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Determination of Cd, Hg, As, Cr and Pb levels in meat from the Kumasi Central Abattoir

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Abstract- The purpose of this study was to determine the concentrations of toxic metals (Cd, Hg, Cr, Pb, As) in meat at the Kumasi Central Abattoir, Ghana by using a Varian 220 Atom Absorption Spectrophotometer. The levels of toxic metals in meat (cow, pig, sheep, goat, grass cutter, deer) varied in concentration. The concentration of lead was above the tolerance level in all the meat samples with the highest concentration recorded in beef at 1.154 mg/kg and the lowest at 0.037 mg/kg in pork. The amount of mercury, Hg observed in the various meat samples fell within the range of 0.059 mg/kg to 0.012 mg/kg, a little over the tolerable level of 0.05 mg/kg. The highest mercury, Hg concentration was observed in grasscutter meat (0.071 mg/kg) and the lowest concentration in pork, which was observed at 0.012 mg/kg, with the former above the permissible limit and the latter below the permissible limit. The concentrations of As, Cd and Cr were all within the tolerance limit. The meat analyzed may have a potential health risk to consumers.

Index Terms- Trace metals, meat, contamination, Atomic absorption

I. INTRODUCTION

Meat makes up an essential part of the food we eat and is mainly composed of protein, fat and some important essential elements (Akan et al. 2010). It is also a good source of niacin, vitamins B6 and B12, phosphorous, zinc, and iron (Williams 2007). Animal proteins have a high biological value (Ziegler 1968 in Dabuo 2011), and the presence of essential amino acids in them makes a complete protein (Bastin 2007).

Apart from meat and meat products forming an important part of the human diet as well as an important source of a wide range of nutrients, they may also carry certain toxic substances (Fathy et al. 2011). Toxic substances in meat tissues can be caused by a variety of sources including animal drugs, pesticides, feed and other agricultural or industrial chemicals substances (Fathy et al. 2011). Instances of heavy metal contamination in meat products during processing have also been reported (Akan et al. 2010; Harlia and Balia 2010). Methods such as singeing off the hairs of the animals in flame fuelled by various substances such as wood mixed with spent engine oil, plastics mixed with refuse or tyres. These materials contain toxic substances such as heavy metals which can contaminate the meat and render them unfit for human consumption (Okiei et al. 2009). In other cases, contaminated animal feed and rearing of livestock in proximity to polluted environment were reportedly responsible for heavy metal contamination in meat (Fathy et al. 2011).

Heavy metals in their standard state have a specific gravity (density) of more than about 5 g/cm3. Some of them, such as copper, nickel, chromium and iron, are essential in very low concentrations for the survival of all forms of life (AIUM IND-015 2013), Specific elements that are normally toxic for some organisms are under certain conditions, beneficial, examples include vanadium, tungsten, and cadmium. Only when they are present in greater quantities, can these, cause metabolic anomalies. The boundary between the essential and the toxic effect therefore becomes problematic (AIUM IND-015 2013).

Contamination with heavy metals is a serious threat because of their toxicity, bioaccumulation and biomagnification in the food chain. These pollutants often have direct physiological toxic effects because they are stored or incorporated in tissues, sometimes permanently (Abd EI-Salam et al. 2013). Heavy metals such as mercury, plutonium, and lead are toxic metals that have no known vital or beneficial effect on organism and their accumulation over time in the bodies of animals and humans can cause serious ailments. Among all heavy metals, however, cadmium and lead are known as highly toxic (Binkowski 2012). The risk associated with the exposure to heavy metals present in food product have aroused widespread concern in human health. Cadmium is primarily toxic to kidney, especially to proximal tubular cells. Bone demineralization is affected by cadmium toxicity directly by bone damage and indirectly as results of renal dysfunction (Solidum et al. 2013). Overexposure to lead affects the neurological, reproductive, renal, haematological systems. Studies show that children are more prone to lead toxicity as compared to adults (Gonzalez - Waller et al. 2006).

In Ghana, chicken meat, the liver, kidney and meat of goat, sheep and beef are a major source of protein to the population and are widely consumed with a per capita meat consumption of 9.2 kg.. The main source of metals in meat arises from contamination of animal feed and drinking water (Hussain et al. 2012).

In this study, concentrations of various metals in meat were determined. Meat from different sources were purchased and investigated for toxic metals and their concentrations, and compared to international standards. The study was aimed at determining the content of the toxic elements ; Cr, Cd, Hg, Pb and As in meat from seven different animals; sheep, goat, pig, cow, deer, rat, and grass-cuter, from the Kumasi Central Abattoir.

II. METERIALS AND METHODS

Analar grade of reagents were used in all situations.

A total of three fresh samples each of the meat of a pig, cow, sheep, goat, deer, rat, and grass-cutter from the Kumasi Central abattoir were collected between the months of November to December, 2012. Samples were randomly selected. The meat (liver, flesh, etc) of each of the selected animals was packed in sterile polythene bags, properly labeled with a permanent marker and transported to the laboratory for analysis.

Meat samples were subjected to dry ashing, followed by acid digestion with aqua regia adopted from Dalton and Malanoski (1969).

Standard solutions ranging from 0.2 to 5 mg/l of the metals determined were prepared for the plotting of calibration curves and the metals were determined with Varian 220 Atomic Absorption Spectrophotometer.

III. RESULTS AND DISCUSSION

The data obtained from the AAS analysis of meat samples for metals has been presented in Table1. The following abbreviations have been used: B – Beef, M – Mutton, C – Chevon, R – Rat. D – Deer, P – Pork, G – Grass- cutter.

Table 1: Summary of levels of metals in various meat samples (μg/g)

Meat	Cadmium	Mercury	Chromium	Lead	Arsenic
Beef	0.079±0.00012	0.052 ± 0.010	0.304 ± 0.101	1.154 ± 0.288	0.007± 0.0005
Mutton	0.019±0.00240	0.015 ± 0.305	0.957 ± 0.553	0.377 ± 0.004	0.014 ±0.0020
Chevon	0.018±0.00250	0.034 ± 0.052	0.632 ± 0.228	0.377 ± 0.057	0.012± 0.0001
Rat	0.085±0.00029	0.0219 ±0.186	0.219 ± 0.186	1.054 ± 0.190	0.001 ±0.0110
Deer	0.032 ± 0.0012	0.051 ± 0.005	0.0472± 0.067	0.362 ± 0.144	0.020 ±0.0080
Pork	0.010 ± 0.0033	0.012 ± 0.119	0.060 ± 0.245	0.237 ± 0.144	0.008± 0.0040
Grasscutter	0.062±0.00004	0.071 ± 0.046	0.190 ± 0.215	0.728 ± 0.012	0.021± 0.0090

Chromium was detected in all the meat samples and varied in the range of 0.0472mg/kg to 0.957mg/Kg . The highest concentration of chromium, Cr was found in the meat of sheep (mutton) while the lowest in the meat of the deer. Cr is an essential element helping the body to use sugar, protein and fat, and at the same time carcinogenic for organisms. Excessive amounts may cause adverse health effects, Abd EI-Salam et al. 2013) and can reduce how effective insulin is at controlling blood sugar and cause irritation itching and flushing (UMMC 2013).The chromium, Cr level in the meat samples was found to be lower than the tolerable level of 1.0 mg/kg (USDA 2006).

The highest cadmium, Cd concentration was observed in the meat of the rat at 0.085 mg/kg and the lowest in pork meat at 0.010 mg/kg, far below the permissible limit of 0.500 mg/kg, as recorded by USDA, 2006 (USDA 2006). Cadmium exists in low concentrations in all soils. It is spread by air and water (sewage sludge) far over sea and land, but especially in the vicinity of heavy industrial plants and hence absorbed by many plants and sea organisms. The highest level of cadmium detected in the rat could therefore be as a result of bush rats having more contact with both soil and plants as compared to the other animals. Cadmium is primarily toxic to kidney, especially to proximal tubular cells. Bone demineralization is affected by cadmium toxicity directly by bone damage and indirectly as a result of renal dysfunction (Solidum et al. 2013). Cadmium may catalyze diabetes-induced effects on kidneys. Kidney damage may further progress to end stage renal disease (ESRD) and death if exposure is high and prolonged. Recent investigations show that cadmium may also play a role in the development of other cancers, such as testicular cancer, bladder cancer, pancreatic cancer and cancer of the gall bladder (Ilie et al. 2007). The levels of cadmium detected in all meat samples however, pose no toxicological risk to consumers.

The amount of mercury, Hg observed in the various meat samples fell within the range of 0.071mg/kg to 0.012mg/kg . The highest mercury, Hg concentration was observed in the meat of the grass cutter. Some forms of human activity such as the application of agricultural fertilizers and industrial waste water disposal, release mercury directly into the soil. Mercury released into the environment eventually end up in soils or surface waters (Solidum et al. 2013). Grass cutters

are not domesticated and are usually obtained from the wild by hunting and trapping. They are herbivorous animals; feeding on roots, tubers, grains of cereals and wood of all sorts. During digging for tubers, and roots, they might consume bits of soil on roots and tubers (Golow 1993), thereby introducing mercury through their mode of feeding. The lowest concentration of mercury was in the meat of pig (pork).

Lead is a toxic metal that has no known vital or beneficial effect on organisms and its accumulation over time in the bodies of animals and humans can cause serious ailments (Binkowski, 2012). The highest concentration of lead was 1.154 mg/kg and the lowest at 0.237 mg/kg, all above the tolerable limit of 0.1mg/kg. Its highest concentration was recorded in the meat of cow (beef) and the lowest in that of the pig (pork). Pb may enter the atmosphere during mining, smelting, refining, manufacturing processes and by the use of lead containing products (Abd EI-Salam et al, 2013). The source of Pb contamination of livestock come from the air, water they drink and food they eat. All the meat analysed contain lead in high doses (above the tolerable limit), and this could be due to the use of lead containing products during meat processing. Higher levels of lead in beef could be as a result of the areas in which cattle were reared (Harlia and Balia 2010).

The greatest threat to public health through arsenic originates from contaminated groundwater. Inorganic arsenic is naturally present at high levels in the groundwater of a number of countries. Drinking-water, crops irrigated with contaminated water and food prepared with contaminated water by these animals might be sources of arsenic exposure (Flanagan et al., 2012). Experimental data showed levels of arsenic (As); the highest in concentration being the meat of cow (beef) and the lowest, that of the sheep at 0.001 mg/kg and 0.021 mg/kg respectively, all below the permissible limit of 0.05 mg/kg (USDA 2006).

IV. CONCLUSION

The results of the study confirmed the presence of heavy metals namely, Cr, Cd, Hg, Pb and As in all the samples analysed. Among all the heavy metals determined in the study, Pb showed the greatest number of samples that exceeded the tolerance limit. Hg levels in beef, rat meat and grass cutter were also found to be beyond the tolerated dose. However, the concentrations of As, Cd and Cr were all within the tolerance limits. The consumption of meat in which metal concentrations beyond the tolerated dose were detected might be harmful to the health of consumers, doses below the tolerance limit, though not harmful, might pose health hazards when consumed in large quantities due to bioaccumulation.

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