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The contents of Pb, Cu, Zn and Cd in meat in Nairobi, Kenya

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Abstract

The most important uptake of heavy metals by man occurs through ingestion, hence food analysis is of great importance. In Kenya, meat is sold in butcheries, which are strategically situated near the roadsides and near bus stops. Most of these butcheries have their doors open, and there is likelihood that meat is contaminated by heavy metals. In the current research Pb, Cu, Zn and Cd content in meat were determined. Samples of the kidney, liver and muscles from various cattle were taken from Nairobi and its surroundings. The overall concentration of Pb, Cu, Cd and Zn were below 2 ppm. Generally, the muscle had high concentration of Pb and Cd as compared with kidney and liver. This observation is an anomaly from what has been reported in the literature so far with the liver indicating high metal content. Since most of the butcheries in the study area are located along the highway with high vehicular density, there is a high possibility of direct deposition of Pb and Cd in the meat. The Pearson Chi-square gave a value of 0.231 for the lead and cadmium indicating that the two metals have a common source, which is thought to be vehicular density.

Key words: AAS, muscle, kidney, lead, copper, zinc, cadmium, meat, content, Chi-square.

Introduction

The rate of urbanization and industrialization is rapidly increasing day by day in Nairobi, Kenya. There are many problems associated with urbanization such as lack of good drinking water, setting of informal settlements and pollution. There are many types of environmental pollution like noise pollution, heavy metal pollution and poly-aromatic hydrocarbons (PAHs).

Meat is food material, which is composed of mainly proteins, fats and some important essential elements. Meat is essential for growth and maintenance of human body. Contamination to cattle is transferred to animals via direct exposure [1], polluted water and crops grown on irrigated sewage water and industrial effluents. Another important source of contamination of meat is the deposition of contaminants from vehicle emission and from dirty slaughterhouses [2]. It is therefore important to keep monitoring the various pollutants in the meat since most of the butcheries sell their meat in strategic places like roadsides and near bus stops. Most of the butcheries are open and allow free air circulation and the meat, which is usually hanged, is exposed to direct air from outside which can be a source of contamination. In some cases meat is roasted in cafes near the roadsides and is sold to travelers.

Contaminated meat is a source of illness in human beings; in this case, heavy metals are directly related to health diseases in humans. Although it is increasingly difficult to classify trace metals into essential and toxic groups, it is a well known fact that essential metals become toxic at sufficiently high intakes [3].

The main sources of lead pollution in the environment are industrial production, road traffic with leaded petrol, cigarette smoking, dust emissions of coal, gas-fired power stations, lead sheets by roofers as well as the use of paints and anti-rust agents[2]. Excess Pb can cause serious damage to the brain, kidney, nervous system and red blood cells [4].

Basically, as a result of their comparatively high affinity for proteins, the lead ions form bond with the haemoglobin (red blood pigment) and the plasma protein of the blood. This leads to inhibition of the synthesis of red blood cells and thus of the vital transport of oxygen. If the bonding capacity is exceeded, lead passes into the bone marrow, liver and kidneys.

Cadmium is absorbed by many plants and sea creatures and, because of its toxicity, presents a major problem in foodstuffs. Contamination through fertilizers has become an increasing problem. Cadmium is concentrated particularly in the kidneys, the liver, the blood-forming organs and the lungs. It most frequently results in kidney damage and metabolic anomalies caused by enzyme inhibitions [13].

Zinc is essential for normal functioning of cells including protein, carbohydrates metabolism, cell growth and cell division [5]. Although humans can handle proportionally large concentrations of zinc, too much zinc can cause eminent health problems, such as stomach cramps, skin irritations, vomiting, nausea and anemia. Very high levels of zinc can damage the pancreas, disturb the protein metabolism and cause arteriosclerosis. Extensive exposure to zinc chloride can cause respiratory disorders [5].

The copper containing alloys such as pipefitting may add measurable amount of copper into the water. Copper concentrations above 15 mg intake results in nausea, vomiting, diarrhea and intestinal pain. Copper deficiency results in anemia and congenital inability to excrete copper resulting in accumulation and Wilson disease [6].

The aim of the study was to determine Pb, Cu, Zn and Cd content in meat samples of the kidney, liver and muscles from various cattle taken from Nairobi and its surroundings.

Material and Methods

Sampling and sample preparation: The liver, kidney and muscle samples were collected from various butcheries in Nairobi and its surroundings. In the laboratory, samples were sun-dried for 5 days. Samples were then oven-dried at 105ºC for 12 hours and each separately ground to powder in a porcelain mortar. The powder was then stored in plastic bottles ready for analysis.

Procedure for AAS analysis: For the analysis of heavy metals in the meat samples, one gram of each sample was digested with triacid (nitric:perchloric:sulphuric acid in the ratio 5:1:5 v/v) and filtered through Whatman paper No. 42. The filtrates were placed in 100 ml volumetric flasks and made up to volume with distilled water. The determination was carried out using atomic absorption spectrophotometer (AAS, model 210 VGP).

Percentage recovery: In order to determine recovery, three sets of meat samples were weighed out accordingly and two of these were added to known aliquots of a standard solution, so that the concentration could be close to that of the highest sample. Each of the samples was analyzed as described above. AAS readings were taken for the three samples and percentage recovery then calculated.

Results and Discussion

The highest level of lead was recorded in muscle at Ngara with a value of 0.386 ppm (Table 1) and the lowest level was recorded in the kidney at Kileleshwa with a value of 0.161 ppm (Table 2). The muscle had the highest mean value of lead with a value of 0.290 ppm while the liver had the lowest with a mean value of 0.033 ppm (Fig. 1). The lead concentrations in kidney, liver and muscle in our study were greater than the values recorded in earlier studies where the mean values in ruminant muscle were found to be 0.05, 0.04 and 0.01 ppm respectively in Slovenia, Poland and Finland [11, 12, 16]. Values obtained in the current study are comparable to those found in Austria [17] and Slovenia [11] of 0.239 ppm and 0.1 ppm, respectively, less than those recorded in Slovak [18] but higher than those found in European Union of 0.1 ppm in meat of bovine animals [7].

Table 1. Heavy metal concentrations (ppm) in the muscle.

Area	Lead	Cadmium	Zinc	Copper
Kariobangi	0.227±0.001	0.024±0.031	0.016±0.000	0.039±0.000
Juja	0.227±0.001	0.015±0.008	0.126±0.094	0.038±0.000
Thika	0.227±0.001	0.011±0.000	0.182±0.000	0.038±0.000
Ngara	0.386±0.139	0.046±0.014	0.203±0.001	0.039±0.000
Gachororo	0.315±0.112	0.030±0.023	0.269±0.012	0.039±0.000
Ruiru	0.226±0.000	0.016±0.008	0.224±0.006	0.039±0.000
Zimmerman	0.385±0.039	0.092±0.118	0.199±0.024	0.038±0.000
Kileleshwa	0.374±0.069	0.044±0.015	0.194±0.010	0.039±0.000
Westlands	0.302±0.106	0.038±0.021	0.193±0.010	0.037±0.000
Githurai	0.228±0.001	0.019±0.016	0.152±0.097	0.039±0.000

Table 2. Heavy metal concentrations (ppm) in the kidney.

Area	Lead	Cadmium	Zinc	Copper
Kariobangi	0.174±0.004	0.006±0.000	1.277±0.002	0.0774±0.007
Juja	0.172±0.004	0.006±0.000	1.253±0.002	0.0755±0.000
Thika	0.165±0.001	0.006±0.012	1.318±0.003	0.888±0.012
Ngara	0.162±0.002	0.006±0.017	1.381±0.007	0.793±0.017
Gachororo	0.170±0.006	0.006±0.001	1.956±0.002	0.800±0.000
Ruiru	0.164±0.003	0.006±0.001	1.732±0.001	0.853±0.003
Zimmerman	0.165±0.004	0.006±0.000	1.906±0.020	0.712±0.000
Kileleshwa	0.161±0.003	0.006±0.000	1.293±0.004	0.800±0.010
Westlands	0.162±0.003	0.006±0.002	1.485±0.002	0.789±0.017
Githurai	0.165±0.004	0.006±0.001	1.927±0.002	0.758±0.014

Table 3. Heavy metal concentrations (ppm) in the liver.

Area	Lead	Cadmium	Zinc	Copper
Kariobangi	0.171±0.003	0.005±0.000	1.791±0.004	3.283±0.003
Juja	0.166±0.002	0.005±0.002	1.536±0.008	3.280±0.006
Thika	0.162±0.002	0.003±0.000	1.750±0.006	1.583±0.000
Ngara	0.162±0.003	0.003±0.000	1.750±0.006	1.329±0.003
Gachororo	0.164±0.001	0.004±0.000	1.571±0.008	0.989±0.008
Ruiru	0.163±0.003	0.005±0.000	2.179±0.005	4.751±0.002
Zimmerman	0.166±0.003	0.006±0.000	1.260±0.004	0.762±0.001
Kileleshwa	0.167±0.001	0.004±0.000	1.696±0.100	1.918±0.020
Westlands	0.170±0.003	0.009±0.001	1.896±0.008	2.029±0.001
Githurai	0.166±0.003	0.007±0.001	4.269±0.050	0.070±0.002

The highest level of zinc was recorded in liver at Githurai with a value of 4.269 ppm (Table 3) and the lowest level was recorded in the kidney at Kariobangi with a value of 0.016 ppm (Table 1). The liver had the highest mean value of zinc with a value of 1.899 ppm while the muscle had the lowest with a mean value of 0.1758 ppm (Fig. 1). The concentration of zinc was highest in the liver, followed by the kidney and the muscle had the least concentration. The levels of zinc in liver and kidney were lower than values of 40, 49 and 42, 34 ppm reported in Sweden and Poland respectively [12, 14]. The zinc content in the current study was found to be below the maximum limits of South Africa of value 40 ppm of foodstuffs [8].

The highest level of Cu was recorded in the liver at Juja with a value of 3.280 ppm (Table 3) and the lowest level was recorded in the muscle at Westlands with a value of 0.037 ppm (Table 1). Generally, the copper content in the muscle did not vary much with sampling areas. The liver had the highest mean value of copper with a value of 2.005 ppm while the muscle had the lowest with a mean value of 0.039 ppm (Fig. 1). In our study, the levels of copper were found to be higher in liver, followed by kidney and finally muscle. Similar results have been reported in Slovak [18]. The values of copper in kidney and muscle in our study were lower than those reported in Sweden, Poland and Slovakia

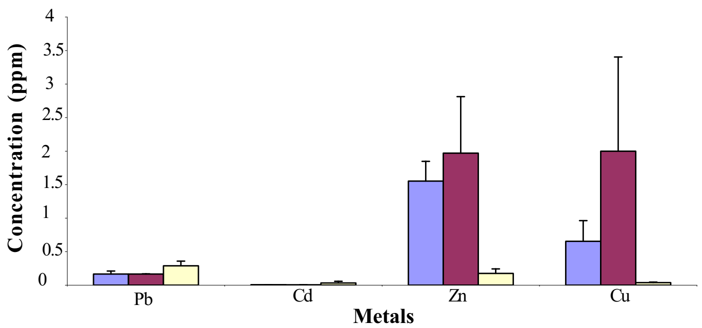

Figure 1. Specimens versus mean metal concentrations (ppm).

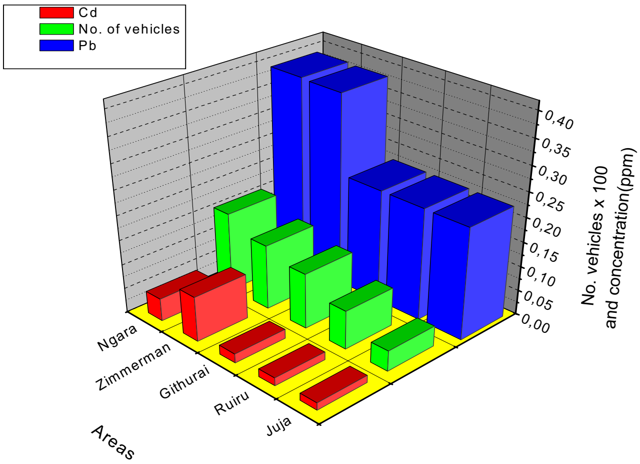

Figure 2. Areas versus no. of vehicles and metal concentrations (ppm).

respectively [12, 14, 18]. Values in current study are below the maximum limit set by South Africa of 30 ppm [8].

The highest level of Cd was recorded in muscle at Ngara with a value of 0.046 ppm (Table 1) and the lowest level was recorded in the liver at Thika with a value of 0.003 ppm (Table 3). The muscle had the highest mean value of cadmium 0.033 ppm while the liver had the lowest mean value of 0.005 ppm (Fig. 1). The mean concentrations of cadmium in the liver and kidney were less than those reported from Slovak Republic [10, 18]. Cadmium levels in this study were comparable to those found in the liver and muscle with a value of 0.97 to 0.001 ppm determined in Spain [15]. It is only at Zimmerman where the level of Cd in muscle exceeded that of European Union value of 0.05 ppm [7].

Generally, the Zn and Cu concentrations were highest in the liver followed by kidney and the least value was found in the muscle. For Pb and Cd the muscle had the highest levels as compared to the liver or kidney (Fig. 1). The Chi- square test gave a value of 0.231 between Pb and Cd, this showed that there was a relationship between the two values. We found that the levels of Pb and Cd depended on the vehicular density and this was thought to be the source of these metals (Fig. 2).

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