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Full Length Research Paper

Evaluation of Heavy Metal Residues in Slaughtered Cattle at Sokoto and Gusau Modern Abattoirs: Implications for Human Health and Environmental Safety

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Some heavy metals are classified under environmental pollutant due to their toxic effects on animals, human and plants. These metals are not biodegradable in environment and find their way into the food chain. Concentrations of lead (Pb), cadmium (Cd), and chromium (Cr) were determined in some selected organs and tissues (kidney, liver, muscle, hide and blood) of slaughtered cattle at Sokoto and Gusau modern abattoirs using atomic absorption spectrophotometry. At Sokoto modern abattoir, the prevalence rates of Pb and Cr were 100% each, while the prevalence rate of Cd was 98.67%. At Gusau modern abattoir, the prevalence rates of Pb and Cd were 100% each, while that of Cr was 98.67%. The overall mean concentrations of Pb, Cd, and Cr in slaughtered cattle at Sokoto modern abattoir ranged from 0.18 to 0.75 mg/kg, 0.03 to 0.34 mg/kg and 0.42 to 0.48 mg/kg, respectively. At Gusau modern abattoir, the concentrations ranged from 0.15 to 1.07, 0.01 to 0.17 and 0.26 to 0.36 mg/kg for Pb, Cd, and Cr respectively. There was a significant difference ($P \leq 0.05$) in the concentration of Pb, Cd, and Cr between different organs and tissue collected at both Sokoto and Gusau modern abattoirs. The main aim of this research is to determine the concentrations of lead (Pb), cadmium (Cd), and chromium (Cr) in kidney, liver, muscle, hide, and blood of slaughtered cattle at both Sokoto and Gusau modern abattoirs.

Key words: Abattoir, cattle, kidney, liver, muscle, hide, blood.

INTRODUCTION

Contamination of environment with heavy metal is a global problem (Matthew et al., 2002) which is caused by various human and natural activities (Srikanth et al., 2004) such as dumping of waste materials, use of agricultural pesticides and some chemical fertilizer, oil spillages, volcanic eruption etc. These toxic metals find their way into the food chain which may cause health problems to both human and animals.

In Nigeria, common sources of animal protein were obtained from both domestic animals (cattle, pigs, goats, sheep, chickens etc.) and wild animals (snails, antelopes, monkey, fish elephant etc.). The habitats of these animals are usually polluted with heavy metals, due to indiscriminate dumping of household and industrial waste materials on the land and water bodies, and un-authorized mining activities (Kamal and Kumar, 1998; Dioka et al., 2004). Some of these waste materials from the households, industries and mining sites may contain some heavy metals that are of public health importance to both humans and animals**.** Food animals (Domestic and wild animals) are freely reared or grazed on such contaminated environments. This may result in bioaccumulation of these metals in their tissues and organs**.** Contamination of animal feed and human food with heavy metals is a threat due to their toxicity, bioaccumulation, and bio-magnifications in the food chain (Demirezen and Uruc, 2006). The effects of heavy metals toxicity have been described in animals under relatively low concentrations of exposure (Kostial, 1986); the earliest effect of heavy metal toxicity is the disruption of trace element metabolism (Goyer, 1997; Lopez-Alonso et al., 2002**).** Reduction in litter size and weight, organs failure in animals and human may occur when large quantities of toxic and non- toxic heavy metals are ingested (Blowes, 2002).

Arsenic, cadmium, lead, and mercury are considered to be one of the major environmental pollutants**,** due to bio-accumulation in human and animal's tissues and organs. Clinical signs may occur when the blood concentration of these metals is above 10 µg/dl but it varies with individuals (Miranda et al., 2009). Some of these metals have been identified as a leading cause of accidental poisoning in domestic animals more than any other substance (Casas and Sordo, 2006). Some of these heavy metals can be transported to a few kilometer by atmospheric transport before being deposited on the surface of plants, soil and water (Bolter et al., 1975). Ruminants and other animals serve as indicators of environmental pollution by heavy metals (Debackere, 1983).

The above show how man and animals are exposed to heavy metals, hence public health problems. This study was carried out to determine the concentrations of lead (Pb), cadmium (Cd), and chromium (Cr) residue in some selected organs and tissues of slaughtered cattle at Sokoto and Gusau modern abattoirs.

MATERIALS AND METHODS

Study areas

Sokoto modern abattoir

Sokoto modern abattoir is located in Sokoto-North Local Government Area of Sokoto State. Sokoto State is located in North west agro-ecological zone of Nigeria; it lies between longitudes 4°8'E and 6°54' E and latitudes 12°N and 13°58'N (UNEP/OCHA, 2010). The state shares boundaries with Niger Republic to the North, to the West is Kebbi State, and to the east is Zamfara State. The State covers a land mass of about 32,000 km^2. Its human population is estimated to be 3,696,999 (NPC, 2006). Livestock population was estimated to have 3 million cattle, 3 million sheep, 5 million goats, 4,600 camels, 52,000 donkeys and host of other species of local and exotic poultry species. These make the State ranks second in Nigerian in terms of livestock population (MOCIT, 2002; Mamman, 2005).

Gusau modern abattoir

Gusau Modern abattoir is located in the outskirt of Gusau town (Capital of Zamfara State), opposite Nigeria National Petroleum Corporation (NNPC) Depot, Gusau (along Gusau-Sokoto Road). Zamfara State is located on Latitude 11° 10' N and Longitude 6° 15' E, covering an area of 39,762 km^2 with an estimated human population of 3,582,912 (NPC, 2006; UNEP/OCHA, 2010). The climate is semi-arid with temperature above 28.5°C; it has annual rainfall of less than 1000 mm and relative humidity below 70% (Odjugo, 2010). It shares borders with Kebbi, Kaduna, Sokoto, Niger and Katsina states. It also shares an international boundary with Niger Republic to the north (UNEP/OCHA, 2010). The State has the following estimated livestock population: 3,190,010 cattle, 4,933,304 sheep, 5,177, 348 goats, 34,796 camels, and host of other species of local and exotic poultry species (MOCIT, 2002; Mamman, 2005). Gusau abattoir is the main abattoir in the State. Cattle, sheep, goats and camels are the ruminants that are slaughtered for human consumption.

Study design

The study is a cross- sectional type and was carried out at Sokoto State and Gusau Modern abattoirs.

Sampling method

Samples were collected on weekly basis using simple random sampling method until desired numbers of samples were collected. Samples were collected from Sokoto and Gusau Modern abattoirs at the same period of the year (April 2013 to January 2014).

Sample types

Kidney, liver, muscle, hide and blood are the samples collected from 30 randomly selected slaughtered cattle at Sokoto and Gusau modern abattoirs.

Samples collection and preservation

In each abattoir (Sokoto, and Gusau modern abattoirs), seventy five samples (75) comprising fifteen (15) liver, fifteen (15) kidney, fifteen (15) muscle, fifteen (15) hide, and fifteen (15) blood were collected from randomly selected slaughtered cattle. About 100 g of liver from any lobe**,** a whole kidney (either right or left), about 100 g of any part of the muscle**,** about 100 g of any part of singe or un-singe hide, and about 100 ml of blood from slaughtered cattle, were purchased. Each of the samples was packed in a sterile polythene bag, properly labeled with indelible marker, and was transported to Veterinary Public Health and Preventive Medicine laboratory of Faculty of Veterinary Medicine, Usmanu Danfodiyo University Sokoto, where it was frozen and stored in freezer until used.

Processing of samples

All the frozen samples were packed on ice block in coolers and transported to National Research Institute for Chemical Technology Zaria, Kaduna State, Nigeria for further processing and analysis.

Digestion of samples

Liver, kidney, muscle, skin/hide, and blood samples were dried at 45°C using oven, after which individual sample was crushed into fine powder using mortar and pestle. 1.0 g of the fine powder sample was weighed out into porcelain crucible. The crucible plus the fine powdered samples was ignited in a muffle furnace at 500°C for eight hours. The samples were then removed from the furnace and allowed to cool in desiccators and weighed again. The difference between the weight of the crucible plus ash and the weight of the crucible alone was used to calculate the percentage ash content of the sample. 5 cm^3 of 1M trioxonitrate (v) acid (HNO_3) solution was added to the left-over ash and evaporated to dryness on a hot plate; it was returned to the furnace and heated again at 400°C for 15-20 min until perfectly grayish-white ash was obtained. The samples were allowed to cool in desiccators followed by the addition of 15 cm^3 of 1M hydrochloric acid (HCl) to dissolve the ash and the solution was filtered into 100 cm^3 volumetric flasks. The volume was made to the mark of 100 cm^3 of the flask with distilled water.

Spectrophotometry techniques for heavy metals detection

In each of the prepared samples, cadmium (Cd), lead (Pb), and chromium (Cr) residues were determined under specified condition according to the manufacturer (AA-6800, Shimadzu Atomic Absorption Spectrophotometer) (Szkoda and Żmudzki, 2005).

Statistical analysis

Data from the study were presented in tables, and bar charts. One-way analysis of variance (ANOVA) was used to establish the significant differences between mean concentration of Pb, Cd and Cr present in the kidney, liver, muscle, hide and blood at 95% confidence limits using Graphpad Instat 3.10, 32 bit software for windows 7.

RESULTS AND DISCUSSION

The prevalence rate of lead (Pb), and chromium (Cr) was 100% in slaughtered cattle at Sokoto modern abattoir. This prevalence rate was in agreement with the findings of Adetunji et al. (2014) who reported 100% prevalence of Pb in muscle and edible tissue of cattle slaughtered at slaughter slab in Ibadan; while the prevalence of Cadmium (Cd) was 98.67%. This prevalence rate was slightly lower compared to the findings of Bala et al. (2012) who reported 100% prevalence rate of cadmium in kidney and liver of slaughtered cattle at Sokoto central abattoir. This variation may be because the cattle slaughtered at Sokoto modern abattoir are from Sokoto State, Kebbi State, Zamfara State, and across international boundary of Niger Republic.

At Gusau modern abattoir, the prevalence rate of lead and cadmium was 100% each. This prevalence rate wis in agreement with the findings of Adetunji et al. (2014), who reported 100% prevalence of Pb, and Cdin muscle and edible tissue of cattle slaughtered at slaughter slab in Ibadan. But the prevalence from this study was higher compared to 93 and 21.3% reported by Nwude et al. (2010), Okareh and Oladipo (2015), in South Eastern, and south western Nigeria respectively. While the prevalence rate of chromium was 98.67%; this prevalence rate was lower than that of Bala et al. (2012) who reported 100% prevalence rate of chromiumin kidney and liver of cattle slaughtered at Sokoto central abattoir.

The prevalence rate of chromium in cattle slaughtered at Sokoto and Gusau modern abattoirs was one hundred percent (100%) and 98.67% respectively; these prevalence rates were higher compared to 95.87% reported by Bala et al. (2014) and 11.3% reported by Okareh and Oladipo (2015). The variation in the above prevalence may be as a result of mining activities, house hold waste, and other industrial pollutions which contaminate the environment in different geographical area. At Sokoto modern abattoir, the overall mean concentrations of lead, cadmium and chromium ranged from 0.18 to 0.75 mg/kg, 0.03 to 0.34 mg/kg and 0.42 to 0.48 mg/kg respectively (Table 1 and 2; Figure 1 to 3). At Gusau modern abattoir, the overall mean concentration of lead, cadmium and chromium ranged from 0.15 to 1.07 mg/kg, 0.01 to 0.17 mg/kg and 0.26 to 0.36 mg/kg respectively (Tables 3 and 4 and Figures 1 to 3).

The mean lead concentration was generally high in liver of slaughtered cattle at Sokoto and Gusau modern abattoirs than other tissues and organs with the overall mean concentration of 0.75 and 1.07 mg/kg respectively. This may be as a result of liver being an organ of detoxification of toxic substances such as heavy metals**,** lead from blood and other tissue may be mobilised and taken to the liver through circulation for detoxification to take place. Excretion of lead to the bile which is later re-absorbed into the liver (enterohepatic biliary cycles); in the process liver may tend to contain high level of lead (Syracuse Research Corporation, 1990; Sedki et al., 2003). This finding was contrary to the findings of Nriagu et al. (2009) and Adetunji et al. (2014) who found the concentration of lead to be high in kidney than any tissues and organs of cattle.

Generally, the concentration of cadmium was found to be high in kidney compared to any tissues or organs. This may be as a result of metallothionein which is a protein found in the liver that usually removes cadmium from hepatocytes forming a cadmium-metallothionein complex; it is then released into the blood stream and filtered by kidney glomeruli, which can be reabsorbed into the kidney. It may result in high concentration of cadmium in the kidney than other tissues and organs (Squibb and Fowler, 1984; Roman et al., 2002). This finding is contrary to the findings of Nriagu et al. (2009) and Adetunji et al. (2014) who observe higher concentration of cadmium in liver than other tissues and organs.

Generally, the mean chromium concentrations in the blood of slaughtered cattle at both Sokoto and Gusau modern abattoirs were higher compared to the mean concentrations of chromium in kidney, liver, muscle, and hide. The result from this study was contrary to the findings of Akan et al. (2010), who reported high

Table 1. Mean and standard error of mean concentration (mg/kg) of lead, cadmium, and chromium (mg/kg) in kidney, liver, muscle, hide and blood of cattle slaughtered at Sokoto modern abattoir.

Metal	Mean ± standard error of mean (SE) (mg/kg)				
	Kidney	Liver	Muscle	Hide	Blood
Lead	0.44±0.06	0.75±0.19	0.18± 0.06	0.20±0.05	0.34±0.06
Cadmium	0.34± 0.16	0.13±0.03	0.03 0.01	0.03 ±0.01	0.04 ±0.02
Chromium	0.42±0.10	0.43±0.10	0.43±0.11	0.46±0.12	0.48±0.13

$P \leq 0.05$.(there was a significant difference in concentration of Pb, Cd, and Cr in kidney, liver, muscle, hide, and blood of camels slaughtered at Sokoto modern abattoir).

Table 2. Mean concentration (mg/kg) of lead, cadmium, and chromium against international standard in selected organs and tissues of cattle slaughtered at Sokoto modern abattoir.

Tissue/organs	Heavy metal (mg/kg)					
	Pb	FAO/WHO	Cd	FAO/WHO	Cr	FAO/WHO
Kidney	0.44	0.5	0.34	1.0	0.42	1.0
Liver	0.75	0.5	0.13	0.5	0.43	1.0
Muscle	0.18	0.1	0.03	0.05	0.43	1.0
Hide	0.20	0.5	0.03	0.5	0.46	1.0
Blood	0.34	0.5	0.04	0.5	0.48	1.0

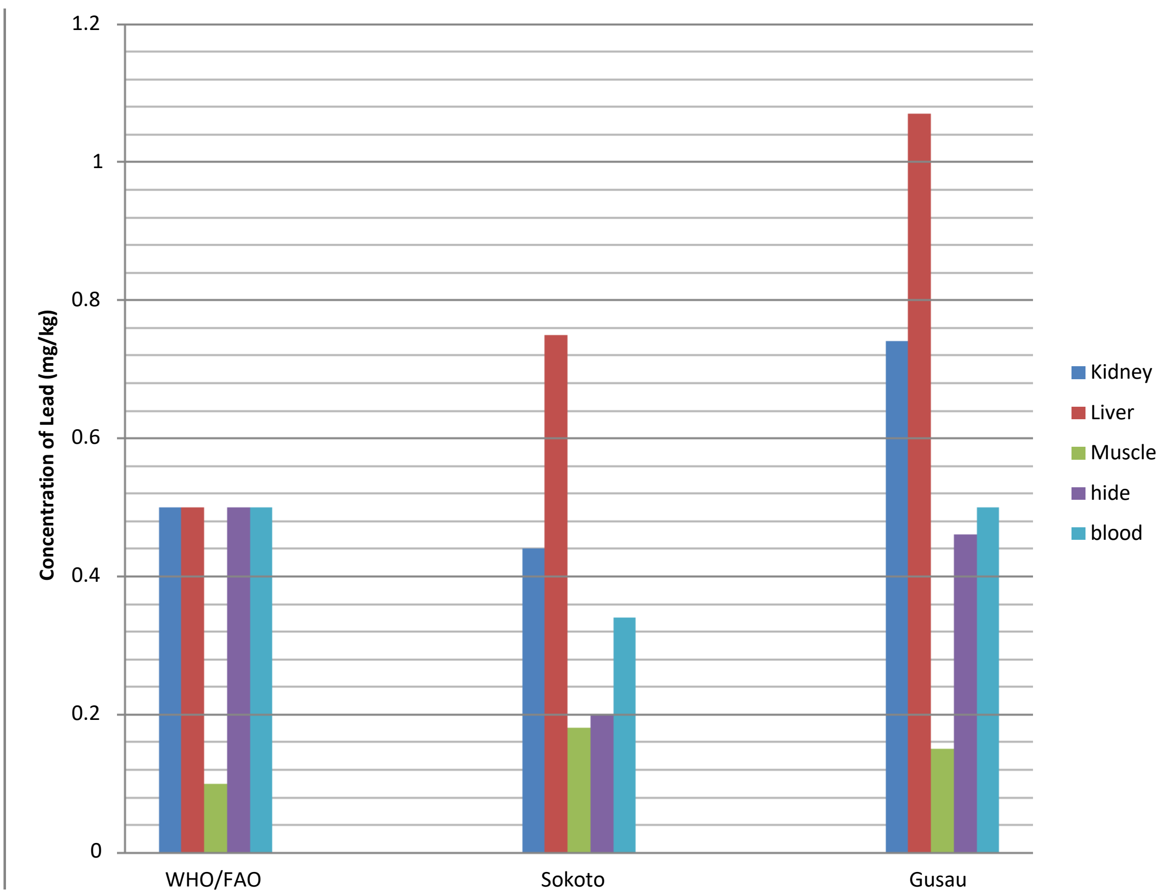

Figure 1. Bar charts showing mean concentration of Pb in kidney, liver, muscle, hide, and blood of slaughtered cattle at Sokoto and Gusau modern abattoirs against WHO/FAO permissible concentration.

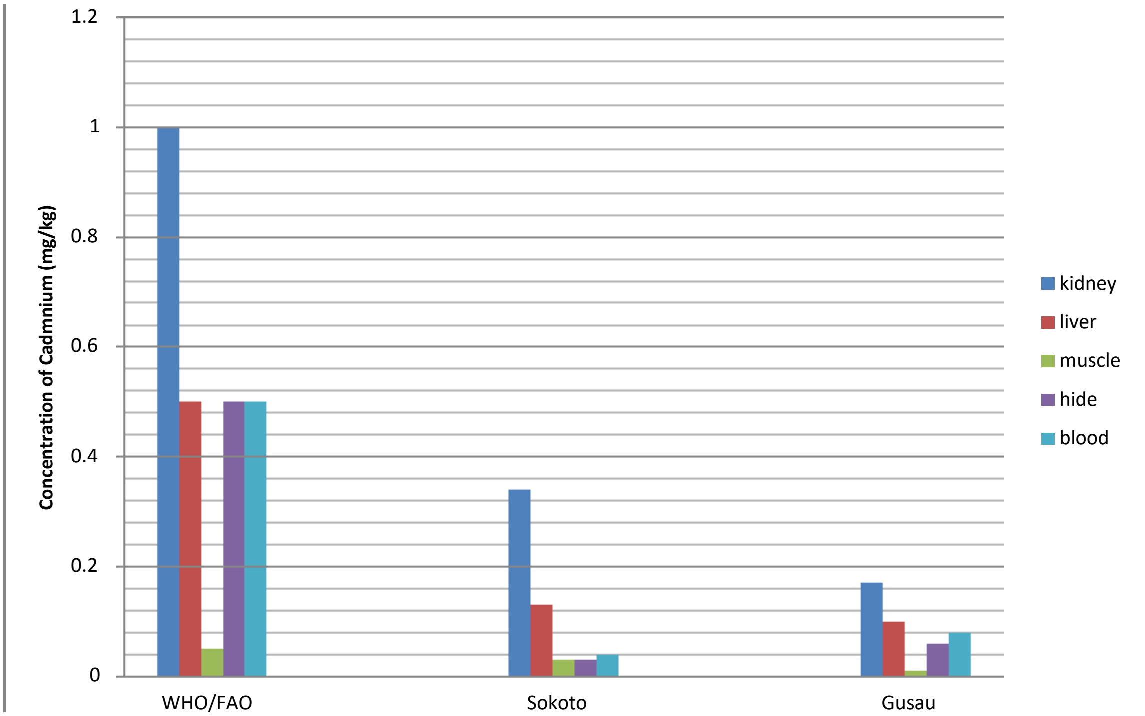

Figure 2. Bar charts showing mean concentration of Cdin kidney, liver, muscle, hide, and blood of slaughtered cattle at Sokoto and Gusau modern abattoirs against WHO/FAO permissible concentration.

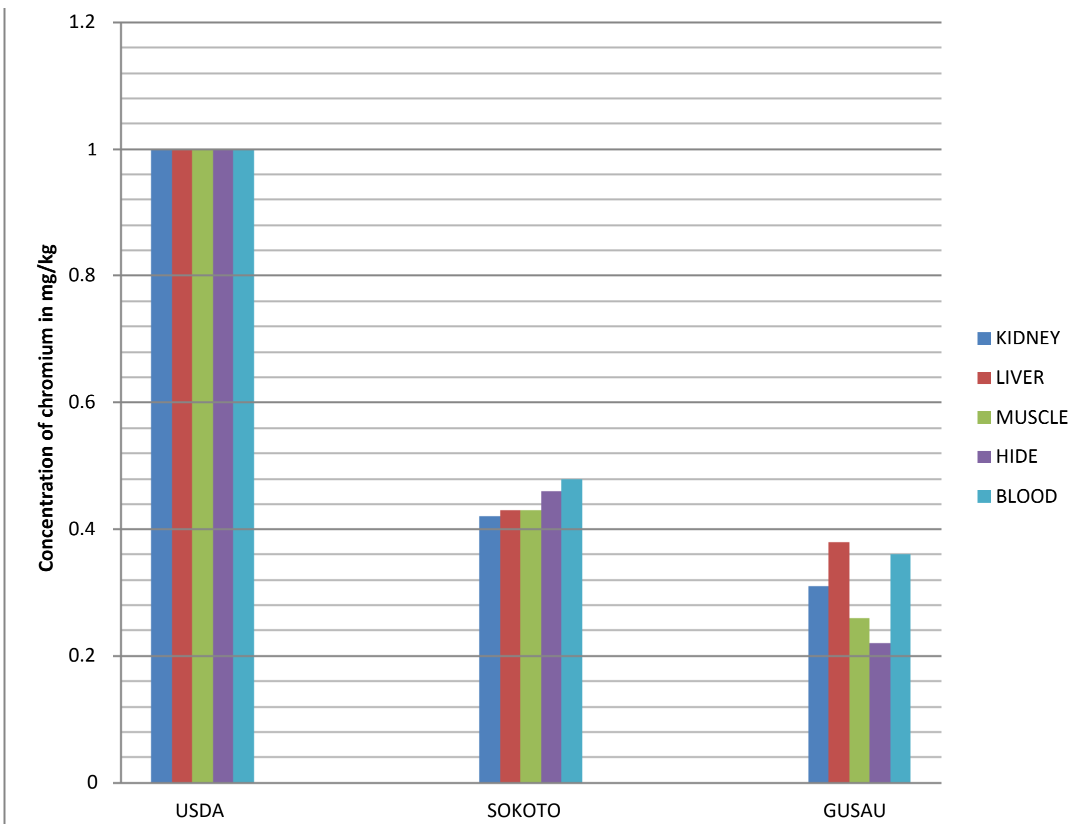

Figure 3. Bar charts showing mean concentration of Crin kidney, liver, muscle, hide, and blood of slaughtered camels at Sokoto and Gusau modern abattoirs against United States Department of Agriculture (USDA) permissible concentration.

Table 3. Mean and standard error of mean concentration (mg/kg) of lead, cadmium, and chromium (mg/kg) in kidney, liver, muscle, hide and blood of cattle slaughtered at Gusau modern abattoir.

Metal	Mean ± standard error of mean (SE) (mg/kg)				
	Kidney	Liver	Muscle	Hide	Blood
Lead	0.74±0.20	1.07±0.28	0.15±0.04	0.46±0.16	0.50±0.08
Cadmium	0.17±0.05	0.10±0.03	0.01±0.00	0.06±0.02	0.08±0.02
Chromium	0.31±0.09	0.38±0.09	0.26±0.09	0.22±0.09	0.36±0.10

P ≤ 0.05.(there was a significant difference in concentration of Pb, Cd, and Cr in kidney, liver, muscle, hide, and blood of camels slaughtered at Sokoto modern abattoir).

Table 4. Mean concentration (mg/kg) of lead, cadmium, and chromium against international standard in selected organs and tissues of cattle slaughtered at Gusau modern abattoir.

Tissue/organs	Heavy metal (mg/kg)					
	Pb	FAO/WHO	Cd	FAO/WHO	Cr	FAO/WHO
Kidney	0.74	0.5	0.17	1.0	0.31	1.0
Liver	1.07	0.5	0.10	0.5	0.38	1.0
Muscle	0.15	0.1	0.01	0.05	0.26	1.0
Hide	0.46	0.5	0.06	0.5	0.22	1.0
Blood	0.50	0.5	0.08	0.5	0.36	1.0

concentration of chromium in liver than other tissues and organs of cattle, goats and sheep. Higher concentration of chromium in the blood observed from this study may be as a result of recent exposure of the animal to the metal in the environment, feed or water. The comparative mean lead (Pb) concentration in organs and tissues (kidney, liver, muscle, blood and hide/skin) of cattle, slaughtered at Gusau modern abattoir were higher compared to cattle slaughtered at Sokoto modern abattoir. This indicates cattle slaughtered at Sokoto modern abattoir were safer for human and animals consumption in terms of public health. The mean cadmium (Cd) and chromium (Cr) concentrations in organs and tissues of cattle slaughtered at Sokoto abattoir were higher compared to those slaughtered at Gusau modern abattoir. This shows that consumption of ruminants slaughtered at Gusau modern abattoir are safer in terms of Cd related health problems, and consumption of ruminants slaughtered at Sokoto modern abattoir may be of more advantage to diabetic patients since Cr increases the metabolism of carbohydrate, protein and fat, and with low level of production of insulin by the pancreas in diabetic patient which may result to normal sugar level in the blood (Chen et al., 2009). The results from this study were in line with the findings of Mariam et al. (2004) and Javed et al. (2009), who reported different concentration of heavy metals in tissues and organs of different animals within the same geographical location, and also in different geographical location.

At Sokotro modern abattoir, the mean Pb concentration in liver and muscle of slaughtered cattle exceeded the permissible concentration recommended by Food and Agricultural Organization (FAO)/World Head Organization (FAO/WHO, 2000). This means consumption of these organs/tissues of these slaughtered cattle may result in public health implications due to bioaccumulation of lead. While in kidney, hides, and blood the mean Pb concentrations are within the permissible concentration.

At Gusau modern abattoir, the mean Pb concentration in kidney, liver, and muscle of cattle slaughtered exceeded the permissible concentration recommended by FAO/WHO. Consumption of kidney, liver, and muscle from these slaughtered cattle whose samples were collected for this research may result in public health problems associated with lead; while mean Cd, concentration in all tissues and organs collected from slaughtered cattle at both Sokoto and Gusau modern abattoirs were within the permissible concentration recommended by FAO/WHO. The mean Cr, concentration in all tissues and organs collected from slaughtered cattle at both Sokoto and Gusau modern abattoirs were within the permissible concentration recommended by USDA (2006).

Conclusions

The results of this study showed that cattle slaughtered at both Sokoto and Gusau Modern abattoirs were exposed and contained different concentration of Pb, Cd, and Cr in their tissues and organs. Liver samples contained high concentrations of Pb than kidney, muscle, hide and blood samples. Also, the concentration of Cd in kidney samples was high compared to liver, muscle, hide and blood. This has serious public health implications based on the large population which depends on these slaughtered animals for protein.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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