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https://dx.doi.org/10.4314/nvj.v40i4.1 **ORIGINAL ARTICLE**

Determination of Heavy Metals in Selected Tissues of Cattle Slaughtered across Nasarawa State, Nigeria

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SUMMARY

This study was conducted to determine the concentrations of some toxic heavy metals in cattle slaughtered from the three agricultural zones of Nasarawa State, Nigeria. Selected tissues of muscle, intestine, skin, kidney and liver were analyzed for the presence of Cadmium (Cd), Chromium (Cr), Lead (Pb), Copper (Cu) and Nickel (Ni) using Atomic Absorption Spectrophotometer (AAS). Thirty cattle were used for sampling. Five samples of the tissues were collected from each of the cattle, making a total of one hundred and fifty samples. Values obtained were compared with that of FAO/WHO guidelines. Statistical analysis was done using descriptive statistics, t-test and ANOVA. The mean concentrations (mg/kg) of Ni, Cd, Pb and Cu in all the sampled tissues were generally low and below the codex standards. Cr was detected above permissible limit with mean concentrations (mg/kg) of 1.19±5.94, 1.07±4.42, 3.01±6.65, 1.18±5.56 and 1.35±6.94 in intestine, kidney, liver, muscle and skin respectively. There was a significant ($P < 0.05$) difference in the level of Ni and Cd across two agricultural zones. Government and private sectors should establish cattle ranch and colonies across Nigeria so as to reduce pasture contamination. Public enlightenment on the grazing of cattle in heavy metals prone areas such as automobile workshops, construction sites and paint factory premises should be advocated. Measures should be put in place for continuous monitoring of heavy metals in Nasarawa state in order to curtail their potential negative effect in human and animal tissues.
Key words: cattle, heavy metals, AAS, Nasarawa state.

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INTRODUCTION

A toxic heavy metal is any relatively dense metal or metalloid that is noted for its potential toxicity (Bánfalvi, 2011). The term has particular application to cadmium, mercury, lead and arsenic, all of which appeared in the World Health Organization's list of 10 chemicals of major public health concern. Some heavy metals are otherwise regarded as essential elements, they are needed by the body in trace amount and they accomplish important role in biological systems, however these essential metals can also produce toxic effects at high concentrations. They include metals such as iron, copper, zinc and manganese. Toxic heavy metals on the other hand are hazardous in nature even in trace amount; they are completely excluded in food for human consumption. Thus, they have been included in the regulations of the European Union for hazardous metals (EC, 2001). These elements have caused the most concern in terms of adverse effects on human health. This is because they are readily transferred through food chains and are not known to serve any essential biological function. Cattle meat is an important component of human food and has the potential to accumulate toxic minerals and signifies one of the sources of heavy metals for humans (FAO, 2011). Beef represents the main source of protein in the diet of Nigerians with an average consumption rate at 7g/day/person (FMARD, 2011).

In Nigeria, cattle are free grazing and drink water from trenches, water courses, streams and other potential polluted water bases. They graze along runways and other sites that might have been contaminated with toxic substances, hence the risk of exposure to high levels of contaminants. The World Health Organization (WHO) estimates that about a quarter of the diseases facing mankind today occur due to prolonged exposure to environmental pollution (USEP, 2014).

A number of serious health problems can develop as a result of excessive uptake of dietary heavy metals. Lead can adversely affect many organs and cause numerous disease conditions, such as high blood pressure, anaemia, kidney damage and mental retardation. Young children are considered at great risk because of their ability to effectively absorb lead and thereby suffer mental and physical developmental retardation (Kocak *et. al*., 2005). Cadmium affects many target tissues such as appetite and pain centers (in the brain). Furthermore, the consumption of heavy metal-contaminated meat can seriously deplete some essential nutrients in the body causing a decrease in immunological defenses, intra-uterine growth retardation, impaired psycho-social behaviours, disabilities associated with malnutrition and a high prevalence of upper gastrointestinal cancer (Arora *et. al*. 2008). Toxic heavy metals can bind to vital cellular components, such as structural proteins, enzymes and nucleic acids, and interfere with their functioning (Emsley 2011). Long-term exposure to toxic heavy metals can have carcinogenic, central and peripheral nervous system and circulatory disorders. 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.

MATERIALS AND METHODS

Study Location

Nasarawa State falls within the Guinea Savannah Agro-Ecological Zone and is found between latitudes 70°52′N and 80° 56′N and longitudes 70° 25′E and 90° 37′E respectively. Annual rainfall figures range from 1100 to 2000 mm. The mean monthly temperatures in the state ranges between 20°C and 34°C (Lyam, 2000). The state is bounded on the north by Kaduna state, on the east by Plateau state, on the south by Benue state and on the west by Kogi state and the Federal Capital Territory, Abuja. The vegetation type is of Guinea Savannah which is conducive for farming and rearing of livestock. Nasarawa state plays an important role in food animal production with several cattle markets distributed across the state. The state consists of three agricultural zones (Southern, Northern and Western zones) with 13 local government areas.

Study Design

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

Sample Collection

A total of thirty (30) cattle comprising eight bulls and twenty two cows were randomly selected over a period of 4 months (March-June 2018). About 50 g each of muscle, liver, intestine, skin and kidneys were collected from the randomly selected slaughter houses from the three agricultural zones. The samples were permanently labeled into polyethylene bags and transported in an ice box containing ice pack to Animal Science Laboratory, Nasarawa State University, Shabu-Lafia campus where it was frozen and preserved before being transported in an ice pack to the laboratory for elemental analyses. The characteristics of the sampled cattle were presented in Table I.

Sample Processing and Analyses

The samples of intestine, muscle, liver, skin and kidney from the cattle were weighed and decomposed by wet-acid digestion method for determination of lead, chromium, nickel, copper and cadmium residues as described by Miranda *et al*. (2005). 1.0 g of each raw sample was weighed and introduced into the digestion beaker. 10-15 ml of Nitric acid was put in beaker containing samples. Hydrochloric and per chloric acids were added to the mixture. The digestion beaker was heated on a hot plate at 100^oC for 50 min to 1 hour until a semi-dry mixture was formed. The beaker was then taken out of the hot plate to settle for about 15 min. at room temperature. Deionized water was added to the digester and stirred using glass rod. The digested sample was then filtered into a 100 ml volumetric tube and filled up with deionized water to 60 ml and stored at 4^0C before determination using Atomic Absorption Spectrophotometer (Manufactured by Shimadzu, Model AA 6800, Japan) in the laboratory of the National Research Institute for Chemical Technology, Zaria, Nigeria.

The absorbance of each sample were measured at a lamp current of 20-25 mA of lamp and the peak height of the wave lengths used were 232.0nm, 324.8nm, 228.8nm, 283.3nm and 357.9nm for nickel (Ni), copper (Cu), cadmium (Cd), lead (Pb) and chromium (Cr), respectively.

Statistical Analysis

Data collected were presented as mean ± standard deviation and subjected to one way analysis of variance (ANOVA) to assess the levels of significant between the three agricultural zones. Values of $P < 0.05$ were considered significant.

RESULTS

Table I shows the characteristics of the sampled cattle. The males were 8 (26.7%), 22 (73.3%) were females. Also, 23 (76.7%) cattle were in the age range of 3-5 years while 7 (23.3%) falls within the age range of 6-8 years. The maximum age of all the sampled cattle was 8 years while the minimum age was 3 years.

Table II represents the overall concentrations in mg/kg of Ni, Cu, Cr, Pb and Cd from all the tissues sampled across Nasarawa state. The detection limits for all metals was below 0 mg/kg. Chromium had the maximum value of 13.92 mg/kg and was the other metals. Cadmium had the least the concentration from all the sampled tissues. the most detected metal when compared to The mean concentrations (mg/kg) of Ni, Cu, Cr, Pb and Cd from 150 tissues sampled across Nasarawa state were presented in Table III. With the exception of Cr, all the metals detected from the sampled organs were within the statutory recommended limit. Cr was found to be higher in intestine, kidney, liver and skin, compared to the muscle

TABLE I: Characteristics of cattle sampled in Nasarawa State

Categorical variable	Frequency (%)
Gender	
Male	8 (26.7)
Female	22 (73.3)
Age	
3-5 years	23 (76.7)
6-8 years	7 (23.3)

TABLE II: Concentrations of heavy metals from tissues of slaughtered cattle in Nasarawa State

Heavy Metal	Concentration (mg/kg)		
	Minimum	Maximum	Mean ±SD
Ni	-0.50	1.19	0.17±0.34
Cu	-0.02	0.03	0.003±0.01
Cr	-13.19	13.92	1.49±5.93
Pb	-0.93	0.21	0.03±0.11
Cd	-0.01	0.01	0.002±0.003

DISCUSSION

Heavy metals were analyzed from meat samples across Nasarawa state. AAS was used for the analysis and the raw data were subjected to statistical interpretations. Heavy metals discovered in organs (muscle, kidney, Hide, intestine and liver) of cattle sampled in Nasarawa state are Ni, Cu, Cr, Pb and Cd. The characteristics of the sampled cattle include Sex and age. 76.7% of the sampled cattle were in the age range

TABLE III: Mean concentrations (mg/kg) of metals in tissues of cattle

Heavy metal	Tissue/Organ				
	Intestine	**Kidney**	**Liver**	**Muscle**	**Skin**
Ni	0.26±0.37	0.21±0.36	0.15±0.31	0.19±0.37	0.05±0.25
Cu	0.003±0.01	0.003±0.01	0.002±0.01	0.003±0.01	0.003±0.01
Cr	1.19±5.94	1.07±4.42	3.01±6.65	1.18±5.56	1.35±6.94
Pb	0.04±0.06	0.03±0.07	0.06±0.07	-0.004±0.19	0.05±0.07
Cd	0.002±0.003	0.002±0.002	0.002±0.003	0.002±0.003	0.001±0.004

of 3-5 years while 23.3% falls within the age range of 6-8 years. The maximum age of all the sampled cattle was 8 years while the minimum age was 3 years. The males were 8 (26.7%), 22 (73.3%) were females. This shows that the cattle slaughtered in Nasarawa state were mostly female (reproductively inactive), with the males usually reserved for breeding and festivals.

The mean concentration of Ni obtained from the different tissues shows the intestines have the highest mean concentration while the least concentration was detected in the skin. This value was lower than the statutory permissible level of 0.5 mg/kg for fresh meat (FAO, 2011). This finding contradicts the study conducted by Bala *et. al*. (2014), who reported high concentrations (mg/kg) of Ni in kidney and liver (0.77 mg/kg and 0.94 mg/kg, respectively) above the recommended intake level. The concentrations of Ni in the kidney samples were higher than that of the liver. This is in agreement with the findings of Iwegbue (2008) who reported higher nickel concentrations in the kidneys (0.16 mg/kg) than that of the liver (0.10mg/kg) from southern Nigeria. Similar findings of higher Ni concentration in kidneys than liver were reported by Flanjank and Lee (1979). The current study shows that the intestine, kidneys, muscle and skin have nearly equal mean Cu concentrations of 0.003 mg/kg with the liver having the least mean concentration of 0.002 mg/kg. This is in contrast to the findings of Oymak *et. al.* (2017) who showed that Cu bio-accumulates primarily in the liver, compared to other tissues. All the concentrations observed were far below the FAO acceptable limits of 20 mg/kg. The Cu concentrations obtained from this study were lower than those recorded by Abou-Arab (2002), where he obtained a value that ranged between 2.20 mg/kg (2.20 µg/g) in fresh meat and even far lower than the average values detected by Oymak *et. al.* (2017) in muscle (3.85 mg/kg), liver (280.86 mg/kg) and kidneys (15.82 mg/kg). Although, Cu is essential for good health, very high intake can cause health problems such as liver and kidney damage.

The mean concentration of Cr across the state shows that liver had the highest mean concentration, with the kidneys having the least mean concentration. These values exceed the WHO/FAO maximum permissible limit of 1 mg/kg. The skin, intestines and muscle had nearly equal concentrations. The total concentration of Cr residues detected in all the tissue samples was generally high. Fathy *et. al.* (2011) detected lower residual levels of Cr in muscle, liver and kidneys. The findings of the current study are higher than the results obtained by Okareh and Oladipo (2015) conducted in southern Nigeria, who obtained a mean concentration of 2.33±2.99 mg/kg in the kidneys. Also, lower Cr concentration was detected in muscle than obtained from this study. The high level of Cr detected in the present study is similar to the result obtained by Zahurul *et. al.* (2001) where they detected high levels of Cr in fresh cattle organs above the maximum permissible limit. Cr is usually incorporated in stainless steel, anti-corrosive agent in pipes, tanks and in wood treated chemicals as shown by Helena (2012). This indicates that the high levels of Cr detected across the state may be as a result of anthropogenic activities due to extensive usage of chromium-bond utensils. Additionally, Cr is the most environmentally stable metals when compared to Ni, Cd, Cu and Pb and exist in several oxidation states as shown by Zayed *et. al*. (2003). This could also explain why Cr was found in higher concentrations than the rest of the metals.

The highest Pb concentration (0.06±0.07 mg/kg) was observed in the liver, with muscle having the least mean concentration. This is in agreement with the study conducted by Miranda *et. al.* (2005) and Koréneková *et. al.* (2002), who showed that the liver accumulates Pb more than other tissues in the body. However, the findings of the current study is below the Codex standards for Pb in meat (0.1 mg/kg) and 0.5 mg/kg for edible offals of cattle. This is in contrast with the findings of Okoye and Ugwu (2010) conducted in Enugu, Nigeria where a high concentration of Pb was reported in the liver (127.90 mg-1) and intestines (108.02 mg-1) of cattle above the maximum permissible limit. The low values of Pb detected in Nasarawa state may be a reflection of very low industrialization activities in the state. The mean Pb values in muscle obtained in this study was insignificant and lower than the mean values in ruminant muscles detected in some countries of the world including Slovenia (Doganoc and Gacnick, 1995), Poland (Falandysz, 1994) and Finland (Tahvonen and Kumpulainen, 1994). Monitoring the concentration of Pb in different meat parts and organs is important for human health. Lead has been shown to increases blood pressure and cardiovascular diseases in adults (Badis *et. al.* 2014). The levels of Pb observed from this study shows that human populace in Nasarawa state may not be exposed to substantial health risks associated with the consumption of cattle meat. This result is similar to the findings of Ihedioha and Okoye (2013) who conducted a study on lead and cadmium in meat and internal organs of cattle in Enugu state, Nigeria.

From the results of this study, the mean concentrations of Cd in all the samples studied across the state were found to be low and within the permissible limit of 0.5-1.0 mg/kg. The low levels observed in the kidneys contradicts with studies which have shown that Cd bio- accumulates in the kidneys more than other organs of the body (Doganoc and Gacnick, 1995). Milam *et. al.* (2015) recorded a higher mean concentration of Cd in the kidney of cows and bulls as 0.04 ± 0.01mg/kg and 0.40 ± 0.38 mg/kg respectively in Yola central abattoir Adamawa state. Zmudzki and Szkoda (1995) from Poland reported 0.14 mg/kg and 0.58 mg/kg respectively as Cd levels in the liver and kidneys of young cattle which is higher than values detected from the present study. Similarly, Falandysz (1994) reported in northern Poland Cd concentrations of 0.45 mg/kg and 0.10 mg/kg in kidneys and liver of cattle respectively, values that are over 50 times higher than obtained in this study. The permissible limit for Cd in kidney and liver has been reported as 1 ppm (mg/kg) and 0.5 ppm (mg/kg) respectively (Vos e*t. al.* 1991). Generally, the low levels of these metals across the State may be a reflection of the low population density, low industrialization and urbanization in the state. However, Cr was found to be higher in some of the sampled organs and was above the permissible limit. There was a significant ($p < 0.05$) difference in the level of Ni and Cd between Southern and Northern zones, with the Northern zone having higher concentrations of Ni and Cd. This is probably as a result of higher anthropogenic (due to population) and agricultural activities in the Northern zone. Additionally, the northern zone has abundant rock sediments which can increase heavy metals contamination.

CONCLUSION

This study revealed that cattle meat and offal consumed in Nasarawa state contain some level of toxic heavy metals but mostly within permissible limits. Agricultural activities and age have significant effect on the level of some heavy metals ($P < 0.05$). The concentrations of Ni, Cu, Cd and Pb from all the tissues sampled across Nasarawa state were generally low and were all within the permissible limit set-up by joint WHO/FAO. Cr was however detected in higher concentrations across the State.

RECOMMENDATIONS

Since there can be bio-accumulation and biomagnification of these metals overtime, it is essential to routinely evaluate and monitor the levels of toxic heavy metals in Nasarawa state. Government and private sector intervention should include establishment of ranches and cattle colonies across Nigeria. These measures will drastically reduce the exposure of cattle to heavy metals contaminated environment. Public enlightenment on the danger of grazing cattle near construction sites, automobile workshops, battery dump areas and any potential sources of heavy metals should be adopted.

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