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

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Abstract
Meat and offal obtained from goat has been widely accepted as delicacy and serve as important source of protein consumed daily by all strata of the society. In contrast, consumers' knowledge on the possible exposure to heavy metals in meat and its associated health risk in Nigeria is generally low. Therefore, this study aimed at assessing heavy metal levels in selected tissues and organs of slaughtered goats.An exploratory study design with observational and laboratory analysis component was adopted. Lead, cadmium and chromium in blood, muscle, liver and kidney of goat slaughtered in central abattoir, Akinyele, Ibadan were studied. Samples of blood from jugular vein at slaughter, external abdominus muscles, liver apical lobes and kidney cortices were collected. A total of twenty (20) goats were purposively selected over a period of 8 weeks. Samples were analyzed using Atomic Absorption Spectrophotometer (AAS). Statistical analysis was done using descriptive statistics, t-test and ANOVA.Male (60%) and 40% female goats with mean age of 28.8 months were included. Samples (4) comprising of blood, muscle tissue, liver and kidney were taken from each animal totaling 80 samples. Samples were analyzed for lead, chromium and cadmium. In the 80 samples, heavy metal levels found included cadmium in 52 samples (65.0%), lead in 8 samples (10.0%) and chromium in 8 samples (10.0%). Values were compared with Joint FAO/WHO guidelines. Mean chromium residual values in blood, muscle tissue, liver and kidney for the goats were (2.37±2.55, 0.00, 0.62±0.00 and 0.01±0.00 mg/kg). Chromium residue was only higher in the blood. Mean cadmium values in blood, muscle tissue, liver and kidney of goat were (6.75±3.03, 5.43±1.94, 5.51 ±2.92 and 4.77±1.93 mg/kg). These values were generally higher than permissible limit of 0.5-1.0mg/kg. Mean lead residual values in blood, muscle, liver and kidney were within the permissible limits. The goat meat contained levels of cadmium in all tissues sampled while chromium was only found in blood at a level that is above the tolerable limit; hence this could pose health risk to consumers. It is therefore recommended that goat be raised away from environment that is known for cadmium and chromium discharge or emission, so as to reduce their bioaccumulation.
Keywords: Goat, Cadmium, Lead, Chromium, Abattoir

Introduction

The International Agency for Research on Cancer (IARC monographs, 2014) classified heavy metals into different groups which include groups 1, 2A, 2B, 3 and 4. Groups 1 are those carcinogenic to humans and there are 113 agents found in this group. Groups 2A are those probably carcinogenic to humans (66 agents in this group). Groups 2B are those possibly carcinogenic to humans (285 agents are found). Groups 3 are those not classifiable as to its carcinogenicity to humans (505 agents found). Groups 4 are those not probably carcinogenic to humans (1 agent found). Here there is no evidence of carcinogenicity in humans and in animals.
The three heavy metals under assessment in this research were cadmium, lead and chromium. Cadmium and chromium belong to groups 1 on IARC classification. Cadmium is known to be highly carcinogenic to humans. In non-smokers, food is the major source of cadmium exposure. Recent studies show that adverse health effects of cadmium exposure may occur at lower levels than previously anticipated. Lead belongs to groups 2B on IARC classification and is known to possibly have carcinogenic effect on man. The general population is exposed to lead from air and food in roughly equal proportion.

Heavy metals make significant contribution to environmental pollution as a result of anthropogenic activities such as mining, energy and fuel production, power transmission, intensive agricultural practices, sludge and industrial effluent dumping and military operations (Orcutt and Nilsen, 2000, Cseh, 2002). Heavy metal pollution of soil is usually related to human activities. These activities include dumping of wastes, unintentional and process spillages, use of agricultural pesticides and related chemicals, movement of contaminants into a fertile land as vapors, by mobilization of soil, or as dust, or dispersal of sewage mire. Sites near mining activities or heavy industry are often highly contaminated with toxic metals.

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, intrauterine growth retardation, impaired psycho- social behaviours, disabilities associated with malnutrition and a high prevalence of upper gastrointestinal cancer (Arora *et al*. 2008)

This study focuses on the assessment of the level of selected heavy metals in the blood and tissue of goats slaughtered in central abattoir, Akinyele, Ibadan, which serves as the largest abattoir supplying meat and meat products to Ibadan people and its environ.

Material and Method

Study Location

The study was carried out in Central abattoir Akinyele which falls within the rain forest agro-ecological zone and 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, making the abattoir very important and needed to be regulated in order to prevent meat borne disease for improved public health of the goat meat consumers in Ibadan and its environs.

Study Design

An exploratory study design with observational and laboratory analysis component was adopted. **Community Entry:** This was made possible through contact to the head of Animal Health Technologist in the abattoir who introduced the research team to the abattoir manager and the head of the goats section. This entry process helped in fast tracking the sample collection.

Study Duration: The sample collection was done for a period of eight weeks in the abattoir, and consequently the laboratory analysis of the preserved samples.

Study Materials and Equipment

The materials used for the study were classified into 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 used were Nitric acid, cotton wool, funnels, digestion tubes, laboratory sample bottles, sensitive weighing balance, glass petri-dishes, syringe, digestion flask, electric Bunsen burner, heating mantle, fume chamber and a Perkin Elmer Model 4100 Atomic absorption spectrophotometer.

Sample Collection

A total of twenty (20) goats 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 preserved and taken to Laboratory for digestion and elemental analysis. Below is the summary of the samples collected at the abattoir:

- **Number of animals used** – 20 animals comprising of 20 goats.
- **Number of samples collected** – 80 samples
- **Nature of samples collected** – blood, muscle tissue, liver and kidney
- **Heavy metals analyzed** – cadmium, chromium and lead.

Samples were collected every Friday morning (7am) for 8 weeks. Sample bottles used were coded as CD (caprine blood), CE (Caprine muscle), CY (Caprine kidney) and CR (Caprine liver). Blinding method was used to prevent any error of bias in the study that may ensue during analysis.

Digestion and Determination of Lead of Chromium and Cadmium

The collected samples of blood, muscle, liver and kidney 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 was 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 and made up to the mark with distilled water and then transferred into the laboratory sample bottles.

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 at a particular wavelength for the heavy metal to be analyzed. The absorbances 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.

Statistical Analysis

Individual characteristics of the sampled goats were presented in frequency and percentages. Data obtained from other variables were summarized as mean ± SD. Median, Minimum and maximum values were also presented using SPSS 17.0 package.

Results and Discussion

The summary of the age of the goats sampled at the abattoir is as shown in table 1. The mean age of the goats

was 28.8 months and the mode was 24 months. This revealed that most of the goats slaughtered at the abattoir ranges from young to relatively old animals.

Table 2 revealed sex categorization of the goats slaughtered, of which, 60% were males while 40% were females. This is in line with the works of Riehn *et. al*.(2010), reporting sound economic management demand that animals sold for slaughter should be mainly males and reproductively inactive females.

The percentage of the samples containing cadmium, chromium and lead are presented in table 3. From the study, cadmium had the highest percentage (65.0%), while chromium and lead had equal percentage (10.0%) each, which were generally low. This finding was not in consonance with Bala *et. al.*(2014), who reported 87.5%, 95.85%, 79.19% percentage for cadmium, chromium and lead respectively in slaughtered cattle.

The cadmium residual levels in blood, muscle, kidney and liver of goats sampled are as shown in table 4. The highest mean values were found in blood (6.75mg/kg) and liver (5.51mg/kg), while least mean value was 4.77mg/kg in kidney. This result showed that the cadmium residual level was majorly due to recent exposure, revealed by its highest level in blood and lowest in kidney. This is consonance with the study of García-Fernández *et. al.* (1996), who suggested that the kidney is the main storage organ in animals subjected to chronic low-level cadmium exposure, while it is in contrast with the work of Okoye *et.al.*(2010), who reported the highest cadmium residue in kidney of goats.

The chromium residual limit in goats is shown in table 5. Chromium was not detected in all the muscle samples; liver had higher level (0.62mg/kg) than in kidney (0.01mg/kg). The level in blood was the highest (2.37mg/kg) indicating recent exposure to chromium. The level of chromium residues were in agreement with Bala *et. al.* (2012) who stated that the chromium level in kidney and liver within the permissible limit.

Lead residues in goat tissues were presented in table 6. Mean residual level was higher in liver (0.005mg/kg) when compared to that of kidney and muscle with both having 0.001mg/kg. This finding is in line with the works of Koréneková *et. al*. 2002, Miranda *et. al* (2005) who reported that liver accumulate lead more than any other tissues. Blood had higher level (0.007mg/kg) and it follows the same trend with regards to chromium and cadmium.

Table 7 showed comparison of the research findings with international standard. Cadmium mean residual level in blood, muscle, kidney were found to be well above the permissible limit, while chromium mean residual level was only found to be higher only in blood. Lead mean residual were generally within the permissible limits.

Conclusion

It could be conccluded from this researh work that goats slaughtered in Central abattoir Akinyele, Ibadan had cadmium, chromium and lead residues in varying levels. Blood had the highest values revealing recent exposure to these heavy metals which could be from air, water, handling and any other processing methods, while liver was found to have higher levels than in kidney, which may be due to its role in detoxification of hazardous compounds. Cadmium was a major environmental and health challenge, which was present above the permissible limits, while lead and chromium residues were generally below the permissible limits except chromium in blood.

Recommendation

It is therefore, recommended from this work, that goats to be slaughtered for consumption be put in a lairage where recent exposure will be reduced and screening before slaughter for heavy metals residue should be done. Also, cadmium release into the environment should be discouraged through proper advocacy program.

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

Mean	28.8
Median	27.0
Mode	24.0
Standard deviation	8.7
Minimum	18
Maximum	48

Table 2: Sex of the goats

Sex of animal	Frequency	Percentage (%)
Male	12	60.0
Female	8	40.0
Total	20	100.0

Table 3- Percentage of the samples with heavy metals

Animals	Cadmium	chromium	Lead
Goats	52	8	8
Percentage (%)	65.0	10.0	10.0
Total sample	80	80	80

Table 4: Cadmium in the Goats

Tissue type	Number detected	Mean	Standard deviation	Minimum	Maximum
Blood	13	6.75	3.03	3.33	14.44
Muscle	12	5.43	1.94	3.33	8.89
Kidney	13	4.77	1.93	3.25	8.89
Liver	14	5.51	2.92	0.61	11.67

Table 5: Chromium in the Goats

Tissue type	Number detected	Mean	Standard deviation	Minimum	Maximum
Blood	5	2.37	2.55	0.62	6.79
Muscle	-	-	-	-	-
Kidney	1	0.01	-	0.01	0.01
Liver	2	0.62	0.00	0.62	0.62

Table 6: Lead in the Goats

Tissue type	Number detected	Mean	Standard deviation	Minimum	Maximum	Median
Blood	3	0.007	0.005	0.001	0.010	0.010
Muscle	1	0.001	-	0.001	0.001	0.001
Kidney	1	0.001	-	0.001	0.001	0.001
Liver	3	0.005	0.006	0.001	0.011	0.002

Table 7: Levels of Heavy Metals against International Standard

Tissue type	Heavy metals in goats (mg/kg)					
	Cadmium	FAO/WHO	**Chromium**	FAO/WHO	**Lead**	FAO/WHO
Blood	6.75±3.03	0.50	2.37±2.55	1.00	0.007±0.005	0.50
Muscle	5.43±1.94	0.05	Nil	1.00	0.001	0.10
Kidney	4.77±1.93	1.00	0.01	1.00	0.001	0.50
Liver	5.51±2.92	0.50	0.62±0.00	1.00	0.005±0.006	0.50

N/B - value in blood samples presented in µg/ml and in others organs as mg/kg

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