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Determination of Heavy Metals in Selected Tissues and Organs of Slaughtered Cattle from Akinyele Central Abattoir, Ibadan, Nigeria

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Abstract
Meat and offal obtained from cattle are consumed daily as source of protein, but consumers' knowledge on the possible exposure to heavy metals in meat and its associated health risk is generally low. Therefore, this study seeks to determine heavy metal levels in selected tissues and organs of cattle.A cross-sectional study design with laboratory analysis component was adopted. Lead, cadmium and chromium in blood, muscle, liver and kidney of cattle slaughtered in Akinyele central abattoir, Ibadan, Nigeria were studied. Samples of blood from jugular vein at slaughter, external abdominus muscles, liver apical lobes and kidney cortices were collected. Eighty samples were collected for 8 weeks and analyzed for lead, chromium and cadmium, using Atomic Absorption Spectrophotometer (AAS). Values were compared with Joint FAO/WHO guidelines. Statistical analysis was done using descriptive statistics, t-test and ANOVA. Male cattle (75%) and female (25%) with mean age of 49.5 months were used. Mean chromium residual values in blood, muscle tissue, liver and kidney were 0.62±0.00, 0.62±0.00, 1.28±0.93 and 2.33±2.99 mg/kg respectively. Chromium residues were higher in liver and kidney, while lead residues were within the permissible limit. Mean cadmium residues in blood, muscle tissue, liver and kidney were 5.67±2.08, 3.81±2.09, 5.24±2.30 and 5.71±2.31 mg/kg respectively. These values were higher than permissible limit of 0.5-1.0mg/kg. There was significant difference (P=.05) in heavy metals bioaccumulation based on tissue type and age of the cattle.The cattle meat contained levels of cadmium and chromium and this could pose health risk to consumers. Therefore, massive public health awareness on the risk associated with cadmium and chromium ingestion and measures to reduce them in meat and meat products should be advocated. Cattle rearers should also be educated on the grazing areas to be selected.
Keywords: Cattle meat and offal, lead, cadmium and chromium, abattoir

1.0 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 CBN 1999). Nigeria is one of the four leading livestock producers in Sub-Sahara Africa. The population of livestock (ruminant) in Nigeria is estimated to be about 14 million cattle, 13 million sheep and 23 million goats (RIM, 1990). However, these figures have since increased to 15.2 million cattle, 28 million goats and 23 million sheep (FAO 2006)

Livestock production has been a source of supply of animal protein worldwide. Meat from slaughtered cattle at various abattoirs constitutes the largest source of animal protein for Nigerian populace (Idahor *et al.,* 2009). Most of the livestock in Nigeria are being raised in commercial quantity in the Northern part of the country, but the enterprise is not known to be associated with the Southern Nigeria due to the prevalence of Trypanosomiasis. These animals are grazed on a free range system during which they eat grasses in the surroundings and also drink water from any nearby streams and stagnant water which could have been contaminated with heavy metals. Contamination with heavy metal is a serious threat because of their toxicity, bioaccumulation and biomagnifications in the food chain (Demirezen and Uruc, 2006).

Cattle, goats, sheep etc, are classified together as ruminant animals because they digests plant-based food by initially softening it within the animal's first stomach, known as the rumen, then brings back the semi-digested mass, now known as cud, and chews it again. This process of chewing the cud again to further break down plant matter and stimulate digestion is called 'ruminating'. 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. 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 (Zukowska *et al*. 2008)

A number of serious health problems can develop as a result of excessive uptake of dietary heavy metals. Furthermore, the consumption of heavy metal-contaminated food can seriously deplete some essential nutrients in the body causing a decrease in immunological defences, intra-uterine growth retardation, impaired psycho-social behaviours, disabilities associated with malnutrition and a high prevalence of upper gastrointestinal cancer (Arora *et al*. 2008). Cadmium, lead, mercury and chromium are classified as some of the

dangerous heavy metals to health and environment. It is therefore, necessary to investigate the accumulation of heavy metals which are of public health importance in the blood and tissue of animals readily used as food.

This study is aimed at determining the levels of selected heavy metals in the blood and tissue of cattle slaughtered in Akinyele central abattoir located in Ibadan, Nigeria, which serves as the largest abattoir supplying meat and meat products to Ibadan people and its environ.

2.0 Materials and method

2.1 Study location

The study was carried out in Akinyele central abattoir, located in Ibadan, Nigeria. This area falls within the rain forest agro-ecological zone. It is found between latitude 7.5309^0N and longitude 3.9110^0E respectively. This is the largest abattoir supplying both live animals and meat products for general populace consumption in Ibadan and its environs, making the abattoir very important and thus, needed to be regulated in order to prevent meat borne disease and contamination to the consumers.

2.2 Study design

A cross-sectional study design with observational and laboratory analysis component was adopted in the study.

2.3 Community/ abattoir entry

This was made possible through our contact person, who is the head of Animal Health Technologist in the abattoir. He introduced our team to the manager of the abattoir and the sub-head of the cattle section. This link helped in fast tracking the process of sample collection, preservation and transportation to the laboratory for analysis.

2.4 Study duration

The sample collection aspect of this study lasted for eight weeks in the abattoir. Samples were preserved and subsequently taken to the laboratory for analysis.

2.5 Study materials and equipment

The materials used for the study include the field and laboratory materials. The field materials were the plain sample bottles, permanent marker for proper labeling and identification, disposable gloves, and nose mask. The laboratory materials and equipment include the sensitive weighing balance, glass petri-dishes, syringe, digestion flask, electric bunsen burner, heating mantle, fume chamber, cotton wool, funnels, digestion tubes, nitric acid and a Perkin Elmer Model 4100 atomic absorption spectrophotometer.

2.6 Sample Collection

A total of twenty (20) cattle were purposively selected over a period of 8 weeks in conformity with FAO quality control guidelines. Samples of blood from jugular vein at slaughter, external abdominus muscles, liver apical lobes and kidney cortices were collected from these animals. Samples were immediately taken to the Nigerian Institute of Science Laboratory Samonda Ibadan for digestion and elemental analysis. The summary of the samples collected at the abattoir is as shown in the box below:

Number of animals used: 20 cattle.
Number of samples collected: 80 samples
Nature of samples collected: blood, muscle tissue, liver and kidney
Heavy metals analyzed: cadmium, chromium and lead.

Box 1: Samples collected for the study

Samples were collected every Friday morning (7am) for a period of 8 weeks. Sample bottles used were coded as BD (bovine blood), BE (bovine muscle), BY (bovine kidney), BR (bovine liver). Blinding method was used to prevent any error of bias in the study that may ensue during analysis.

2.7 Digestion and determination of lead, chromium and cadmium

The collected samples of blood, muscle, liver and kidney cattle were weighed and decomposed by wet digestion method for the determination of lead, chromium and cadmium residues. Known quantities, 0.5 g of each sample were introduced into the digestion flask and 5 ml of Nitric acid added. The digestion flask was heated for 15 minutes, using electric heater and heating mantle inside the fume chamber. After digestion, the content of the flask was filtered into a 25 ml digestion tube, made up to the mark with distilled water and then transferred into the laboratory sample bottles.

2.8 Elemental analysis of samples

The determination of heavy metals was made directly on each of the final solutions, using Atomic Absorption Spectroscopy (A.A.S). For each heavy metal, there was a specific "hollow cathode lamp" and the machine set a particular wavelength for the heavy metal to be analyzed. The absorbance were measured at 15mA of lamp and the peak height mode of the wave lengths used were 283.3nm, 228.8nm, 356.9nm for lead, cadmium and chromium respectively.

2.9 Statistical Analysis

Characteristics of the sampled cattle were presented in frequency and percentages. Data obtained from other variables were summarized as mean ± SD. Median, Minimum and maximum values including inferential statistics were also presented using SPSS 17.0 package.

3.0 Results and Discussion

3.1 Characteristics of the cattle

Age of the cattle: The age of the cattle used for this study ranges from 30 months to 84 months and the mean age is 49.5 months. Details of the age characteristics of the cattle are as shown in Table 1 below.

Table 1: Summary of the age of cattle sampled in months

Mean	49.5
Median	48.0
Mode	36.0
Standard deviation	14.7
Minimum	30
Maximum	84

Sex of the cattle: Fifteen out of twenty animals sampled were male amounting to 75 percent of the animals sampled as shown in Table 2.

Table 2: Sex of the cattle Sampled

Sex of animal	Frequency	Percentage
Male	15	75.0
Female	5	25.0
Total	20	100.0

This showed that majority of cattle slaughtered in the abattoir were male as female cattle are mostly used for breeding purposes, while only the unproductive and old ones are culled for slaughter in the abattoir. This is in line with the works of Opara *et. al* 2006, Abdulkadir *et. al.* 2008, Riehn *et. al*. 2010, reporting sound economic management demand that animals sold for slaughter should be mainly males and reproductively inactive females.

3.2 Prevalence of the samples with heavy metals

Table 3 shows the prevalence of the sample having residues of the selected heavy metals in all the tissue samples analyzed. It was found that cadmium had the highest prevalence of 78.8% while chromium had the least prevalence 11.3%. The result is in contrast with the work of Bala *et. al.* (2012) who reported 100% prevalence for cadmium, chromium and lead sampled in Sokoto central abattoir and also Bala *et. al.*(2014), who reported 87.5%, 95.85%, 79.19% prevalence for cadmium, chromium and lead respectively. This could largely be due to ecological differences in heavy metal residue deposition.

Table 3: Prevalence of the samples with heavy metals

Type of Animal	Cadmium	Chromium	Lead
Cattle	63	9	17
Percentage (%)	78.8	11.3	21.3
Total samples	80	80	80

3.2.1 Cadmium residual levels

Cadmium residual levels in the various tissues are presented in Table 4.

Cadmium was detected in blood, muscle, kidney and liver. Blood had the highest mean value of 5.67mg/kg indicating recent exposure and the least value of 3.81mg/kg was found in the muscle tissue. The cadmium residues found in the tissues were above the permissible limit which was in contrast with the work of Rahimi and Rokni, 2008, who found the level of cadmium below the permissible limit.

Table 4: Cadmium in cattle

Tissue type	Number sampled	Number detected	Mean mg/kg	Standard deviation	Minimum mg/kg	Maximum mg/kg
Blood	20	16	5.67	2.08	1.32	8.90
Muscle	20	15	3.81	2.09	0.01	6.11
Kidney	20	16	5.71	2.31	2.41	8.89
Liver	20	16	5.24	2.30	3.33	14.44

3.2.2 Chromium residual levels

Blood and muscle tissues had the least mean values of 0.62mg/kg, while kidney had the highest mean level of 2.33mg/kg as shown in Table 5.

Table 5: Chromium in cattle

Tissue type	Number sampled	Number detected	Mean mg/kg	Standard deviation	Minimum mg/kg	Maximum mg/kg
Blood	20	1	0.62	-	0.62	0.62
Muscle	20	2	0.62	0.00	0.62	0.62
Kidney	20	4	2.33	2.99	0.62	6.79
Liver	20	2	1.28	0.93	0.62	1.94

The total number of chromium residues detected in all the tissues sampled was generally low. Fathy *et. al.* 2011 reported lower residual levels of chromium in muscle, liver and kidney with11.20 µg/kg (0.011mg/kg), 21.85 µg/kg (0.022mg/kg) and 25.49 µg/kg (0.025mg/kg) fresh weights respectively.

3.2.3 Lead residual levels

Seventeen out of 80 samples were found to have lead residues distributed in different tissue types as shown in Table 6. Blood had the highest mean residual values of 0.49mg/kg, while the least value of 0.001mg/kg was found in the liver.

Table 6: Lead in cattle

Tissue type	Number sampled	Number detected	Mean mg/kg	Standard deviation	Minimum mg/kg	Maximum mg/kg
Blood	20	8	0.49	0.56	0.01	1.21
Muscle	20	5	0.11	0.22	0.001	0.51
Kidney	20	2	0.017	0.022	0.001	0.03
Liver	20	2	0.001	0.000	0.001	0.001

This was in contrast with Bala *et. al.* 2014, who reported that mean concentration of lead in liver, kidney, and muscle samples were 1.887 mg/kg, 1.2790 mg/kg, and 0.6680 mg/kg respectively. Out of the samples analyzed, only 21 samples (5 samples of liver, 6 samples of kidney and 10 samples of muscles) were within the recommended Food and Agricultural Organisation (FAO, 2002) permissible limits of lead concentration in liver, kidney and muscle of bovine (Bala *et. al.* 2014). However, the results obtained were generally within the permissible limit.

3.3 Comparison of the heavy metals with international Guidelines

The level of cadmium residue in the study was higher in all the tissues when compared with the permissible limit, chromium residues were also found to be higher than limit in the liver and kidney sampled while levels in blood and muscles were within the permissible limit. It was striking to note that the lead residues found in all the tissues under study were within the permissible limit. Details of the result are as shown in Table 7.

Table 7: Levels of heavy metal against international Guidelines

Tissue type	Heavy metals in cattle (mg/kg)					
	Cadmium	FAO/ WHO	Chromium	FAO/ WHO	Lead	FAO/ WHO
Blood	5.67±2.08	0.50	0.62	1.00	0.49±0.56	0.50
Muscle	3.81±2.09	0.05	0.62±0.00	1.00	0.11±0.22	0.10
Kidney	5.71±2.31	1.00	2.33±2.99	1.00	0.017±0.022	0.50
Liver	5.24±2.30	0.50	1.28±0.93	1.00	0.001±0.00	0.50

4.0 Conclusion and Recommendation

Cadmium was found from this study to be higher than the permissible limit in all the tissues (blood, muscle, kidney and liver) and chromium was above the limit in kidney and liver of cattle slaughtered in central abattoir, Akinyele, Ibadan. The presence of these heavy metals above the limit could be associated with environmental release of these toxic metals unto the grazing floors, contaminated water used in processing of abattoir carcasses, exposure during transportation; since most of the cattle slaughtered in the abattoir were transported over several

thousands of kilometers for days before reaching the destination.

Lead level was found to be lower than the permissible limit in blood, muscle, kidney and liver. This could be linked to little or no exposure of the cattle to feeds, water and other materials that may contain lead. It could also be attributed to the public health awareness drive geared towards reduction in the use of leaded gasoline, paints and other related materials that may be associated with cattle business in Nigeria.

Therefore, we recommended 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 and chromium emission into the environment, as well as cooking methods and practices to eliminate heavy metals in meat and meat products should be advocated.

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