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Assessment of Selected Heavy Metal Residues in Meat of Cattle in Ondo State, Nigeria.

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ABSTRACT

The presence of heavy metal residues in food products is a potential hazard to humans and animals as these metals cannot be degraded and stay permanently in the environment hence there is a need to ascertain the safety of these products for human consumption. The concentration heavy metal residues in meat were assessed in three locations in Ondo State. A total number of 90 bulls were sampled for the investigation. The samples were digested with concentrated nitric acid and the resulting solutions were analyzed using Atomic Absorption Spectrophotometer (AAS) for lead, copper, zinc, cadmium and chromium. The result revealed that the concentration of each metal were significantly ($P < 0.05$) different due to the location. The results were compared with Maximum Recommended Limit (MRL) as set by FAO. The cadmium concentration in the kidney samples obtained from Owo has a mean concentration level of 1.23mg/kg, which is above those collected from Ondo (0.53mg/kg). However, Cadmium was not detected in kidney samples from Akure. Chromium concentration was high in kidney samples from Ondo and Owo with values of 1.11 and 1.21mg/kg respectively, than those recorded in Akure (0.31mg/kg). The mean level of copper in skeletal muscle from Akure (3.17kg/kg) was higher when compared with the 2 other locations (Ondo 1.48mg/kg; Owo 1.82mg/kg). The mean concentration of lead in skeletal muscle (2.09mg/kg) and kidney samples (0.89mg/kg) were significantly higher than liver samples (0.78mg/kg). Of these skeletal muscle, kidney and liver samples, 100%, 46.7%, 73.3% exceeded the MRL by FAO respectively. For cadmium, the result showed that kidney samples of slaughtered cattle contained mean value of 0.59mg/kg. Also, the concentration of zinc in skeletal muscle and liver of slaughtered cattle were 37.65and 50.55mg/kg out of which 36.7% and 43.3% exceeded the MRL by FAO for skeletal muscle and liver respectively. The mean concentration of chromium is higher in kidney samples (0.88mg/kg) than skeletal muscle (0.77mg/kg and liver (0.83mg/kg). Of these skeletal muscle, kidney and liver samples, 16.7%, 36.7%, 20% exceeded the MRL as set by FAO respectively. Copper mean concentration was higher in liver samples (20.57mg/kg) of which 100% of liver samples exceeded MRL by FAO.

Introduction

Heavy metals refer to any metallic element that has a relatively high density and is toxic or poisonous even at low concentration (Lenntech, 2004). Heavy metals are a general collective term, which applies to the group of metals and metalloids with atomic density greater than 4 g/cm^3, or 5 times or more, greater than water (Huton and Symon, 1986; Battarbee *et al*., 1988; Nriagu and Pacyna 1988; Nriagu, 1989; Garbarino *et al*., 1995, Hawkes, 1997). However, being a heavy metal has little to do with density but concerns chemical properties. Heavy metals include Lead (Pb), Cadmium (Cd), Zinc (Zn), Mercury (Hg), Arsenic (As), Silver (Ag), Chromium (Cr), Copper (Cu), Iron (Fe) and the platinum group elements. Baykov *et al*., (1996) reported that environmental pollution with heavy metals is considered as one of the most important problems because these metals cannot be degraded and remain permanently in the environment. Demirezen and Aksoy, (2004) observed that these heavy metals will finally appear in the food chain when they are accumulated in plant and animal tissues. Iwegbue *et al*., (2008) reported that meat from edible animal species exposed to heavy metals becomes polluted in the environment, is sold in the market for human consumption. Khurshid and Qureshi, (1984) observed that meat as a food material is composed of main proteins, fat and some important essential elements which are required for the growth and maintenance of good health. Metallic contamination of animal tissue is through direct exposure, polluted water, and crops grown on irrigated sewage water and industrial effluents. Another important means of contamination of meat is by the deposition of contaminants from vehicle emission and the dirty slaughter places.

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The shopkeepers sell most of the meat in the open market and even on the road side. The contaminated food and water cause illness in the affected human consumer. Although it is difficult to classify trace metal into essential and toxic groups, yet it was reported that an essential metal becomes toxic at sufficiently high intakes (Khurshid and Qureshi, 1984). Much attention has been focused on the presence of these metals in the meat of slaughtered animals because these metals cannot be destroyed by heat treatment (Levensen and Barnard, 1988).

Materials and Methods

The study area

Ondo is one of the six states that make up the South West geopolitical zone of Nigeria. It has boundaries with Ekiti and Kogi states to the north, Edo State to the east, Delta State to the southeast, Osun State to the northwest and Ogun State to the southwest. The Gulf of Guinea lies to its south, and its capital is Akure.

Ondo State covers an area of 15,195.2 square kilometers and lies at latitude 7° 10' north and longitude 5° 05' east. It has a population of 3,460,877 (2006 census figures) and a population density of 218 people per square kilometer. It accounts for 2.5% of Nigeria's total population. The state has eighteen Local Government Areas, the major towns being Akoko, Akure, Okitipupa, Ondo, and Owo. Akure central slaughter slab which lies between longitude 07°16.939' and between longitude 07°06.701' and latitude 05°06.495' and Ondo west central slaughter slab which lies between longitude 07°05.243' and latitude 04°49.207'.

Sample collection methods

A total number of 90 bulls were sampled. Meat (skeletal muscle, liver and kidney) samples were collected from the identify abattoirs. Before samples were collected, the purpose of the research was explained to the chairman of each slaughter slabs and owners of the animals and enlightenment was also made on the benefits derivable from the research.

Sampling technique/ sample collection

Each sample was labelled according to animal, slaughter slab and location from where they were collected.

a) Preservation of samples

All collected samples were kept in cool boxes containing ice pack for onward transportation from the field to the laboratory.

Collection of meat samples

Meat samples were collected from cattle from the identified abattoirs in Ondo state. 50 g each of meat (skeletal muscle), liver and kidney were collected from 90 cattle carcasses. The samples were packaged in polyethylene bags and labelled according to the animal and slaughter slab from which they were collected. They were then taken to the laboratory in an ice pack. After that visible fat was removed

Mean concentration of Lead (Pb), Cadmium (Cd), Zinc (Zn), Chromium (Cr) and Copper (Cu) (mg/kg) in bovine Skeletal muscle, Kidney and Liver in Akure, Ondo and Owo Central Slaughter Slab.

Metals	Type of sample examined	Number of sample examined	Locations (Mean Concentration ± SD)			ANOVA	
		n	Akure	Ondo	Owo	F	p-value
	Skeletal Muscle	10	1.83 ± 1.00^a	2.25 ± 1.70^a	2.20 ± 1.03^a	0.307	0.74
Pb	Kidney	10	0.97 ± 1.32^a	0.83 ± 0.72^a	0.87 ± 1.23^a	0.040	0.96
	Liver	10	0.92 ± 0.77^a	0.89 ± 0.54^a	0.55 ± 0.48^a	1.159	0.33
	Skeletal	10	ND	ND	ND	ND	ND
Cd	Kidney	10	ND	0.53 ± 0.77^b	1.23 ± 1.15^a	5.984	*0.01
	Liver	10	ND	ND	ND	ND	ND
	Skeletal	10	36.00 ± 27.62^a	38.87 ± 26.83^a	38.07 ± 22.28^a	0.033	0.97
Zn	Kidney	10	17.56 ± 3.43^a	21.31 ± 7.43^a	19.37 ± 4.89^a	1.163	0.33
	Liver	10	50.78 ± 29.87^a	51.23 ± 20.17^a	49.66 ± 22.07^a	0.011	0.99
	Skeletal	10	1.13 ± 1.73^a	0.52 ± 0.41^a	0.66 ± 0.34^a	0.959	0.40
Cr	Kidney	10	0.31 ± 0.46^b	1.11 ± 0.89^a	1.21 ± 0.84^a	4.346	*0.02
	Liver	10	0.53 ± 0.29^a	0.90 ± 0.48^a	0.51 ± 0.53^a	2.417	0.11
	Skeletal	10	3.17 ± 1.12^a	1.48 ± 0.84^b	1.82 ± 0.39^b	11.452	*0.00
	Kidney	10	4.66 ± 0.86^a	4.30 ± 0.76^a	4.53 ± 1.46^a	0.239	0.75
Cu	Liver	10	21.13 ± 14.97^a	24.34 ± 18.72^a	16.24 ± 7.41^a	0.792	0.46

Mean is significant at (p<0.05) Horizontal means with the same superscript are not statistically significantly different horizontal means with the different superscript are statistically significant different, D – Not detected, (mg/kg) – Milligram per kilogram * Significant Pb – Lead, Cd – Cadmium, Zn – Zinc, Cr – Chromium and Cu – copper.

Range and Mean concentration of Lead (Pb), Cadmium (Cd), Zinc (Zn) Chromium (Cr) and Copper (Cu) (mg/kg) in bovine Skeletal muscle, Kidney and Liver.

		Metals										Anova	
		Pb		Cd		Zn		Cr		Cu		F	p
Type of samples examined	No of samples examined	Range	Mean ± SD	Range	Mean ± SD	Range	Mean ± SD	Range	Mean ± SD	Range	Mean ± SD		
Skeletal	30	1.62 – 2.56	2.09 ± 1.26^b	ND	ND	28.38 – 46.91	37.65 ± 24.81^b	0.38 – 1.16	0.77 ± 1.05^b	1.75 – 2.57	2.16 ± 1.10^c	64.329	*0.00
Kidney	30	0.49 – 1.30	0.89 ± 1.08^c	0.24 – 0.93	0.59 ± 0.93^c	17.35 – 21.48	19.42 ± 5.53^c	0.56 – 1.19	0.88 ± 0.84^c	4.11 – 4.89	4.50 ± 1.04^b	284.296	*0.00
Liver	30	0.56 – 1.01	0.78 ± 0.61^c	ND	ND	41.76 – 59.35	50.55 ± 23.55^a	0.47 – 1.18	0.83 ± 0.47^c	15.20 – 25.94	20.57 ± 14.38^a	94.811	*0.00

Vertically different letters are significantly different at (p<0.05) * Significant ND – Not detected
(mg/kg) – Milligram per kilogram. Pb – Lead, Cd – Cadmium, Zn – Zinc, Cr – Chromium and Cu – copper.

Number and percentage of bovine skeletal tissue, liver and kidney samples exceeding the maximum Permissible limits (MPL) for lead (Pb), Cadmium (Cd), Zinc (Zn), Chromium(Cr) and Copper(Cu) as proposed by the FAO/WHO.

Metals	Type of examined sample	FAO/WHO (MPL)	Mean Concentration of the metals	Number of examined samples	No. of samples exceeding the FAO/WHO limits	Percentage (%) of samples exceeding the FAO/WHO limits
	Skeletal Muscle	0.1mg/Kg	2.09	30	27	90.0
Pb	Kidney	0.5mg/Kg	0.89	30	14	46.7
	Liver	0.5mg/Kg	0.78	30	22	73.3
	Skeletal Muscle	0.05mg/Kg	ND	30	0	0.0
Cd	Kidney	1.0mg/Kg	0.59	30	0	0.0
	Liver	0.5mg/Kg	ND	30	0	0.0
	Skeletal Muscle	50mg/Kg	37.65	30	11	36.7
Zn	Kidney	50mg/Kg	19.42	30	0	0.0
	Liver	50mg/Kg	50.55	30	13	43.3
	Skeletal Muscle	1.0mg/Kg	0.77	30	5	16.7
Cr	Kidney	1.0mg/Kg	0.88	30	11	36.7
	Liver	1.0mg/Kg	0.83	30	6	20.0
	Skeletal Muscle	20mg/Kg	2.16	30	0	0.0
Cu	Kidney	20mg/Kg	4.50	30	0	0.0
	Liver	0.5mg/Kg	20.57	30	0	40.0

MPL - (Maximum permissible limit) ND – Not detected. FAO/WHO – (Food and Agricultural Organization/World Health organization) (mg/kg) – Milligram per kilogram. Pb – Lead, Cd – Cadmium, Zn – Zinc, Cr – Chromium and Cu – copper.

and samples were stored at -18^{0}C until required for analysis at Julius Okojie Central Research Laboratory of the Federal University of Technology Akure, Ondo state, Nigeria.

The concentration of individual metal assessed in the samples based on location show that the high cadmium concentration observed in kidney samples obtained from Owo central slaughter slab suggests that it may be due to contaminated drinking water, vehicular emission; smokes from tobacco carried in the air and polluted plant consumed by the sampled animal. Chromium concentration in kidney samples obtained from Ondo and Owo slaughter slabs are significantly high; this may be due to polluted water from burning of refuse. Copper concentration is relatively high in skeletal muscle collected from Akure than the copper concentration in skeletal muscle obtained from Owo and Ondo central slaughter slab; this may be the result of cattle consumption of pasture grown on soil having a high copper level. The mean concentration of lead in skeletal muscle, kidney and liver in this study is higher than those reported by Kottferova and Korenekova (1995) who examined lead concentration in bovine skeletal muscle, kidney and liver of slaughtered cattle and reported the mean lead concentration of 0.08, 0.35 and 0.55 mg/kg respectively. The result of this study were higher than those noticed by Iwegbue (2008) in Southern Nigeria who reported that kidneys and liver samples of cattle generally have low lead concentrations (75% of kidney and liver samples have lead concentration less than 0.001 mg/kg and recorded the range and mean concentration of ND – 0.95 (0.04 mg/kg) in kidneys and ND – 1.23 (0.08 mg/kg) in liver. The concentration of lead reported in this study for the samples (skeletal muscle, kidney and liver) were lower than concentration reported by Mariam *et al.*, (2004) who revealed lead mean concentrations of 2.19, 2.02 and 2.18mg/kg for muscle, kidney and liver respectively for beef in Lahore and also lower for liver samples than those showed by Adei and Forson – Adaboh (2008) who reported that all liver samples observed in their study exceeded the European Commission limit which ranges from 1.3 -13.8 mg/kg in the liver of some domestic animals in including cows in Ghana. The concentration of lead reported in this study was higher than those reported by Stabel- Tancher *et al*., (1975) which show that lead concentration was 0.12mg/kg in muscle, 0.26 mg/kg in kidney and 0.28mg/kg in the liver of Finnish cattle. From this study, the skeletal muscles have the highest lead concentration, followed by kidney and liver samples which had the least. This is not in agreement with Bala *et a*l., (2012) who reported a high concentration of lead in liver than kidney.

The high concentration of lead observed in the skeletal muscle may be due to consumption of pasture laden with lead materials such as lead batteries, lead gasoline and paint cans (West, 1976). Lead is the common cause of accidental poisoning in domestic animals, especially in cattle due to their licking habits and the concentration found in the kidney may be as a result of the excretory function of the kidney, in which some toxic substances are mobilised from the body tissues and are sent to the kidney for excretion. The mean concentration of cadmium in kidney samples is 0.59mg/kg, which implies that none of the kidney samples exceeded the maximum recommended limit (MRL). This is higher to those reported by Iwegbue (2008) who revealed that the mean cadmium concentration of cattle's kidney in Southern Nigeria as 0.14mg/kg. The result of this study is not in agreement with Satarug *et al.*, (2003) who revealed a higher accumulation of cadmium in kidney due to excretory function of this organ and that the kidney is considered as the target organ for cadmium toxicity and Goyer (1995) who reported that cadmium toxicity occurs in kidneys resulting in proximal tubular dysfunction causing decreased absorption of amino acids, glucose, calcium phosphate and low molecular weight protein. The mean cadmium concentration for a kidney in this study is higher than cadmium concentration (0.45mg/kg) in kidney observed by Falandysy (1994). The result of the study is not in agreement to the results observed by Rahimi and Rokni (2008) who reported that the mean concentrations of cadmium in bovine kidneys in Isfahan to be 0.1371 mg/kg. Cadmium is widely distributed throughout the environment, and the traces of cadmium can be detected in all plants, animals and foodstuffs. The application of phosphate fertilizers every year to the soil deposits a considerable amount of cadmium in farmlands, thus increasing its level in the soil. Additionally, acid rain may increase the amount of cadmium in soil and expand the concentration of this metal in agricultural products, (Busceme *et al.,* 1997). The result of this study is similar to the finding of Bernard, (2004) who reported that cadmium is primarily toxic to the kidney. Exposure to cadmium has been associated with nephrotoxicity, osteoporosis, neurotoxicity, genotoxicity, teratogenicity and it has been classified as a human carcinogen (Group 1) by the IARC (Huff *et al*., 2007; Gallagher *et al*., 2008)**.** The result obtained from this study revealed 36.7% mean zinc concentration in skeletal muscle which exceeded the maximum recommended limit, this percentage is lower than were reported by Dallatu *et al*., 2013 and Badis *et al* ., (2014), 43.3% of liver samples which exceeded maximum recommended limit is nearly similar to the result revealed by Abdelrahman *et al* ., (2013).Therefore, the liver is considered as the target organ for zinc accumulation, and this may be due to the detoxification function of the liver. Human beings are exposed to small amount of zinc in food, drinking water each day; levels in the air are generally low and fairly constant. Skeletal muscle and liver have the highest mean concentration of zinc. The concentration of zinc in the plant varies based on the level of the element in the soil. Zinc is an essential diet in the human diet, too little zinc can cause a health problem, and however too much of zinc is harmful to human health (ATSDR, 2004). The result from this study show low mean concentration of copper in skeletal muscle than 26.6mg/kg reported in skeletal muscle by Miranda *et al*., (2005) but higher concentration in liver and kidney samples than 3.94 and 1.46mg/kg reported by Miranda *et al*., (2005) liver and kidney samples respectively. The result for copper concentration in this study was also lower than those reported in skeletal muscle (4.14mg/kg), kidney (8.66mg/kg), liver (36.88mg/kg) by Shariff *et al*., (2005) as well as those reported by Korenekova *et al*., (2002) in skeletal muscle (4.57mg/kg) and liver (31.07mg/kg). However, 70mg/kg copper concentration reported by Sabir *et al*., (2003) for skeletal muscle is higher than the result in this study. The Liver has the highest concentration of copper due to its detoxification function. The concentration of copper in the liver was significantly higher than its level in skeletal muscle and kidney respectively. High copper concentration in the liver can be caused by consumption contaminated pasture which corroborates with findings by Tokarnia *et al.,* (2000). Copper is a naturally occurring element in the earth crust, in rocks, soils, sediments and certain natural waters. This agrees with hypothesis reported by United States Environmental Protection Agency (2003). Copper plays an important role for farm animal health and productivity through their function as a main component of many essential metalloenzymes. These enzymes regulate the metabolism of carbohydrates and lipids and also function as antioxidant. This is in agreement with (Andrieu, 2008).

Conclusion and Recommendation

Conclusion

Most of the samples investigated contain heavy burden of Lead (Pb), Zinc (Zn), copper (Cu), chromium (Cr) and cadmium (Cd) residues, which are toxic for consumption and could have deleterious effects on human health such as cancer, renal failure, anaemia, nausea, vomiting, and drop in intelligent quotient in children. None of the samples investigated is considered safe for human consumption. These selected heavy metals could also have a negative effect on the bovine production system.

Recommendation

In this study, most of the samples investigated contained a high concentration of heavy metal residues above the maximum recommended limit. Based on this finding, it is hereby recommended that government should establish food residue regulatory body that will ensure that food-producing animals conform to the standard limit. The governments should promote harmonized data collection, research, legislation and regulations. Government should enforce law guiding industries on the indiscriminate release of toxic emissions into the environment, upgrade the standard of meat inspection and educate herdsmen and butchers. The government should promote soil bioremediation.

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