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Full Length Research Paper

Distribution of Lead, Cadmium, Nickel and Chromium in Organs and Muscle of Goats from some major Slaughter-houses in Ibadan, Nigeria.

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Abstract
The study was aimed at evaluating the distribution of lead, cadmium, nickel and chromium ions in the muscle, kidney, heart and liver of goats slaughtered in four major slaughter-houses in Ibadan, south-west, Nigeria using Perkin-Elmer Analyst 200 Flame Atomic Absorption Spectrophotometer (FAAS). The metal content in these organs were determined after acid digestion using HNO_3. The overall mean and standard deviation (fresh weight concentration) of these metal in the liver, kidney, muscle and heart of goat was 2.58±0.82, 2.56±1.08, 2.39±0.14 and 2.38±0.34 mg/kg for Pb; 1.25±0.13, 1.30±0.20, 1.21±0.23 and 1.34±0.10 mg/kg for Ni; 0.42±0.49, 0.31±0.36, 0.11±0.22 and 0.03±0.07 mg/kg for Cr, and 4.38±0.37, 4.11±0.98, 3.38±0.64 and 3.84±0.53 mg/kg for Cd. There was a significant difference (p=0.05) in the concentration of the metals in each organ analysed. Liver was observed to accumulate more of the heavy metals, followed by the kidney, heart and the muscle. However, the concentration of lead, cadmium, nickel and chromium, exceeded the statutory safe limits.

***Keywords**: Heavy metals, Ibadan, Slaughter-house, goat organ, pollutants.*

Introduction

Metals which are neither essential nor has beneficial effect, but displays severe toxicological symptoms at low levels has been termed toxic metal. The occurrence of these metals in air, soil and water is a threat to humanity. These heavy metals enter into the food chain and from there; they ultimately make their passage into the tissue (Baykov *et al.,* 1996). Lead, cadmium, chromium, mercury and nickel are among the main toxic metals which accumulate in food chains and have a cumulative effect (Cunningham *et al.,* 1997).

Those metals that are equivocally essential, owe their essentiality to being constituent of enzymes and other important proteins involved in key metabolic pathways (Iwegbue, 2008). However, a deficiency in these micro nutrients will result in reduction of enzyme activity which leads to metabolic dysfunction, whereas; so-called toxic metals cause toxicity when they exceed the tolerance limit of the organism (Alloway, 1994). For example, lead, can adversely affect many organs, system, and numerous condition such as high blood pressure, anemia, kidney damage and learning disability in children (Wagner, 1995). Acute toxicity symptoms of some of these toxic heavy metals like cadmium, lead, nickel and chromium includes abdominal and muscular cramps, headache, enervation, shock, untimely death, depression, diarrhea, paralysis, nose tumor, renal failure, vomiting, neurological effect, gastrointestinal distress, lung cancer and acute renal tubular necrosis (Saryan and Reedy, 1998). Overwhelmingly, concentration of heavy metals presents in food items vary widely depending on the place of their production (Bokori *et al.,* 1996). The risk associated with exposure to heavy metals present in food products has aroused widespread concern in human health. Improvement in food production and processing technology has increased the chance of contamination of meat with various environmental pollutants, especially heavy metals. Due to grazing and feeding of goat and cattle on contaminated soil, higher levels of metals have been found in beef and mutton (Sabir *et al.,* 2003).

Chemical composition of meat depends on both the kind and degree of the feeding of the animal. The need for mineral compounds depends on the age, physiological state and feeding intake as well as on living conditions (Baykov *et al.,* 1996). Contamination with heavy metals is a serious threat because they are toxic and bio accumulate in the food chain (Demirezen and Uruc, 2006). Given the prevalence of these pollutants in the environment, contamination of animal feed by toxic metals cannot be entirely avoided. There is a clear need for such contamination to be minimized (SCAN, 2003). The risk of heavy metal contamination in meat is of great concern for both food safety and human health because of the toxic nature of these metals at relatively minute concentration (Santhi *et al.,* 2008). In some cases, contaminated forage and rearing of livestock in proximity to polluted environment were reported as been responsible for heavy metal contamination in meat (Santhi *et al.,* 2008, Miranda *et al.,* 2005 and Korenekova *et al.,* 2002).

In Ibadan, organs from goat; (liver, kidney and heart) and muscle are consumed as major source of protein by the populace. The main source of metals in goats arises from contaminated forage, water, vehicular emission and indiscriminate discharge of industrial and domestic effluent through drainage channel. However, there is dearth of information on the levels of metals in muscle and organs of goats slaughtered in Ibadan. The objective of this study is to determine the concentration of lead, nickel, cadmium and chromium in liver, kidney, muscle and heart of goat slaughtered in some major slaughter-houses in Ibadan, south-west, Nigeria.

Materials and Methods

A total of 16 samples (liver, kidney, muscle and heart) from goats were randomly collected from four major slaughter-houses in Ibadan. The animals were not selected according to sex or age but on the assumption that they were 2 to 5 years old. The parts that reach the final consumer were taken. The four major slaughter houses include Bodija market slaughter house (longitude E 3º 54.8945 and latitude N7º 26.0376); Ojoo market slaughter house (longitude E 3º 54.7628 and latitude N7º 28.0512); Moniya market slaughter house (longitude E3º 54.4902 and latitude N7º 32.0101) and Onibu-ore slaughter house (longitude E 3º 57.9147 and latitude N7º 25.0617). The map of the study area is shown in Fig. 1.

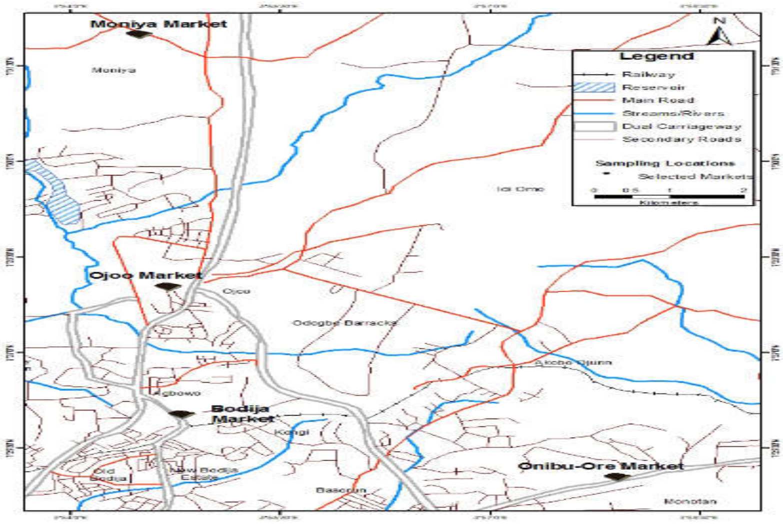

Fig. 1: Map of the study area.

The samples were collected between February and March, 2013. The samples were collected in polyethylene bags separately and were well labeled for easy identification and thereafter, put inside ice-chest and transported to the laboratory for analysis.

Standard solutions: Stock solutions of lead, cadmium, nickel and chromium were prepared from appropriate dilution of spectroscopic grade (1000ppm; CPI international, USA) for instrument calibration.

Method

For metal determination, the samples were allowed to thaw and gross fat was then removed. 2.0 g of the sample was then weighed and digested with concentrated nitric acid (J.T Baker, New Jersey-U.S.A) on a hot-plate. The acid was added at interval until 20 mL was utilized. The digestion was judged completed when a colorless digest was obtained. The digest was allowed to cool and immediately filtered using Whatman No. 1 filter paper. The filtrate was then diluted to 25 mL with 1.0 M nitric acid in a standard flask.

The metal concentration in the sample was analyzed by flame atomic absorption spectrophotometer (Perkin-Elmer AA 200 model) at conditions recommended by the manufacturer using air/acetylene flame. The metals were determined at the most sensitive spectral lines of the metals. The instrumental response for the calibration working standard was used to plot the calibration curves for the metals, automatically by the instrument, and the concentration was extrapolated from the calibration graph.

Recovery study: This was carried out for the heavy metals content in the liver sampled from zone A (Bodija market) and the result is presented in Table 1. The sample was spiked with appropriate standard solution of each metal (Pb, Cd, Ni and Cr) in such a way as to double the initial concentration of these metals. The sample was then carried through the entire analytical process again.

The % recovery was calculated using the relationship below:

$$\%\ Recovery = \frac{(A-B)}{C} \times \frac{100}{1}$$

Where A is the actual concentration metal ion (mg/L), B is the initial concentration metal ion (mg/L) and C is the concentration of spiked metal ion (mg/L).

Statistical analysis: This was done using the Microsoft excel analysis Toolpack, 2007. The actual concentrations of the metal ions in the samples were subjected to descriptive statistical test and the mean, standard deviation and range were reported.

Table 1: Result for the recovery study

Metal	Original concentration (mg/L)	Amount of standard added (mg/L)	Concentration of spiked (mg/L)	Recovery (%)
Pb	0.280	0.200	0.470	95
Cd	0.320	0.200	0.500	90
Ni	0.090	0.200	0.250	80
Cr	0.070	0.200	0.240	85

Results and discussion

The mean, standard deviation and the range of lead, nickel, chromium and cadmium in mg/kg in the kidney, liver, heart and muscle of goat is given in Tables 2, 3, 4 and 5 for each of the metals from the various markets. Table 6 shows the overall concentration of the various metals in each of the organs. Student t-test (p=0.05) shows little variation in the concentrations of the various metals within the markets. This variation is due to the unhygienic nature of each of the slaughter houses.

Table 2 shows the concentration in mg/kg of lead (Pb) in all the organs across the various markets from which samples were collected. The overall range and concentration of lead was 1.63-4.13 (2.48±0.63 mg/kg). This was higher than the maximum tolerable limit (MTL) of 0.5 mg/kg set by FAO [Nauen, 1983]. Higher concentrations of lead were recorded for the various organs of the animal. Lead concentration in the liver, kidney, heart and muscle were 2.58±0.82, 2.56±1.08 2.38±0.34 and 2.39±0.14 mg/kg respectively. The result obtained from this study for the concentration of lead in the liver is higher than 1.34±0.23 µg/g reported by [Akan et al., 2010] for the liver of caprine, which also exceeded the FAO permissible limit of 0.5 mg/kg (Nauen, 1983). Donia (2008), reported lead level in the kidney, liver, heart and muscle in different animals in Cairo as 0.386-0.490, 0.274-0.364, 0.034-0.125 and 0.052-0.104 mg/kg respectively. The high concentration of lead from this present study is due to vehicular emission and from accumulated lead particles from the exhaust of the vehicles which probably used leaded gasoline. The second source is believed to be re-suspension of street dust (lead-bearing dust) by the wind and anthropogenic activities. It could also be from burning of waste, sieging and feeding of these goats with contaminated forages and water from urban run-off. Overall, the concentration of lead in these samples were high compared to the results obtained by Korenkova *et. al.,* (2002) for the liver and muscle of cattle as 1.072 and 0.671 mg/kg respectively. Lazarus *et. al.,* (2005) observed a high concentration of lead in the kidney of red-deer in the eastern Croatia as 2.28 mg/kg. The high result recorded in this study can also be attributed to long range aerial transport and deposition on the surface of leaves on which the animals feed on

Table 2: Concentration (mg/kg) of lead in the liver, kidney, muscle and heart of goat slaughtered in some major slaughter-houses in Ibadan, south-west, Nigeria.

Sample	Bodija market		Ojoo market		Moniya market		Onibu-ore market	
	Range	Mean±SD	Range	Mean±SD	Range	Mean±SD	Range	Mean±SD
Liver	3.38-3.63	3.50±0.18	1.38-1.88	1.63±0.35	2.00-2.50	2.25±0.35	2.75-3.13	2.94±0.27
Kidney	3.88-4.38	4.13±0.35	1.63-1.75	1.69±0.09	2.00-2.50	2.25±0.35	2.00-2.38	2.19±0.27
Heart	2.13-2.25	2.19±0.09	2.13-2.38	2.23±0.15	2.75-3.00	2.88±0.18	2.13-2.25	2.19±0.09
Muscle	2.13-3.10	2.56±0.62	1.88-2.75	2.31±0.62	2.38-2.50	2.44±0.09	2.03-2.27	2.25±0.18

Overall concentration in mg/kg =2.48±0.63 of Pb in all the sampled parts. SD= Standard deviation.

(Falandysz, 1994). Iwegbue (2008), reported lower concentration of lead in the liver and kidney of cattle from southern Nigeria as 1.23 mg/kg and 0.95 mg/kg respectively. Mariam *et al.,* (Mariam *et al.,* 2004) recorded lead concentration of 2.18±0.38ppm and 2.02±0.44ppm for liver and kidney respectively for beef. Within the various zones, concentration of lead is high in samples from Bodija market followed by samples from Moniya market while Ojoo and Onibu-ore markets recorded low lead concentration. Continuous eating of these organs in this nature may be dangerous to human because of bio-accumulative tendency of lead in the body.

Table 3 shows overall concentration of nickel which was recorded as 1.25±0.18 mg/kg across the samples. Nickel concentration was high in the heart (1.34±0.10 mg/kg) and kidney (1.30±0.13 mg/kg) respectively. The liver and muscle shows lower nickel concentration of 1.25±0.13 mg/kg and 1.21±0.23 mg/kg respectively. The high nickel concentration in the heart is believed to be due to the involvement of the heart in blood circulation (Iwegbue, 2008). However, result obtained is high compared to the 0.1 mg/kg set by Commission of the European Communities (Anonymous, 2002). The present result is also high compared to the result reported by Iwegbue (0.12 mg/kg in the liver and 0.20 mg/kg in the kidney) (Iwegbue, 2008) and Akan *et al.,* (2010) who obtained (0.19±0.02 and 1.09±0.26 µg/g) in the liver while the kidney concentration was (0.04±0.01 to 0.24±0.01 µg/g) of caprine, beef and chicken. High nickel concentration which was above the permissible limit was also reported by Iwegbue *et. al.,* (2008), for chicken, gizzard and turkey meat respectively as 0.01-1.37 mg/kg. The major source of contamination was found to be from water sources, the environment and forages. Overall, the result from this present study was below the permissible limit of 50 mg/kg set by Codex Alimentarius (Anonymous, 2001). Within the slaughter-houses; the concentration of nickel was high in samples from Moniya market, followed by samples from Ojoo market. While concentration was obtained for samples from Bodija and Onibu-ore markets compared to the other markets. The observed trend for the concentration in the samples analysed was kidney > liver > heart > muscle. This shows that the kidney accumulates more of nickel.

Table 3: Concentration (mg/kg) of nickel in the liver, kidney, muscle and heart of goat slaughtered in some major slaughter -houses in Ibadan, south-west, Nigeria.

Sample	Bodija market		Ojoo market		Moniya market		Onibu-ore market	
	Range	Mean±SD	Range	Mean±SD	Range	Mean±SD	Range	Mean±SD
Liver	1.01-1.13	1.07±0.08	1.24-1.31	1.28±0.05	1.31-1.48	1.39±0.11	1.16-1.33	1.24±0.11
Kidney	1.14-1.16	1.15±0.02	1.01-1.19	1.10 ±0.12	1.50-1.54	1.52±0.03	1.40-1.44	1.42±0.03
Heart	1.16-1.29	1.23±0.09	1.35-1.38	1.36±0.02	1.45-1.49	1.47±0.03	0.85-1.03	0.94±0.12
Muscle	0.96-0.99	0.98±0.02	1.48-1.50	1.49±0.02	1.04-1.10	1.07±0.04	1.25-1.38	1.31±0.09

Overall concentration in mg/kg =1.25±0.18 of Ni in all the sampled parts. SD=Standard deviation.

Table 4 shows the concentration of chromium in the liver, kidney, muscle and heart of goat obtained from some major markets, while Table 6 shows the overall concentration of chromium in all the samples analyzed. The observed concentrations (mg/kg) in liver, kidney, muscle and heart were 0.42±0.49, 0.31±0.36, 0.11±0.22 and 0.03±0.02 respectively. The concentration of chromium obtained from this study is above the World Health Organization (WHO), maximum limit of 0.05mg/L of Cr (VI) in drinking water, 0.10 mg/kg in other edible offal (WHO, 2003). In some parts of Ibadan, goats are fed with fodder from different sources, sometimes made to drink water from polluted water bodies (like ditches and streams) and other possible contaminated water sources thereby exposing them to contamination by toxic substances.

The concentration of chromium obtained in this study was lower than the values reported by Akan *et al.,* (2010) for the liver of caprine as 1.22±0.21 µg/g, but higher than the WHO permissible limit of 0.10 µg/g, for the liver, kidney and muscle analyzed in this study. However, the concentration of chromium for the heart was below the permissible limit of 0.10 µg/g; for edible offals (WHO, 2003). Chromium was not detected in most of the samples obtained from Ojoo, Moniya and Onibu-ore markets.

Table 4: Concentration (mg/kg) of chromium in the liver, kidney, muscle and heart of goat slaughtered in some major slaughter-houses in Ibadan, south-west, Nigeria.

Sample	Bodija market		Ojoo market		Moniya market		Onibu-ore market	
	Range	Mean±SD	Range	Mean±SD	Range	Mean±SD	Range	Mean±SD
Liver	0.75-1.00	0.88±0.18	0.63-1.00	0.81±0.27	ND	ND	ND	ND
Kidney	0.25-0.88	0.56±0.44	ND	ND	0.63-0.74	0.68±0.08	ND	ND
Heart	ND-0.25	0.13±0.18	ND	ND	ND	ND	ND	ND
Muscle	0.38-0.50	0.44±0.09	ND	ND	ND	ND	ND	ND

Overall concentration in mg/kg =0.22±0.33 of Cr in all the sampled parts
SD=Standard deviation.
ND=below detection limit

The cadmium concentration decreased in the order liver > kidney > heart > muscle with the following values 4.38±0.37, 4.11±0.98, 3.84±0.53 and 3.38±0.64 mg/kg respectively as shown in Table 6. The overall mean cadmium concentration for all the samples was 3.87±0.81 mg/kg (Table 5) which is higher than the permissible limit of 0.5 mg/kg. Falandyz *et al*., (2003) reported that the cadmium permissible limit in the muscle has been set to be 0.1 mg/kg and 0.5 mg/kg by codex of Slovak republic no 98/1996. These authors reported the concentration of cadmium in the kidney, liver and muscle of red deer as 2.2, 0.10 and 0.26 mg/kg wet weight, respectively. The recorded values for cadmium concentration in this present study were higher than values reported by Falandyz et al., (2003). The cadmium concentration in the liver, kidney heart and muscle in this study exceeded the levels reported by Akan *et al.,* (2010), Okoye and Ugwu (2010), and Falandysz (1994). Dip *et al.,* (2001) however reported cadmium concentration of 17.36±5.22 mg/kg in the kidney of red foxes from adjacent urban, sub-urban and rural areas of Switzerland which is higher than values obtained in this study. Samples from Ojoo and Moniya markets had higher concentration of cadmium than samples from Bodija and Onibu-ore markets.

Table 5: Concentration (mg/kg) of cadmium in the liver, kidney, muscle and heart of goat slaughtered in some major slaughter house in Ibadan, south-west, Nigeria.

Sample	Bodija market		Ojoo market		Moniya market		Onibu-ore market	
	Range	mean±SD	Range	mean±SD	Range	mean±SD	Range	mean±SD
Liver	3.38-4.63	4.00±0.88	4.50-4.25	4.88±0.53	3.88-4.75	4.31±0.62	4.00-4.63	4.31±0.44
Kidney	4.88-5.75	5.31±0.62	3.13-3.38	3.25±0.18	4.25-4.75	4.50±0.35	3.13-3.63	3.38±0.35
Heart	4.38-4.63	4.50±0.18	3.50-4.25	3.88±0.53	3.63-4.25	3.94±0.44	2.00-2.38	2.19-0.27
Muscle	4.13-4.50	4.31±0.27	3.00-3.38	3.19±0.27	2.75-3.00	2.88±0.18	3.00-3.25	3.13-0.18

Overall concentration in mg/kg =3.87±0.81 of Cd in all the sampled parts. SD=Standard deviation

Table 6: Concentration (mg/kg) of lead (Pb), nickel (Ni), chromium (Cr) and cadmium (Cd) in liver, kidney, heart and muscle of goat slaughtered in Ibadan, south-west, Nigeria.

Samples		Elements			
		Pb	**Ni**	**Cr**	**Cd**
Liver	**(mean±SD)**	2.58±0.82	1.25±0.13	0.42±0.49	4.38±0.37
	Range	1.63-3.50	1.07-1.39	ND-0.88	4.00-4.88
Kidney	**(mean±SD)**	2.56±1.08	1.30±0.20	0.31±0.36	4.11±0.98
	Range	1.68-4.13	1.10-1.52	ND-0.68	3.25-5.31
Heart	**(mean±SD)**	2.38±0.34	1.34±0.10	0.03±0.07	3.84±0.53
	Range	2.19-2.88	1.23-1.47	ND-0.13	3.13-4.40
Muscle	**(mean±SD)**	2.39±0.14	1.21±0.23	0.11±0.22	3.38±0.64
	range	2.25-2.56	0.98-1.49	nd-0.44	2.88-4.31

Conclusion

It can be concluded that the levels of the various metals in liver, kidney, heart and muscle were high and above the statutory safe limit. Also, many of the concentration of the toxic metals obtained in this study were higher than those earlier reported. Liver was observed to accumulate more of the heavy metals, followed by the kidney, heart and the muscle. The concentration of lead, cadmium, nickel and chromium, exceeded the statutory safe limits. Therefore, these samples can be considered unsafe for human consumption.

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