAO and WHO. Previous research findings collected from other vicinities were found to be higher than the concentrations reported in this investigation. As such, the area of study "The Old Timber Market Abattoir in Gombe State" is not at risk of high contamination levels. A trend in heavy metals contaminations was however established to be: Cr > Pb > Cd in the liver samples whose mean concentrations were 0.41, 0.08 and 0.03 ppm respectively; Cr > Cd > Pb in the heart region with sample concentrations 0.34, 0.02 and 0.01 ppm respectively and Cr > Cd > Pb was observed in the head tissues with sample concentrations 0.99, 0.03 and 0.01 ppm respectively. This study contributes to the understanding of heavy metal distribution in cattle and informs regulatory efforts aimed at safeguarding public health and environmental quality.

Conflicts of Interest

The authors have declared that there were no conflicts of interest regarding the publication of this manuscript.

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3.

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