American Journal of Zoology
2019; 2(1): 1-5
http://www.sciencepublishinggroup.com/j/ajz
doi: 10.11648/j.ajz.20190201.11

Appraisal of Heavy Metals (Lead and Cadmium) in the Muscle and Internal Organs of Cattle Slaughtered in Ibadan

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To cite this article:
Hillary-Frances Ladidi Gwani, Emmanuel Teryila Tyokumbur. Appraisal of Heavy Metals (Lead and Cadmium) in the Muscle and Internal Organs of Cattle Slaughtered in Ibadan. *American Journal of Zoology*. Vol. 2, No. 1, 2019, pp. 1-5. doi: 10.11648/j.ajz.20190201.11

Received: December 14, 2018; **Accepted**: December 28, 2018; **Published**: January 29, 2019

Abstract: This study appraised the levels of two heavy metals: lead (Pb) and cadmium (Cd) in the muscle, liver, kidney, intestine, lungs and heart of cattle slaughtered for sale in the Akinyele Meat Market of Oyo State, Nigeria. The objectives of the study were to assess the distribution of these metals in the different parts of the body of cattle and compared their concentration with international guidelines. Thirty samples made up of six each of muscle, liver, kidney, intestine, heart and lungs were procured from the Akinyele meat market in Oyo State. The samples were pulverized and 0.5g weighed out for acid digestion with 2mL of 3:2 $HNO_3/HClO_4$. Each digestate was made up to the 10 mL mark with de-ionized water, and analysed for the heavy metals (Pb and Cd) with a GBC Avanta ver 2.0 Atomic Absorption Spectrophotometer (AAS) model A6600. Results showed that range of detectable values in parts per million (ppm) metals were: Pb (0.00-0.81ppm), Cd (0.24-0.81ppm) in muscle; Pb (0.00-0.92ppm), Cd (0.00-0.03ppm) in heart; Pb (0.00-0.50ppm), Cd (0.40-7.65ppm) in kidney; Pb (0.00-0.28ppm), Cd (0.00-0.88ppm) in liver; Pb (0.00-0.03ppm), Cd (0.00-0.88ppm) in lungs and Pb (0.00-7.51ppm), Cd (0.10-0.65ppm) in the intestine. The results when compared with the World Health Organization (WHO) permissible limit of 0.01ppm for Pb and 0.05 ppm for Cd showed that the heavy metal concentration in most parts of the cows sampled exceeded the safety limit and are therefore potentially harmful if consumed. The study therefore show the need for regular biomonitoring programmes for heavy metal concentration in cattle in order to safeguard public health.

Keywords: Heavy Metals, Cattle, Muscle, Internal Organs, Ibadan

1. Introduction

There has been growing global apprehension over public health with emphasis on impacts of environmental pollution, in particular, the global burden of heavy metal poisoning [1]. Heavy metals are a group of heterogeneous elements which vary widely in their chemical properties and how they function biologically. They are natural parts of the earth's crust, but due to human activities, they have been considerably altered through their geochemical cycles and biochemical balance [2]. Heavy metals which are common transition metals, such as copper, lead, and zinc are causes of environmental pollution from sources such as leaded petrol, industrial effluents, and leaching of metal ions from the soil into lakes and rivers by acid rain. They are present in virtually every area of modern consumerism, from construction materials to cosmetics, from medicine to processed food, from fuel sources to agents of destruction and from appliances to personal care products [3].

Heavy metals are any metal (or metalloid) species that may be considered a “contaminant” if it occurs where it is unwanted, or in a form or concentration that causes detrimental human or environmental health effect [4]. Metals or metalloids include lead (Pb), cadmium (Cd), mercury (Hg), arsenic (As), chromium (Cr), copper (Cu), selenium (Se), nickel (Ni), silver (Ag), and zinc (Zn). Other less common metallic contaminants include aluminium (Al), caesium (Cs), cobalt (Co), manganese (Mn), molybdenum (Mo), strontium (Sr), and uranium (U) [5].

According to Lane and Morel [6], living organisms require varying amounts of some essential heavy metals. Iron, cobalt, copper, manganese, molybdenum, and zinc are required by humans, but, prolonged exposure to heavy metals such as cadmium, copper, lead, nickel, and zinc can cause injurious health effects in humans. However, any toxic metal may be called heavy metal, notwithstanding their atomic mass or density [7]. Chronopoulos *et al* [8] asserts that all metals are toxic at higher concentrations. Excessive levels can be damaging to the organism. In other words, metals can at a point be beneficial to man and animals, examples of which include vanadium, tungsten, and even cadmium [5, 9]. Heavy metals are also called trace elements due to their presence in trace (10mg Kg^{-1}) or in ultra-trace (1µg kg^{-1}) quantities in the environmental matrices [9]. Cadmium is toxic to virtually every system in the animal body even though daily dietary intake of Cd ranges from 40-50 µg/ day [10].

Livestock play a very important role in Nigerian agriculture contributing about 19.71% to the nominal gross domestic product (GDP) as recorded in the second quarter of 2016 [11]. Nigeria is one of the four leading livestock producers in sub-Saharan Africa. A survey by the National Bureau of Statistics estimated the population of various species of livestock as cattle (19,200,000), Sheep (39,300,000), goats (63,300,000), pigs (6,700,000) and poultry (153,000,000) [12]. Farm animals, such as cattle serve as a major source of meat in Nigeria and are exposed to heavy metal contamination which can be transferred to these animals through direct exposure, drinking polluted water, eating crops grown on sewerage, contact with industrial seepages, and inhalation of vehicle and other discharges as they move from one place to the other to graze [4]. Thus, toxic metals can bioaccumulate in the tissues and organs of these animals hence the need for this study [4]. The prevalence of heavy metals in the Nigerian environment has been extensively studied with the presence of these heavy metals at enhanced concentrations has been reported in fish, water, soil and plants [13-19]. It becomes necessary to study the concentrations of toxic heavy metals in meat in order to assess the levels of exposure of consumers to toxic metals, and henceforth, maintain an on-going knowledge of the levels of these metals both in the environment and in meat to safeguard public health good [4].

2. Materials and Methods

2.1. Study Area

The study was carried out in the Akinyele Local Government area which is one of the local government areas located within the city of Ibadan. The city of Ibadan is the capital of Oyo State of Nigeria and lies approximately on latitude 7°23ˈN and longitude 3°56ˈE of the Greenwich meridian [20]. It is the largest city in West Africa south of the Sahara covering a land mass of 35,742.84 sq. km.

2.2. Sample Collection and Preparation

According to Namie´snik [21], sample collection and sample preparation are ordinarily the most important steps in any analytical procedure such that errors committed at these stages usually influence the quality of the final results. There are so many sampling tools available for the various techniques used in the detection of heavy metals; however, their usefulness depends largely on the samples to be analysed and anticipated concentrations of analytes to be determined in the sample. In order to minimise errors or interference in the process and results of the analysis for the determination of heavy metals, the character of the targeted compounds (metals) are considered so that the collection of sample items for heavy metal determination has to be carried out by applying carefully selected and cleaned vessels.

Following from the understanding of the fact that there are risks in maintaining the representative character of the collected food sample to be analysed, the next step will be to know how to counteract chemical composition changes in samples. Boutron [22] suggests the following basic principles that can be followed.

i. use of a clean laboratory, together with a very careful choice of laboratory ware, ultra-pure water, and reagents of high purity,
ii. all standard solutions should be acidified and stored in a refrigerator or freezer,
iii. prudent choice of laboratory materials used during the various stages of the analytical procedure,
iv. cleaning of all the containers and the laboratory wares using acid cleaning baths,
v. storage of food samples for a short time in a refrigerator, and for longer periods in a freezer.

2.2.1. Sample Collection

Samples of heart, liver, lungs, kidney, muscle and intestines were collected from five (5) cows. A total of 30 samples were used in the study. Each set of samples i.e. heart, lungs, liver, kidney, muscle and intestines were collected from a single slaughtered cow while taking care that the samples did not mix up. These samples were collected from animals of varying age, colour and sex. Sample collection and analysis were carried out between the months of June and November 2017.

2.2.2. Sample Preparation

Samples were collected from the Akinyele Meat Market (Moniya) and were then brought to the lab for laboratory analysis which includes dry ashing, wet digestion or wet ashing and elemental analysis.

2.2.3. Dry Ashing

This is the simplest method for decomposing an organic sample. It involves burning off organic matter in the sample at an elevated temperature in a muffle furnace until all the carbonaceous material has been oxidized to carbon dioxide [4]. The samples were then placed inside an ashing dish (crucible) that is resistant to high temperature and the furnace set to a temperature of 400°C for two hours for each set of samples. Following from this, the ashes were then stored in sample bottles prior to wet ashing or wet digestion.

2.2.4. Wet Digestion or Wet Ashing

Wet ashing is used primarily for the digestion of samples for trace elements and metallic poisons. The use of a single acid is desirable, but usually not practical for the complete decomposition of organic material to which extent therefore, mixed acids are the usual reagents for the decomposition of organic material in wet ashing procedures [4].

After dry ashing the samples, 0.5g of each dried sample was digested with 2mL of 3:2 $HNO_3/HClO_4$ mixture and allowed to stand for 24 hours. After 24 hours, 1mL of 30% hydrogen peroxide was added to each of the digested sample in the ratio 2:1 and allowed to simmer down. Following from this stage, the solution was filtered using acid resistant filter papers into acid-rinsed polyethylene bottles. The digestion was then made up to 10ml mark by adding distilled water and then taken for elemental analysis.

2.2.5. Elemental Analysis

Elemental analysis is using the procedures for versatile and highly sensitive tools for the determination of metals in biologic and environmental samples. In this study, the concentration of lead and cadmium were to be determined in the 30 samples that have been collected from five (5) cows. The concentration of these elements was determined in the samples using the Buck Scientific Atomic Absorption Spectrophotometer. Each analysis was done in triplicates while the standard and blank samples were analysed for all 30 samples.

3. Results

The results of the lead (Pb) and cadmium (Cd) concentration in the muscle and offal of cattle from the study are shown in Tables 1 and 2.

Table 1. *Concentration of lead (Pb) in muscle and offal of cow from the study.*

Sample	Muscle (ppm)	Heart (ppm)	Kidney (ppm)	Liver (ppm)	Lung (ppm)	Intestine (ppm)	Mean (ppm)	Standard Deviation
1	0.81	0.68	0.38	0.13	ND	0.03	0.34	0.771
2	ND	0.92	ND	0.09	ND	ND	0.17	0.338
3	ND	ND	ND	0.28	ND	ND	0.013	0.11
4	ND	ND	0.02	ND	ND	7.51	1.255	2.80
5	ND	ND	0.50	ND	0.03	ND	0.088	0.184

ND= Not Detected. World Health Organization guideline limit for Pb= 0.01ppm [10].

Table 2. *Concentration of Cadmium (Cd) in muscle and offal of cow from the study.*

Sample	Muscle (ppm)	Heart (ppm)	Kidney (ppm)	Liver (ppm)	Lung (ppm)	Intestine (ppm)	Mean (ppm)	Standard Deviation
1	0.51	0.03	0.40	2.36	0.00	0.40	0.62	0.77
2	0.81	0.02	4.11	1.14	0.63	0.10	1.14	1.39
3	0.41	ND	6.79	1.27	ND	0.46	1.49	2.41
4	ND	ND	5.61	ND	1.72	0.65	1.33	2.01
5	0.24	ND	7.65	0.09	0.88	0.33	1.53	2.75

ND= Not Detected. World Health Organization guideline limit for Cd= 0.05ppm [10].

The muscle part in sample 1 had the highest concentration of lead (Pb) at 0.81ppm while the intestine had the lowest at 0.03ppm no trace was detected in the lung. For the cadmium concentration in this sample, the highest was found in the liver at 2.36ppm with the heart recording the least at 0.03ppm. Of interest is the fact that the lung in this sample too did not have any trace of cadmium also.

In sample 2, the heart had the highest concentration lead (Pb) at 0.92ppm while the liver records a concentration of 0.09ppm as the lowest. No trace was found in the intestine, kidney, muscle and lung. For cadmium, the kidney had the highest concentration at 4.11ppm and the heart the lowest at 0.02ppm. Cadmium was detected in the other parts tested from this sample, but in varying amounts.

Of note is the fact that only the liver had a concentration of 0.28ppm of lead (Pb) in sample 3 as the other parts had no detectable traces in them. However, the kidney had a concentration of 6.79ppm of cadmium (highest) while the muscle recorded 0.41ppm as the lowest even though no trace was detected in the heart and the lung.

Interestingly, only the intestine and kidney had records of 7.51ppm and 0.02ppm of Pb respectively in sample 4. The liver, heart, muscle and lungs had no detectable value in them. For the cadmium, the kidney recorded the highest concentration at 5.61ppm, followed by the lung at 1.72ppm with the lowest at 0.65ppm in the intestine. The liver, heart and muscle had no detectable traces.

In sample 5, only the kidney and lungs had Pb concentration of 0.50ppm and 0.03ppm respectively with no detectable traces in the liver, heart, intestine and muscle. For the record of the cadmium in this sample, the kidney had the highest concentration of 7.65ppm and the lowest of 0.09ppm in the liver. However, the heart had no trace with the lung having 0.88ppm, intestine 0.33ppm and muscle at 0.24ppm. Generally, from the parts tested from the samples, the kidney seemed to have the highest concentration of cadmium all through while the intestine of sample 4 had the highest level of lead (Pb).

Comparison of the Current Findings with Previous Works

Results from this study corroborate with previous findings on heavy metals in cattle in Nigeria. For instance lead and cadmium were found to be elevated above World Health Organization guideline standards in most of the organs assessed as previously reported by Ugwu [4]. In sample 3, lead was 0.28ppm in the liver and no other organ which could be attributed to the detoxification and storage role of the liver. The high lead level in the kidney (0.50ppm) found in sample 5 is similar to earlier findings by Milam *et al* [23] that also found elevated levels of heavy metals in the kidney. However, the effectiveness and reliability of using the levels of metals in living organisms as biomarker of pollution are functions of several factors such as species, age of the organism and sex [24], animal parts and tissues considered [25-27], feeding habit, animal management system, animal physiology, season, level of pollution, type and chemistry of the metal, metal uptake potential of the dominant plant species the animals feed on [28-30] in the environment under consideration, nature of the soil at the polluted site, leaching potentials of the metals [31], influence of the presence and /or level of the a metal on the other in the living organism and in the concerned environmental media [32].

Therefore, assessing the levels of metals in some organs of cattle as biomarker should put into consideration which cattle organ is to be analysed. For example, when examining investigations by Miranda *et al* [25], kidney had the highest accumulation of some metals, Cd, Pb and As, in the industrialized area; and Cd as well in the rural area. The trends were followed by the levels in the liver for all the metals, except in the rural area where Pb and As were highest in the liver.

4. Discussion

Considering the rapid and continuous growth in population, urbanisation, industrialisation and transportation in Nigeria in recent years, there has been the issues of indiscriminate exploitation of the natural resources and the environment [4]. To this extent, several industrial establishments of varying sizes and capacities, including chemical manufacturing, iron/steel foundries and re-rolling mills, paints, agro-chemicals, leather tanning, electroplating, electric cables and appliances, plastics, brick kilns, petroleum refining and servicing industries have taken root in different parts of the country [4]. Following from this, is the fact that environmental management practices are virtually poor in Nigeria with unavailability of some standards and/or un-operational environmental pollution laws. Therefore, toxic wastes generated by these industries are discharged indiscriminately into the air, soil and water, with least or no treatment. This results in undue levels of toxic substances like heavy metals in the local environment which exposes animals to the potential risk of these heavy metals from the environment given the challenges of free-range grazing, scavenging in open waste dumps for fodder, drinking water from polluted drains and streams and exposure to atmospheric depositions especially from automobile fumes and open burning of solid waste. Close correlation have been reported between heavy metals concentration in cattle tissues with that in soil, feed, and drinking water [33].

Although, the levels of the studied trace metals in the muscle and edible offal of cow showed an accumulation of appreciable amounts when compared to permissible limits stipulated by some international standards, there is little or no biomonitoring programs in place. This high level is indicative of the general contamination level of the environment. Of the two heavy metals studied, cadmium seemed to be the most heavily accumulated and this was in the kidneys of four of the sampled cows, thus, this storage site can be a good indicator in monitoring of this metal in livestock, and consumers may be exposed to high doses of this metal through the consumption of the kidney which is a favourite part for consumers of roasted meat known locally as *Suya*.

5. Conclusion and Recommendation

Given the permissible limit of Pb concentration as 0.01ppm, it could be asserted that the concentration levels in the various parts of the cows are harmful, except for those which were below detection limit. The source of the metal contamination could be traced to the nature of their feed, water, and location such as presence of refineries. Since the observed levels of metals in this study were higher than the WHO standards, pollution could be inferred; and the quantification of these metals in organs of cattle could be used as biomarkers of pollution, though several factors have to be put into consideration.

The levels of cadmium and lead in cow meat call for continuous monitoring of our environment to ensure protection from further pollution. Therefore, there is need for the Federal Government to encourage and financially support extensive study on heavy metals levels in food materials and their dietary intake and thus be able to monitor nationally set standards.

Acknowledgements

The authors are thankful to Dr. Joan-Mary Ogiogwa for her financial support to the study.

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