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Assessing the concentration of heavy metals in some organs and blood of cattle raised in Jimeta, Yola, Nigeria

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Abstract Assessment of heavy metals concentration in livestock is important for assessing the potential effects of pollutants on grazing cattle, and for quantifying contaminant intakes by humans. Essential elements, such as copper and zinc, are toxic when ingested in excess. The aim of this study is to investigate the presence and concentration of heavy metals (Pb, Cd, Co, Cu and Zn) in the blood and other selected organs (liver, intestine, stomach, heart and kidney) of cows and bulls' slaughter at Jimeta abattoir, Yola, using Atomic Absorption Spectroscopy (AAS). Zn has high concentration in the blood than other metals. Zn levels ranged between 1.91±0.46 and 3.96±3.07 mg/kg; 0.15±0.02 and 0.17±0.02 mg/kg Pb; 0.00±0.00 and 0.01±0.01 mg/kg Co; 0.03±0.01 and 0.3±0.34 mg/kg Cd; 0.20±0.09 and 1.98±02.47 mg/kg Cu. The highest concentration of zinc and copper were found in the liver while lead is deposited more in the kidney and heart. Cadmium was found to be concentrated in the kidney, while cobalt was not detected in most of the tissues. The Analysis of Variance (ANOVA) test on the concentrations of all the metals in the blood, heart, intestine, stomach, kidney, and liver resulted in ($p>0.05$), i.e. there is no significant difference in the amount of the elements in this samples. The concentrations of all the metals were low and within the international statutory safe limits.

Keywords heavy metals, organs, blood, cattle

1. Introduction

Reports on heavy metal contamination of meat and other edible tissues including blood is a matter of great concern for food safety. Heavy metals are persistent contaminants in the environment that can cause serious environmental and health hazards. Exposure of heavy metals to humans is higher today than ever before in modern history due to increased in industrialization around the globe hence environmental pollution has been on the increase, so it has become necessary to study exposure of heavy metals [1,2].

Heavy metals present in soil, sediments and water accumulate in plants and are finally transferred to the bodies of grazing animals. Soil contains essential as well as non essential elements in varying range. Commonly found metals in soil include, Al, Fe, Mn, Cu, Cr, Cd, Zn, Se, Ni, Ag, Pb and Hg. These metal contents are taken up from the soil by the crops grown on it and finally enter in food chain of animal. Consciousness of the concentration of metals in food items is necessary as food is the major source of heavy metals accumulation [1].

Heavy metals are widely dispersed in the environment. They accumulate in (water-soil-plant-animal) and leads to undesirable consequences for live organism. Free-living animals are important indicators of the environmental pollution with heavy metals [3]. They are released into the environment from natural and man-made activities. Some heavy metals (like Fe) are essential to maintain proper metabolic activity in living organisms; others (like Pb and Cd) are non-essential and have no biological role. However, at high concentrations, they can cause toxicity to living organisms [2].

Heavy metals are not only found in soil and in water by human industrial activity but can be artificially added in commercial feeds which are enriched with essential elements such as Cu, Zn, and As so as to promote optimum growth rate and to infuse antimicrobial properties [4,5]. Other nonessential elements such as Cd, Pb, Cr may be present in feed due to their presence in concentrates and supplements and environmental pollution, hence the variation in heavy metal contain among feed in different farms [6].

Recently studies have shown that animals raised in industrial areas have higher concentrations of heavy metals in their internal organs, than animals reared in rural areas**.** Dairy cows raised in rust scrub metals polluted areas in Nigeria, showed increased in concentration of Pb in blood, milk and animal wastes compared with cows raised in uncontaminated areas of the country [7]. Miranda *et al*., reported high levels of some toxic and trace metals in calves and kids from a polluted area of Northern Spain, [8] even as Juka, *et al*., reported moderate levels of heavy metals in the viscera and muscles of Lithuanian cattle [9]. Furthermore high concentrations of some heavy metals in cattle reared in the vicinity of a metallurgic industry have also been reported [10]. Others include report of low copper and mercury levels in local Jordanian and imported goat and pig meat and organs [11] and low cadmium levels in poultry meat [12]. Similarly, Okoye *et al*., in his studies on blood from cows grazed in open fields in Nigeria reported high levels of cadmium and lead [13], hence Reports on heavy metal contamination of meat and other edible tissues including blood is a matter of great concern for food safety [14].

As human population grow, mining, industrialization, transportation and excessive utilization of natural resources have augmented environmental pollution and many countries lack local standards for metal levels in food products such as meat and internal organs of animals. Contaminated animals with high levels of toxic metals may not show any apparent symptoms of disease and pass health inspection. This study aimed at detecting Heavy metals that animals orally get from their forage and water, or they receive from their surroundings which accumulate in the blood and other tissue of their organs, such as liver, kidney, and other parts which is widely consumed by humans as a source of animal protein. Consumers have no knowledge of the quantity of the heavy metal in the content of these products and the risk they carry for the health [15, 16]. Therefore, monitoring the heavy metal concentration present in the tissues of this organ is significant regarding the control of the biochemical processes and ecosystem. In addition, heavy metal content in organisms provides insight into the risk of environmental pollution [17].

Materials and Methods

Sources of Sample and Sampling

The samples consist of blood, heart, intestine, stomach, liver and kidney of cattle from some randomly selected cattle (bulls and cows) which were purchased at Yola abattoir in Yola, Adamawa State, Nigeria. The sampling was carried out four times, twice within the month of August and twice in September.

Sample Preparation (Heart, Intestine, Stomach, Liver and Kidney)

Digestion

The samples were dried in the oven for three days at temperature 105^oC. After which they were grinded in a mortar into fine powder. 2g of the well grounded samples was weighed into 1000cm^3 Kjeldahl flasks; 20cm^3 of distilled water was added followed by 20cm^3 of concentrated HNO_3. The mixtures were boiled at about 100^oC for 60 min, when the samples pass into colloidal solution, the solution was cooled and 10cm^3 of conc. H_2SO_4 was added. The mixture was heated again and continued at a temperature of 140^oC, for 20 min when a dense white fume of the conc. H_2SO_4 is noticed. The solution was allowed to cool and transferred quantitatively into 100cm^3 volumetric flask and made up to the mark.

Sample Collection and Preservation of Blood Sample

Blood Samples analyzed in this work was collected from cattle slaughtered at yola abattoir by means of sterilized disposable syringe, about 10mL of blood was collected into sterilized 20mL polypropylene tubes. The tubes and their contents was preserved in ice packed cold box and transported to department of Chemistry laboratory, Modibbo Adama University of Technology (MAUTECH), Adamawa-Nigeria and stored in a freezer until analysis.

Sample Preparation (Blood)

1g of the blood sample was digested with concentrated HNO_3 and concentrated H_2O_2 in a ratio of 3:1 on a hot plate. At the end of complete digestion it was filtered hot using a Whatman filter paper No. 1 into 50mL volumetric flask and made up to mark with ultrapure water as described by Ogabiela E.E *et al* [18].

Metal Analysis

The presence and quantity of Zn, Co, Cu, Cd and Pb were determined using AA240 FS with spectra software Atomic Absorption Spectroscopy (AAS) based on comparison with external standards. The standards were freshly prepared from standard stock metal solutions and were used for initial calibration for each substance. The content of heavy metals in the assessed tissues was expressed in mg/kg of fresh mass

Statistical Analysis

Data collected were presented as mean and standard deviation and were subjected to one way analysis of variance (ANOVA) ($p<0.05$) to assess whether heavy metals varied significantly between the organs sample in the study.

Result and Discussions

Table 1: Mean concentration of heavy metal in the blood (mg/L) and organs (mg/kg) of the female cattle (Cows) slaughter at Yola abattoir

Elements	Samples 1					
	CB	**CH**	**CI**	**CS**	**CK**	**CL**
Zinc	0.48±0.12	2.14±0.38	2.07±0.31	3.19±0.55	1.21±0.26	2.03±0.35
Lead	0.17±0.09	0.17±0.00	0.16±0.00	0.15±0.01	0.17±0.05	0.14±0.01
Cobalt	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00
Cadmium	0.04±0.00	0.03±0.00	0.03±0.00	0.04±0.01	0.04±0.01	0.04±0.01
Copper	0.05±0.02	0.29±0.07	0.09±0.04	1.32±0.86	0.25±0.25	0.81±0.27

CB…. Cow Blood, CH...... Cow Heart, CI…..Cow intestine, CS….Cow stomach, CK…….Cow Kidney,

The mean concentration of heavy metals in the blood (mg/L), heart, intestine, stomach, kidney and liver in (mg/kg) of cows slaughter at Yola abattoir are presented in Table 1. Zn has high concentration in the blood than other metals. Zn levels ranged between 1.21±0.26 and 3.19±0.55 mg/kg; 0.14±0.01 and 0.17±0.00 mg/kg Pb; 0.00±0.00 and 0.00±0.00 mg/kg Co; 0.03±0.00 and 0.04±0.01 mg/kg Cd; 0.05±0.02 and 1.32±0.86 mg/kg Cu; in the organs.

Table 2: Mean concentration of heavy metal in the blood (mg/L) and organs (mg/kg) of the organs of the male cattle (Bulls) slaughter at Yola abattoir in mg/kg.

Elements	Samples 2					
	BB	**BH**	**BI**	**BS**	**BK**	**BL**
Zinc	1.06 ±0.19	2.10±0.45	1.93±0.15	2.92±0.87	2.07±0.48	4.9±3.54
Lead	0.15 ±0.02	0.17±0.03	0.15±0.03	0.15±0.03	0.17±0.12	0.15±0.02
Cobalt	0.01± 0.01	0.00± 0.00	0.00± 0.00	0.00± 0.00	0.00± 0.00	0.01± 0.01
Cadmium	0.05 ±0.01	0.04±0.01	0.04±0.02	0.05±0.01	0.40±0.38	0.04±0.01
Copper	0.35 ±0.54	0.18±0.07	0.11±0.05	0.32±0.24	0.42±0.60	2.66±2.87

BH... Bull Heart, BI… Bull intestine, BS… Bull stomach, BK… Bull Kidney, BL….Bull Liver

Table 2 shows the mean concentration of heavy metals in the blood (mg/L), heart, intestine, stomach, kidney and liver in (mg/kg) of bulls slaughter at Yola abattoir. Zn has high concentration in the blood than other metals. Zn concentration ranged from 1.93±0.46 and 4.9±3.07 mg/kg; 0.15±0.02 and 0.17±0.03 mg/kg Pb; 0.00±0.00 and 0.01±0.01 mg/kg Co; 0.04±0.01 and 0.40±0.38 mg/kg Cd; 0.11±0.05 and 2.66±2.87 mg/kg Cu; in the organs.

Table 3: Overall mean (±SD) concentration of metals in the blood (mg/L) and organs (mg/kg) of cattle (cows and bulls) slaughter at Yola abattoir

Elements	Samples					
(mg/kg)	**blood**	**heart**	**intestine**	**stomach**	**kidney**	**liver**
Zn	0.87±0.41	2.05±0.51	2.35±0.71	2.58±1.02	1.91±0.46	3.96±3.07
Pb	0.16±0.01	0.17±0.02	0.15±0.03	0.15±0.02	0.17±0.02	0.15±0.02
Co	0.01 ±0.01	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.01±0.01

Cd	0.04 ±0.00	0.04±0.01	0.03±0.12	0.04±0.01	0.30±0.34	0.03±0.01
Cu	0.20 ±0.22	0.20±0.09	0.45±0.82	0.40±0.24	0.40±0.50	1.98±2.47

The mean concentrations of heavy metals in the blood, heart, intestine, stomach, kidney and liver of cattle (cows and bulls) are presented in Table 3. Zn has high concentration in the blood than other metals. Zn levels ranged between 1.91±0.46 and 3.96±3.07 mg/kg; 0.15±0.02 and 0.17±0.02 mg/kg Pb; 0.00±0.00 and 0.01±0.01 mg/kg Co; 0.03±0.01 and 0.3±0.34 mg/kg Cd; 0.20±0.09 and 1.98±02.47 mg/kg Cu.

Highest cadmium concentration was observed in the kidney (0.3±0.34 mg/kg) as seen from Table. In blood a mean concentration of 0.04 ±0.00 mg/L was found. Cadmium is toxic to virtually every system in the animal body. It is almost absent in the human body at birth, however accumulates with age. 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 [19]. The high levels observed in kidney agree with several studies which have shown that cadmium bioaccumulate more in kidney than in other parts of body [20, 21]. Rodriguez et *al.*, have suggested that the higher concentration of cadmium in kidney tissue is due to the detoxification function of the organ and its rate of elimination from this organ could be relatively low [22] This is partly due to binding of Cd to sulfhydryl groups in the protein metallothione in the kidney. Animals exposed to cadmium accumulate it in their kidneys because of the presence of free protein-thiol groups which leads to a strong fixation of heavy metals [14].

Cadmium causes tissue damage in humans and animals and many toxicological studies have found the functional and structural changes in the kidneys, liver, lungs, bones, ovaries and fetal effects [23, 24]. Cadmium has been suggested to have some of its toxic effects by disturbing metabolism of essential metals, such as selenium. Zinc and selenium are believed to be the antagonists of cadmium toxic effect [25]. Cadmium showed highest concentration of 0.04±0.01 and 0.40±0.38 in the kidney of cows and bulls respectively (Table 1 and 2). From the results of this study, the concentrations of cadmium in all the samples studied were found to be below the permissible limit of 1.5 mg/kg [26].

Lead showed higher concentration in the kidney and heart from Table 3. Both sample 1 and 2 showed more accumulations of lead in the kidney and heart (0.17±0.05 and 0.17±0.00; 0.17±0.12 and 0.17±0.03) respectively. For the blood sample, 0.16±0.01 was detected. Lead is recognized as a known neurotoxicant with major public health concern which causes both acute and chronic intoxication. The toxicity may show in the form of anemia, abdominal colic, liver dysfunction, renal damage, peripheral neuropathy in adults, CNS disorders in the form of permanent brain damage in children and in case of extreme lead poisoning, convulsion followed by coma and death, might occur. Moreover, lead has a biological half life of about 27 years in human bones [6]. The effect of lead to man can cause delays in physical and mental development and slight deficit in attention span and learning abilities in infants and children; Kidney problems and high blood pressure in adults [2].

However, the permissible values of lead have been reported in food stuff as 2.5 mg/kg and the concentration of lead in all the samples studied were found to be below the permissible limit. This result is similar to a finding in Enugu state, Nigeria when the dietary intake of lead and cadmium and health risk from consumption of various parts of cow meat by the urban population was studied. The values indicate that the subjects are not exposed to any significant health risk via cow meat consumption [27].

Zinc is an essential plant micronutrient, indispensable to the proper growth of plants. Zinc deficiency hinders plant growth, causes interveinal chlorosis and yellowing on young leaves, and reduces leaf size. Soluble zinc forms are easily taken in by plants from soil. Zinc is one of the most mobile elements in soil. Although, many metals are essential, all metals are toxic at higher concentration because they cause oxidative stress by formation of free radicals. Another reason why metals may be toxic is that they can replace essential metals in pigments or enzymes disrupting their functions. Thus, metals render the soil unsuitable for plant growth and destroy the biodiversity [28]. High concentration of zinc was found in the liver of sample 2 (4.9±3.07 mg/kg), while the least value was in the kidney of sample 1 (1.21±0.26 mg/kg). 0.87±0.41mg/L was detected as the mean value in blood. Zinc is an essential element in human diet. Too little Zn can cause problems; however, too much Zn is harmful to human health [30]. Zn is relatively nontoxic to animals and has a depressing effect if the amount taken exceeds 700 mg/kg DM and it depends on Cu concentrations. From the results of this study, the concentrations of zinc in all the samples studied were found to be below the permissible limit.

The highest copper concentration was found in the liver of sample 2 (2.66±2.87 mg/kg) as seen from Table 2. The lowest concentration is observed in the intestine of sample 1 (0.09±0.04). A concentration of 0.20± 0.22 mg/L was detected in blood. Copper is deposited more in the liver compared to the other organs as observed from the mean result for both cows and bulls from Table 3. A similar study found out that copper is deposited most in the liver of cattle [31]. Excess accumulation of copper in liver can led to hepatitis or cirrhosis, but the concentration of copper in all the samples in this study is within the acceptable limit (20 ppm) [32]. The provisional tolerable weekly intakes (PTWI) copper for fresh meat has been proposed as 14 mg/week/ person by food and nutrition board.

Cobalt was not detected in most of the sample. A concentration of 0.01 ±0.01 mg/kg was found in the liver of sample 2 as observed from Table 2. A concentration of 0.01±0.01 was found in the blood. The daily intake is reported to be 3 mg. The concentration obtained from the analysis is however not low, taking into consideration the quantity of the sample used which is 2 grams. The concentrations of cobalt in all the samples studied were found to be below the permissible limit.

Conclusion

Industrialization have give raise to increase in environmental load of the toxins to levels that they are found in every consumerism, hence it become necessary to monitor the level of heavy metal in food items. These metals have direct effect on animal health and indirect effect on human health. The Analysis of Variance (ANOVA) test on the concentrations of all the metals in the heart, intestine, stomach, kidney and liver resulted in ($p>0.05$), i.e. there is no significant difference in the amount of the elements in this samples. The various parts of cattle consumed in Yola metropolis in Adamawa State, Nigeria, seem to be safe for consumption, considering the concentrations of Cadmium, lead, zinc, cobalt and copper present in them. It is expected that animals that graze freely will accumulate high concentrations of toxic metals in their organs, but from this findings, the levels of the metals was generally low. This may be due to low levels of industrialization in this part of the country where the animals are raised. Though the concentrations of these metals seem to be moderate, it might pose health hazards when consumed in large quantities due to bioaccumulation.

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