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Determination of Heavy Metals in Selected Tissues and Organs of Cattle from Central Abattoir in Ado-Ekiti, Akure and Owena

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Authors' contributions

This work was carried out in collaboration both authors. Authors DUM and AOO designed the study. Author DUM conducted the study and wrote the first draft of the manuscript. Author AOO supervised the work. Both authors read and approved the final manuscript.

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ABSTRACT

This study was to determine the concentrations of lead (Pb), cadmium (Cd) and zinc (Zn) in the organs (liver, kidney and heart) and tissues (intestine and blood) of slaughtered cattle using spectroscopy method based on comparison with standards. The results obtained for these heavy metals have values that ranged from 0.00±0.00 to 7.33±5.01mg/kg for Pb, 0.00±0.00 to 0.50±0.50 mg/kg for Cd and 0.00±0.00 to 51.67±10.54 mg/kg for Zn. Generally, Zn was found to be present at the higher significant levels in the liver, heart, kidney and intestine. It was also found that there was no detection for Zn in the blood. Pb was found relatively high than the standard permissible limit by FAO/WHO [1] in the tissues. Cd was found to be present at the lowest concentration level. Hence, the concentrations of all the heavy metals were within the tolerance limits with the exception of Pb.

Keywords: Heavy metals; lead; cadmium; zinc; tissues and organ.

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1. INTRODUCTION

Some essential elements, though necessary for life and are particularly involved in some metabolic processes, if taken in excess could be toxic [2]. Exposure of humans to some heavy metals have indicated risk factors for breast lesions [3]. Food chain contamination has been a common route of exposure to heavy metals for humans [4]. Diet and season have been identified as factors determining the transfer of metals from the surrounding environment to terrestrial animals [2].

Rapid industrialization and urbanization have contaminated air quality and soil by heavy metals and metalloids from biogenic, geogenic and anthropogenic sources in many areas of the world, either directly or indirectly [5]. With industrial advancement, a demand for the measurement of environmental pollution-related hazardous substances to the body has been on the rise. It has been known that environmental pollutants such as heavy metal cause a problem in immune system functions or in various physiological functions. They can also result to disease susceptibility including cancer. Because people can be exposed to heavy metals in diverse routes, it is desirable to estimate the exact exposure levels and evaluate risk using biological indexes in order to figure out the exposure to heavy metals Haddad et al., 1998 [6-8].

The increasing levels of environmental pollutions by toxic metals from various sources have generated a great concern on the impact on human health. Humans are prone to several routes of exposure and hence the need to evaluate the levels in human diet which is one of the easiest routes of exposure. While the occurrence of toxic metals in some cattle which form human diet have been of great concern in that they could accumulate at a level exceeding the proportion that occur in the environment, bioaccumulation by animals raised for human consumption has been dreaded as a great risk to humans [9].

The effects of moderate pollution on toxic and trace metal levels in calves from a polluted area of northern Spain were studied [10]. In the determination of heavy metal contents in Egyptian meat, Abou-Arab, (2001) observed that the Pb, Cd, Zn, Cu, Mn and Fe contents in muscle, liver, kidney, heart and spleen in industrial areas were higher than in the same organs for rural areas. Bovines grazing on the municipal wastewater spreading field of Marrakech City (Morocco) were found to be seriously contaminated by toxic metals [11].

In the evaluation of metal accumulation in cattle raised in a serpentine-soil area, Miranda et al., [12] observed that tissue accumulation in animals was related to concentrations of the metals in soils and forage. Concentrations of some heavy metals in animal tissues were correlated with the heavy metal content in the soil (Lopez-Alonso et al., 2002). Apart from being in contact with polluted soil environment and grazing on contaminated plants, cattle could as well be exposed to heavy metals through contaminated feeds [10,13] The aim of this study was to assess the levels of Pb, Cd, and Zn in the organs (liver, kidney and heart) and tissues (intestine and blood) of cow obtained from different towns in the South Western part of Nigeria.

2. MATERIALS AND METHODS

2.1 Materials

Analytical balance, digestion flask, Bunsen burner, heating mantle, fume chamber, funnels, digestion tubes, nitric acid (HNO_3), sulphuric acid (H_2SO_4), distilled water, aluminum foil, spatula, gloves and Whatman grade II filter papers, transparent polyethene bag, pre-treated sample bottles and glassware.

2.2 Sample Collection

Samples were collected from three (3) towns which include Ado-ekiti (Ekiti State), Akure (Ondo State) and Owena (Osun State). Five (5) parts were collected from each slaughtered cow which included heart, liver, intestine kidney and blood. The blood samples from jugular vein, liver apical lobes and kidney cortices, heart and large intestine were collected from these cows. Samples were immediately transferred into polyethene bags and transported in ice bath to the Chemistry laboratory, Joseph Ayo Babalola University for digestion and elemental analysis. Quality control measures were observed from the point of materials collection, sample collection, sample preparation, through to the point of sample analysis, to reduce interference due to contamination by external metallic sources.

2.3 Sample Preparation

2.3.1 Solid sample preparation

Each of the collected samples (liver, heart, intestine and kidney) from each location were dried in the oven for seventy-two (72) hours at temperature 105ºC and grinded in a laboratory mortar into fine powder. 2 g of the well-grounded portion was dissolved in 20 cm^3 of distilled water and 20 cm^3 of concentrated HNO_3 was added. The mixture was boiled at 100ºC for 60 min to form colloidal solution and then cooled. 10 cm^3 of conc. H_2SO_4 was added to the solution and the mixture was heated and maintained at 140ºC until a dense white fume of the conc. H_2SO_4 was noticed. The solution was allowed to cool, filtered using a Whatman filter paper, transferred quantitatively into 50 cm^3 volumetric flask and made up to the mark with distilled water. The solution was then finally transferred into labelled sample bottles.

2.3.2 Liquid sample preparation

1.5 cm^3 of each blood sample collected from the different abattoir location was mixed with 0.5 cm^3 mixed-solution of HNO_3 and H_2SO_4 (20:1, v/v), then 10cm^3 of distilled water was added and stirred thoroughly. The mixture was heated to 70ºC in a water bath till the sample reached half of its original volume and 1 cm^3 of HNO_3 was added. Heating of the sample continued until a clear solution was obtained, filtered using a Whatman filter paper and transferred quantitatively into 50 cm^3 volumetric flask and made up to mark with distilled water. The solution was then finally transferred into labelled sample bottles.

2.4 Elemental Analysis

The determination of heavy metals was made directly on each of the final solutions, using BUCK Scientific 210 VGP. Serial No: 1619 Atomic Absorption Spectroscopy (AAS) at a wavelength of 283.2 nm, 228.9 nm and 213.9 nm for Pb, Cd and Zn respectively, based on comparison with standards at Rota soilab LTD (Ibadan). For each heavy metal, there was a specific “hollow cathode lamp” and the machine set a particular wavelength for the heavy metal analysis. Blank was prepared for each sample per location. Triplicate of every sample was prepared and analyzed.

2.5 Statistical Analysis

Data collected were presented as mean ± standard deviation using spread sheet (Microsoft Excel 2010).

3. RESULTS AND DISCUSSION

The concentrations of heavy metals in the cow organs (liver, kidney and heart) and tissues (blood and intestine) were shown in Table 1 to Table 5. The concentration of lead in the cattle liver from Ekiti, Akure and Owena ranged from 0.00±0.00 to 3.08±3.19 (mg/kg) as shown in Table 1. The bull from Akure was observed to contain the highest concentration of lead in the liver 3.08±3.19 (mg/kg). This could be due to the kind of feeding and the area the cow grazed.

For example, cattle that feed along the high way, highly industrialized areas and battery dumps where much of lead is released unto the surrounding vegetation could contain some amount of lead. It was also observed from the result that no detection was observed for lead in the liver of the cow from Owena (0.00±0.00 mg/kg). This could also have been due to grazing far from high way or areas with little or no lead present. Rearing cattle in less industrialized areas can also be the reason for little or no detection of lead in the liver of the cattle. In every sample, the lead content exceeded the FAO/WHO permissible limit (0.5 mg/kg) for cattle liver excluding Owena (Table 1).

The concentration of cadmium in the cattle liver from Ekiti, Akure and Owena ranged from 0.08±0.14 to 0.17±0.29 (mg/kg). The concentration of cadmium in the liver was observed to be less than the permissible limit by FAO/WHO 2006 (0.50 mg/kg). This could also be due to the fact that Ado Ekiti, Akure and Owena

Table 1. Concentrations of heavy metals in Cattle liver

Towns	Concentration (mg/kg)			
	Standard	Pb	Cd	Zn
Ado Ekiti (Ekiti State)		0.92±0.38	0.08±0.14	44.08±2.74
Akure (Ondo State)		3.08±3.19	0.08±0.14	45.17±3.51
Owena (Osun State)		0.00±0.00	0.17±0.29	4.17±7.22
	FAO/WHO standard	0.1	0.5	10-50

are less industrialized towns. For example, cattle grazing industrial areas and battery dump could contain some amount of cadmium in the liver. This result is similar to a finding, where the concentration of cadmium in the kidney is more than that of the liver of free grazing cattle from abattoirs situated in seven widely spread localities in southern Nigeria [14].

The concentration of zinc in the cattle liver from Ekiti, Akure and Owena ranged from 45.17±3.51 to 4.17±7.22 (mg/kg). These concentrations of Zn in the liver were found to be below the permissible limit 150 mg/kg [15]. Zinc is an essential element in human diet. Limited Zn can cause problems; however, too much Zn is harmful to human health [16].

The concentration of lead in the cattle heart from Ekiti, Akure and Owena ranged from 1.17±0.63 to 4.33±2.52 (mg/kg) as shown in Table 2. The bull from Akure was observed to contain the highest concentration of lead in the heart 4.33±2.52 (mg/kg). It was also observed from the result that least detection of lead was observed in the liver of the cow from Ado Ekiti (1.17±0.63 mg/kg). This could also because of low industrialization and low release of lead from the exhaust of vehicles in this area. In every sample, the lead content exceeded the FAO/WHO [17] permissible limit for cattle liver (0.5 mg/kg).

The concentration of cadmium in the cattle heart from Ado Ekiti, Akure and Owena ranged from 0.08±0.14 to 0.50±0.50 (mg/kg). The concentration of cadmium in the heart was observed to be at the permissible limit by FAO/WHO 2006 (0.50 mg/kg) in the cattle from Ado Ekiti and Owena while sample from Akure showed a lower concentration of cadmium. The concentration of Zinc in the cattle heart from Ado Ekiti, Akure and Owena ranged from 24.50±7.89 to 51.67±10.54 (mg/kg). This value was found to be within the permissible limit 150 mg/kg as stated by ANZFA [15].

It was observed that the concentration of lead in the cattle kidney from Ekiti, Akure and Owena ranged from 0.00±0.00 to 7.33±5.01 (mg/kg) as shown in Table 3. The bull from Akure was observed to show no detection of lead in the kidney. The highest concentration of lead in the kidney was observed to be 7.33±5.01 (mg/kg). All the food of animal origin contains lead in higher concentration [18]. Thus, the contamination of the human consumer can occur by consuming meat. A study in cattle showed that lead accumulates in the tissues or organs of cattle and their concentrations were higher in liver and kidneys than the other organs and tissues [19]. In all samples in this study, the lead content exceeded the FAO/WHO [17] permissible limit for cattle kidney (0.5 mg/kg) excluding lead contained in cow kidney from Akure.

High concentrations of Cu and Zn are added to pig and poultry feeds; application of pig and poultry manures as fertilizers may then result in pollution of agricultural lands by these metals [20] and uptake by plants; these then pose risks to grazing cattle. In all tissues analyzed in gray whale carcasses from the Northern Pacific Mexican Coast, Fe, Cu, Zn and Mn were present in the highest concentrations (Mendez et al, 2002).

The concentration of cadmium in the cattle kidney from Ado Ekiti, Akure and Owena ranged from 0.08±0.14 to 0.33±0.29 (mg/kg). The concentration of cadmium in the kidney was observed to be less than the permissible limit by FAO/WHO 2006 (0.00 mg/kg). This result is similar to a finding, where the concentration of cadmium in the kidney is more than that of the liver of free grazing cattle from abattoirs situated in seven widely spread localities in southern Nigeria [14]. The concentration of zinc in the cattle kidney from Ado Ekiti, Akure and Owena ranged from 0.00±0.00 to 44.08±10.63 (mg/kg). The concentration of Zinc in the kidney was observed to give the highest value in cow Akure 44.08±10.63 (mg/kg). This value was found to be within the permissible limit 150 mg/kg as stated by ANZFA [15].

Lead in the cattle intestine from Ekiti, Akure and Owena ranged from 0.00±0.00 to 5.83±6.0 (mg/kg) as shown in Table 4. The cow from Akure was observed to contain the highest concentration of lead in the intestine 5.83±6.0 (mg/kg). It was also observed from the result that no detection was observed for lead in the intestine of the bull from Akure (0.00±0.00 mg/kg). This could also be because the cow was reared in areas far from high ways with little or lead present in these areas. In every sample, the lead content exceeded the FAO/WHO [17] permissible limit for cattle intestine (0.5 mg/kg) excluding lead in cow intestine from Akure.

The concentration of cadmium in the cattle intestine from Ado Ekiti, Akure and Owena ranged from 0.00±0.00 to 0.17±0.29 (mg/kg).

The concentration of cadmium in the intestine was observed to be at the permissible limit by FAO/WHO 2006 (0.50 mg/kg) in the cattle from Ado Ekiti and Owena while sample from Akure showed no detection for cadmium concentration. Zinc in the cattle intestine from Ekiti, Akure and Owena ranged from 27.17±17.24 to 20.83±14.47 (mg/kg). These concentrations of Zn in the intestine were found to be below the permissible limit 150 mg/kg [15].

It was observed that the concentration of lead in the cattle blood from Ekiti, Akure and Owena ranged from 0.00±0.00 to 3.00±2.41 (mg/L) as shown in Table 5. The cow from Owena was observed to show no detection of lead in the blood. The highest concentration of lead in the blood was observed to be 3.00±2.41 (mg/L). All the food of animal origin contains lead in higher concentration [18]. The lead content exceeded the permissible limit for cattle blood in cow blood from Akure (0.5 mg/L) [17], while blood from Ado Ekiti and Owena showed a lower concentration compared with the permissible limit (Table 5).

The concentration of cadmium in the cattle blood from Ekiti, Akure and Owena ranged from 0.00±0.00 to 0.17±0.29 (mg/kg). The concentration of cadmium in the blood was observed to be less than the permissible limit by FAO/WHO 2006 (0.50 mg/kg). This may be because, Akure and Owena are less industrialized towns; hence the cattle from these areas are likely to possess less cadmium in the blood. No detection of cadmium was observed in blood from Ado Ekiti.

Table 2. Concentration of heavy metals in Cattle heart

Towns		Concentration (mg/kg)		
	Standard	**Pb**	**Cd**	**Zn**
Ado Ekiti (Ekiti State)		1.17±0.63	0.50±0.25	24.50±7.89
Akure (Ondo State)		4.33±2.52	0.08±0.14	29.25±10.15
Owena (Osun State)		1.67±2.89	0.50±0.50	51.67±10.54
	FAO/WHO standard	0.1	0.5	10-50

Table 3. Concentration of heavy metals in Cattle kidney

Towns		Concentration (mg/kg)		
	Standard	**Pb**	**Cd**	**Zn**
Ado Ekiti (Ekiti State)		2.50±0.75	0.08±0.14	22.92±5.01
Akure (Ondo State)		0.00±0.00	0.08±0.14	44.08±10.63
Owena (Osun State)		7.33±5.01	0.33±0.29	0.00±0.00
	FAO/WHO standard	0.1	0.5	10-50

Table 4. Concentration of heavy metals in Cattle intestine

Towns		Concentration (mg/kg)		
	Standard	**Pb**	**Cd**	**Zn**
Ado Ekiti (Ekiti State)		0.50±0.66	0.17±0.29	20.83±14.47
Akure (Ondo State)		0.00±0.00	0.00±0.00	23.83±5.93
Owena (Osun State)		5.83±6.01	0.17±0.29	27.17±17.24
	FAO/WHO standard	0.1	0.5	10-50

Table 5. Concentration of heavy metals in Cattle blood (mg/L)

Towns		Concentration (mg/L)		
	Standard	**Pb**	**Cd**	**Zn**
Ado Ekiti (Ekiti State)		0.17±0.29	0.00±0.00	0.00±0.00
Akure (Ondo State)		3.00±2.41	0.08±0.14	0.00±0.00
Owena (Osun State)		0.00±0.00	0.17±0.29	0.00±0.00
	FAO/WHO standard	0.1	0.5	10-50

It was also found that no detection of zinc in the blood in Table 5 (0.00±0.00 mg/L). This could be because zinc is required in the body of the animal. Hence, the entire zinc in the blood diffused into the various organs since concentration was within the permissible limit 150 mg/kg [15].

4. CONCLUSION

Cadmium was found from this study to be lower than the permissible limit in the blood, kidney and liver while highest concentration of Cd was recorded in the from cow from Owena and Ado Ekiti respectively. Lead level was found to be higher than the permissible limit in all the tables. This could be linked to high exposure of the cattle to feeds, water and other materials that may contain lead. The concentration of Zn was observed to be relatively high, although below the permissible limit except for the slaughtered cow heart from Owena, which was noticed to be slightly above the permissible limit. Therefore, measures to reduce Cd and Pb pollution in the environment should be advocated.

5. RECOMMENDATION

The study recommends that more awareness program should be championed on the risk involved in the consumption of meat containing these heavy metals in food. Also, measures to reduce cadmium Lead and Zinc emission into the environment should be put in place by both the government and individuals.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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