

Heavy Metals in Pig Livers; A Case of Munyaka Estate-Uasin-Gishu County, Kenya

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Abstract

Heavy metals are natural constituents of the earth's crust; indiscriminate human activities have lead to alteration of their natural geochemical and biochemical cycle and balance. The risk of heavy metal contamination in meat/pork is of public health concern for both food safety and human health. The study aimed at determining the levels of lead, cadmium and mercury in pigs reared in two husbandry systems in Uasin-Gishu County, Kenya. A comparative cross-sectional study was employed. Thirty two pigs representing close to a thousand pigs in Munyaka estate were studied under two husbandry systems. Four branded manufactured feeds and 6 forage plants were analyzed by AAS machine for lead, cadmium and mercury. Results were summarized using means. The mean levels of lead, cadmium and mercury among intensively produced pigs were 0.10 ± 0.04 , 0.13 ± 0.04 and 0.12 ± 0.04 mg/kg.wet weight respectively. The mean levels of lead, cadmiu and mercury in extensively produced pigs were 0.09 ± 0.03 , 0.18 ± 0.05 and 0.14 ± 0.09 mg/kg.wet weight respectively. There was a significant difference ($p < 0.05$) in cadmium levels in pigs under intensive and extensive husbandry system with extensively produced pigs having higher levels. Manufactured feed B had mean Pb levels of 0.26 ± 0.01 mg/kg.dry weight while feed D had Pb levels of 0.38 ± 0.02 mg/kg.dry weight. Cabbage leaves had mean Pb levels of 0.60 ± 0.26 mg/kg.dry weight whereas grass on the roadside had mean Hg levels of 0.03 ± 0.02 mg/kg.dry weight with banana peelings also having mean Hg levels of 0.03 ± 0.04 mg/kg.dry weight. There was a significant difference ($p < 0.05$) in cadmium levels in pigs under intensive and extensive husbandry systems with extensively produced pigs having higher levels. The study showed that pig livers under the study were not safe for human consumption due to the presence of mercury levels above the WHO maximum recommended levels. These metals are known to cause adverse health effects including neurological and renal disturbances neurological and renal disturbances. The Government shoul strictly enforce The Animal Diseases Act; Cap364 on prohibition of extensive husbandry system. Kenya bureau of standards (KEBS) and Department of Veterinary Services (DVS) should regularly monitor and evaluate pork to safeguard human health. Farmers should be educated on the need to discriminately use of Phosphatic fertilizers and pesticides as they contribute to HMs in the soil and the consequent uptake by plants.

Key words: Heavy metals, Munyaka, Lead, Mercury, Cadmium

INTRODUCTION

The risk of heavy metal contamination in meat is of public health concern for both food safety and human health because of the toxic nature of these metals at relatively minute concentrations (Amfo-Out *et al.*, 2014).

With increasing industrialization, more and more metals are entering into the environment and the food chain from where they ultimately make their passage into the tissues of living organisms especially man and domestic animals; posing health hazards(Jaishankar *et al.*, 2014; LennTech, 2017; Tchounwou *et al.*, 2012)

Several studies have shown that heavy metals aflatoxin (aflatoxin B1, aflatoxin B2, aflatoxin G1 (AFG1) and aflatoxin G2 (AFG2)) and heavy metal (Pb, Cd, As and Hg) exist at various concentrations in animal feeds (Amlund *et al.*, 2012; Eskandari & Pakfetrat, 2014; Kan & Meijer, 2007). These accumulations pose a lot of risks to the host animal and the final consumer of the animal product.

Contaminated animal feed and rearing of livestock in proximity to polluted environment have also been reported as responsible for heavy metal contamination in meat(Jakimska *et al.*, 2011; Kan & Meijer, 2007; Sherene, 2010; Singh *et al.*, 2011).

Contamination of animal feed by toxic metals cannot be entirely avoided given the prevalence of these pollutants in the environment, there is clear need for such contamination to be minimized, with the aim of reducing both direct effects on animal health and indirect effects on human health(Kan & Meijer, 2007). The bioaccumulation of metals in an animal depends on a multitude of factors: biotic and abiotic factors, metal distribution in the environment, salinity, temperature, and pH of the water, habitat type, and interactions with other metals(Jakimska *et al.*, 2011). Therefore Pigs under extensive system are not restricted in what they eat or drink and the consequence of this is that humans are ultimately affected health wise.

Heavy metal pollution has a worldwide economic impact due to industrial wastes, geochemical structure, agricultural and mining activities. All these sources of pollution affect the physicochemical nature of the water, sediments and biological components, thus negatively affecting the quality and quantity marine foods(Zeitoun *et al.*, 2014)

Statement of the problem

Indiscriminate dumping of industrial and domestic waste in Munyaka Estate is a great problem though large amounts of these waste comprise organic material, there are considerable proportions of plastic, paper, metal waste and batteries which are known to be real sources of heavy metal. These wastes may contaminate the other organic waste in the same dump site and therefore extensively reared pigs foraging in these dump sites are exposed to heavy metals with human beings as consumers of Pork being also at risk.

Moreover, heavy metals are non-biodegradable and can accumulate in soils to toxic concentrations that affect plant and animal life; Animals can absorb and bio-accumulate cadmium from the environment although several studies have been carried out to assess exposure of wild animals to heavy metals, however ; there is little information on exposure to pollutants of domestic animals. This is so especially to foraging pigs which are exposed to environmental pollutants during foraging.

Exposure to humans results in brain damage, mental retardation, cerebral palsy, lung cancer, gastrointestinal abnormalities, and dermatitis, and death of the unborn fetus. These health effects are therefore a public health concern(Castro-González & Méndez-Armenta, 2008; Dixit *et al.*, 2015). Heavy metals enter into the food chain and from there they ultimately make their passage into the human tissue. Of more importance is the fact that contamination

with these metals is a serious threat because of their toxicity and bioaccumulation in the food chain. Lead, cadmium, mercury and arsenic are among the main toxic metals which accumulate in food chains and have a cumulative effect (Eneji *et al.*, 2011; Velusamy *et al.*, 2014).

It is estimated that more than 674,000 deaths occur per year from exposure to lead. Further, heavy metals are widely used in all fields of life (batteries, dyes, alloys, chemical compounds, pharmaceutical and cosmetic products thus the risk of pollution is very high (Wasana *et al.*, 2017).

MATERIALS AND METHODS

Study Design

A comparative cross-sectional study design was used to determine the levels of heavy metals in pigs under two husbandry systems.

Study Area;

The research was carried out in Munyaka Estate, Uasin-Gishu County. Munyaka is a residential Estate located North-East of Eldoret town of Uasin-Gishu County. People in this region are predominantly involved in business activities including farming. Solid waste collection in the area is poor and there are constant disputes between the tendered waste collectors and the residents.

Study Population

The total number of pigs in Munyaka estate is estimated to be 1,000 out of which 480 are under intensive and 520 under extensive systems (Kenya National Bureau of Statistics (KNBS); ORC Macro, 2010). Using a formula for comparison of two means, a sample of 32 pigs was selected for the study where by 16 pigs were those under extensive and the other 16 were those under intensive husbandry systems

Sampling and data collection

Sampling of the Pig Livers

Farmers from both systems were identified purposefully with the assistance from livestock officer from the area questionnaires were then administered on what they fed their pigs with. Day of sell/slaughter of the pigs was communicated to the researcher for liver collection. Consecutive sampling was employed whereby pigs from both systems were accessible in the slaughter house and originating from Munyaka was selected. The liver sample (200 grams each) of the selected pigs was collected after inspection by veterinary officer.

Sampling of Forage

Six different forage samples (approximately 50grams each) foraged by extensively reared pigs were purposively picked from the estate. Banana and potato peelings, cabbage and kale leaves were purposively picked at selected groceries in the estate. This was informed by the fact that extensive husbandry pigs access and feed on these forage. Kikuyu grass samples were picked at 3 different points on the roadside and 3 different points inside the estate accessed by extensively produced pigs.

Sampling of Manufactured Feed

Sixteen manufactured feed samples (approximately 50grams each) were conveniently collected from 4 branded manufacturers from retail outlets in Eldoret town where 80% of farmers-based on the questionnaires bought and fed their pigs on respectively. All samples collected were then transported to laboratory, dried and digested becoming ready for analysis.

Sample Preparation

Liver, forage and manufactured feeds sample Preparation

The liver samples were digested and analyzed using modified Environmental Protection Agency 3050B method (US EPA, 2012) while forage was thawed washed with deionized water then digested procedurally(Vanhaverbeke *et al.*, 2008). Whereas manufactured feeds was digested in triplicates as recommended by(Gupta *et al.*, 2006)

The respective liver, the forage and the manufactured feed samples was then analyzed for lead using Contr AA 700, cadmium SpectrAA-200 and mercury was analyzed using graphite furnace varian 220z spectrophotometer machine.

Samples were generally carefully handled to avoid contamination. Glassware was properly cleaned and the reagents were of analytical grade. Double distilled deionized water was used throughout the study. Reagents blank determinations were used to correct the instrument readings.

Ethical Considerations

Ethical clearance was sought from the ministry of livestock development and the County Authorities of Uasin-Gishu.

RESULTS

A. Lead, cadmium and mercury in intensive system

a. Lead Levels in pigs under intensive husbandry system

All the samples had lead levels lower than 0.5mg/kg with the highest level of 0.16 ± 0.04 mg/kg obtained with mean of 0.10 mg/kg and range being 0.15 mg/kg. Close to 50% had lead levels above 0.12mg/kg with least having 0.01mg/kg and maximum having 0.16 mg/kg.

b. Cadmium levels in pigs under intensive husbandry system

All the samples had cadmium levels lower than 0.5mg/kg which is the accepted maximum level. A mean of 0.13 ± 0.04 mg/kg was obtained with 0.04 mg/kg and 0.18 mg/kg minimum and maximum respectively; majority having between 0.11mg/kg and 0.14 mg/kg.

c. Mercury in pigs under intensive husbandry system

All the samples had mercury above 0.0155mg/kg which is the standard recommended level. Mean level was 0.12 ± 0.04 mg/kg and range was between 0.06 and 0.18 mg/kg. The figure below further explains the ranges in various Pigs.

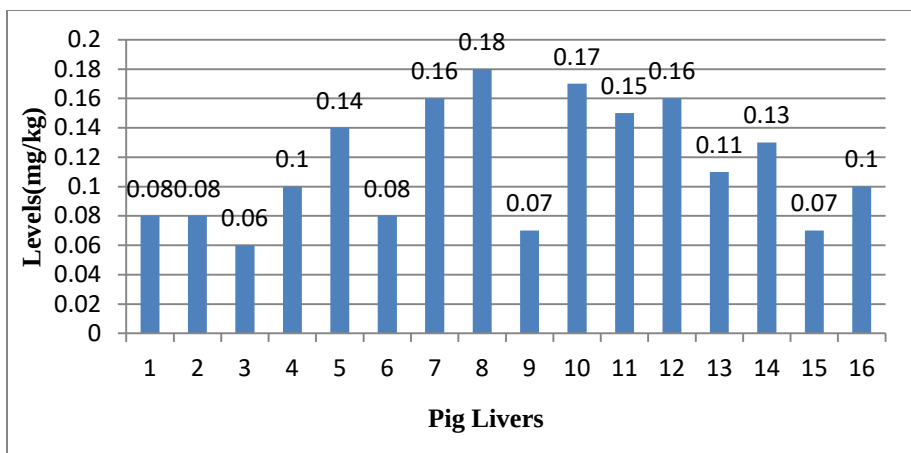


Figure 1: mercury levels in pigs under intensive husbandry system

B. Lead , cadmium and mercury in Extensive system

a. Lead in Pigs under Extensive Husbandry System

A mean of 0.09 mg/kg and a range of between 0.00 and 0.15 mg/kg were obtained. All the samples had lead levels lower than 0.5mg/kg the maximum recommended level. Slightly more than half (55%) had lead levels below 0.11 mg/kg

b. Cadmium levels in Pigs under Extensive Husbandry System

A Mean of 0.18 mg/kg and a range of between 0.10 and 0.25 mg/kg were obtained. 60% had cadmium level between 0.20 mg/kg and 0.25 mg/kg. All the samples had cadmium levels lower than 0.5mg/kg, the maximum recommended levels.

c. Mercury levels in Pigs under Extensive Husbandry System

A mean of 0.14 mg/kg and a range of between 0.00 and 0.44 mg/kg were obtained. All the samples had mercury levels higher than 0.0155mg/kg recommended. The figure 2 describes this further.

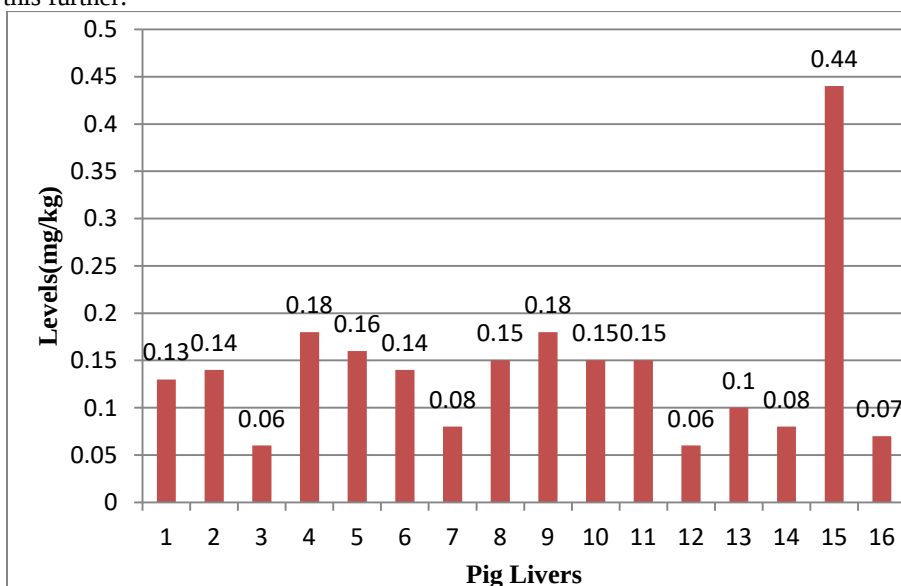


Figure 2: Mercury levels in Pigs under Extensive Husbandry System

C. Lead, Cadmium and Mercury in Forages

Cabbage leaves had the highest mean Lead levels of 0.60 ± 0.26 mg/kg with road side kikuyu grass and kikuyu grass inside the estate having mean levels of 0.60 ± 0.15 mg/kg and 0.59 ± 0.26 mg/kg respectively.

The highest Cd level of 0.83 ± 0.14 mg/kg was obtained in kikuyu grass inside the estate closely followed by 0.71 ± 0.30 mg/kg in the road side Kikuyu grass with the lowest level of 0.13 ± 0.09 mg/kg being obtained in potatoes.

Cabbage leaves had the lowest Mercury level of 0.00 ± 0.04 mg/kg with banana peelings having the highest levels of 0.03 ± 0.04 mg/kg. Refer to table 1.0 below.

Table 1: Lead, Cadmium and Mercury levels in forages

Plant	Lead Mean Mg/Kg	Cadmium Mean Mg/Kg	Mercury Mean Mg/Kg
Kales	0.42 ± 0.16	0.35 ± 0.17	0.02 ± 0.04
Potatoes	0.42 ± 0.09	0.13 ± 0.09	0.02 ± 0.04
Cabbages	0.60 ± 0.26	0.33 ± 0.16	0.00 ± 0.04
Bananas	0.52 ± 0.22	0.57 ± 0.25	0.03 ± 0.04
Kikuyu grass(roadside)	0.60 ± 0.15	0.71 ± 0.30	0.03 ± 0.02
Kikuyu grass (inside estate)	0.59 ± 0.26	0.83 ± 0.14	0.02 ± 0.05

D. Lead ,cadmium and mercury in Manufactured feeds

The highest Lead level of 0.43 ± 0.01 mg/kg in feed A was obtained with the lowest being 0.26 ± 0.01 mg/kg being obtained in feed B.

The highest Cadmium level in manufactured feed was 0.36 ± 0.12 mg/kg in feed D and the lowest level being feed A at 0.25 ± 0.02 with mg/kg.

The highest mercury level of 0.03 ± 0.05 mg/kg was obtained in feed B whereas the lowest level of 0.01 ± 0.03 mg/kg was obtained in feed D.

Feed D had the highest accumulation of heavy metals as opposed to feed A, B and C. Table 2 further explains each feed.

Table 2: Lead, Cadmium and Mercury levels in manufactured feeds

Brand	Lead Mean(mg/kg)±SD	Cadmium Mean(mg/kg)±SD	Mercury Mean(mg/kg)±SD
Feed A	0.43 ± 0.01	0.25 ± 0.02	0.02 ± 0.04
Feed B	0.26 ± 0.01	0.35 ± 0.0	0.03 ± 0.05
Feed C	0.34 ± 0.02	0.28 ± 0.17	0.01 ± 0.03
Feed D	0.38 ± 0.02	0.36 ± 0.12	0.01 ± 0.04

DISCUSSION

The study demonstrated that Pb levels in the liver of Pigs under intensive husbandry system were lower than the maximum recommended levels of 0.5 mg/kg set by (Tchounwou *et al.*, 2012). All samples were also lower than the EU maximum levels of 0.3 mg/kg (Govind, 2014). Findings of this study on the presence of Pb in the pig livers agrees with (Singh *et al.*, 2011) who pointed out that heavy metals can be found in livestock tissues and organs.

Under extensive husbandry system lead levels were lower than the maximum recommended levels of 0.5 mg/kg set by (Buculei *et al.*, 2014; Singh *et al.*, 2011). All samples were also lower than the EU maximum levels of 0.3 mg/kg (Govind, 2014). Extensively reared pigs

could have been exposed by indiscriminate dumping of waste. The levels in this study were higher than the levels found in pig livers in various countries; Canada (Kazemeini *et al.*, 2010), Hungary (Williams *et al.*, 2005), Sweden (Weiss & Larink, 1991) Environmental contamination (Kerin & Lin, 2010; Sherene, 2010), indiscriminate waste disposal like Nickel-Cadmium batteries (Sheppard, 1993), use of pesticides and Phosphatic fertilizers (Gimeno-García *et al.*, 1996) used in feeds of pigs could have also contributed the difference in the levels. Kikuyu grass on the roadside had slightly higher Pb levels of 0.60mg/kg compared to grass inside Munyaka which had levels of 0.59mg/kg. This is because in the past lead was used in gasoline and hence a major contributor to lead in soil, and automotive exhaust emitted when gasoline contained lead. Luilo & Othman, (2003) found high levels of lead in both soil and couch grass grown along the road in Dar es Salaam which agrees with the findings of this study. Carolyn & Aqilah, (2014) and Xiong, (1998) also detected Pb in forages produced in busy highways and near cities.

From the study findings in intensive system there was no sample with Cadmium above the EU maximum level of 0.2 mg/kg (Govind, 2014) This means that with time, the levels Cd in this study could reach toxic levels. While In extensive system presence of Cadmium could be due to intensive agricultural practices including the use of fertilizers and agricultural lime to raise crops used for manufacturing feeds, motor vehicle traffic in the estate could also be a contributor to this. The levels obtained in Italy by (Amodio-Cocchieri *et al.*, 2003) of 0.199mg/kg were much higher than the levels obtained in this study whereas the findings from this study were higher than the levels obtained from pig livers in other countries like Sweden (Tchounwou *et al.*, 2012), Slovenia (Gutleb, 1994) and Netherlands (Chowdhury, Mazumder *et al.*, 2016). From the study findings Cd in manufactured feeds could be as a result of certain Phosphatic fertilizers used in growing cereals that are later converted to manufactured feeds (Nagajyoti *et al.*, 2010). While in Cadmium in forage was the highest in within the estate which could be as a result of indiscriminate dumping of chemical and electronic waste.

All the samples in extensive system from the study contained Hg above permissible levels set by FAO/WHO (Tchounwou *et al.*, 2012) levels of 0.0155mg/day and they pose immediate health risk to human consumers. Bioaccumulation of mercury through food chain is a primary cause for much of the concern with this metal. The levels in the study were higher than the findings observed in pig livers from various countries; Netherlands (Chowdhury *et al.*, 2016), Sweden (Nagajyoti *et al.*, 2010; Tchounwou *et al.*, 2012) Canada (Tchounwou *et al.*, 2012). The presence of Mercury in all forages, though in low levels compared to Pd and Cd, could be due to contaminated soils on which they grew as plants take up Hg from the soil though in low levels (Sherene, 2010). The presence of Hg containing products found indiscriminately dumped in the area like the fluorescent tubes, electrical switches, used paint cans and batteries broken thermometers all of which contain some form of mercury could be responsible for soil contamination which end up being taken by plants (Nagajyoti *et al.*, 2010).

CONCLUSIONS

The study showed that pig livers under the study were not safe for human consumption due to the presence of mercury levels above the WHO maximum recommended levels. Through manufactured feeds, pigs were exposed to heavy metals and consequently man is exposed when he consumes pig products.

It was statistically significant that extensively produced pigs were having higher levels of Cadmium above the recommended levels. The detection of heavy metals in forages within Munyaka estate is a pointer to the fact that the estate is polluted by heavy metals hence humans are also at risk of being exposed to these toxic metals.

RECOMMENDATIONS

The Government should strictly enforce The Animal Diseases Act; Cap364 which prohibits extensive husbandry system of pigs hence reducing exposure of pigs to heavy metals.

Kenya bureau of standards (KEBS) and Department of Veterinary Services (DVS) should regularly Monitor and evaluate Pork to safeguard human health.

Further studies also need to be done on the levels of heavy metals in other livestock products so as to determine their safety for human consumption.

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