Assessment of heavy metal residues in retail meat and offals

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Abstract: This study was carried out to determine the residual levels of heavy metals (lead, cadmium, copper and zinc) in meat, liver and kidney of cattle, camel, sheep and buffalo collected from butcher´s shop in Beni-Suef, Egypt by using Atomic Absorption Spectrometer UNICAM 969. The means residue levels of lead in muscle of cattle, camel, sheep and buffalo were (3.135±0.35, 1.402±0.52, 0.94±0.81 and1.13±0.31ppm. While that of cadmium residual level in muscles were 0.2±0.01, 0.2±0.03, 0.7±0.03 and 0.91±0.02 ppm, respectively. As for copper the mean residual level were 0.79±0.18, 1.29±0.14, 1.9±0.19, 1.16±0.75 ppm, while that of zinc were 53.23±1.37, 57.64±1.46, 43.84±1.35 and 53.3±2.1 ppm, respectively. The level of heavy metals residues in liver of (cattle, camel, sheep and buffalo) were (3.99±0.1, 3.4±0.31, 1.8±0.85 and 0.174±0.07 ppm for lead; 0.25±0.043, 0.46±0.09, 0.35±0.02 and 0.00±0.00 ppm for cadmium; 56.09±10.55, 71.56±8.48, 109.81±13.5 and 26.12±3.82 ppm for copper; while these values were 36.74±1.16, 51.71±2.46, 38.06±1.56 and 22.12±1.25 ppm for zinc. More ever the means of heavy metal residues in kidney were 1.76±0.30, 1.41±0.23, 2.94±0.18 and 3.47±0.14 ppm for lead; 0.11±0.019, 0.85±0.26, 0. 21±0.1 and0.2±0.2 ppm for cadmium; 4.2±2.02, 1.77±0.9, 7.92±5.19 and 1.02±0.11 ppm for copper; 16.41±0.79, 17.49±0.6, 22.9±0.99 and 14.11±0.96 ppm for zinc for cattle, camel, sheep and buffalo, respectively. The residual level of all the metals in different tissues(muscle, liver and kidney) of cattle, camel, sheep and buffalo were found to be significantly difference$p \leq 0.05$.

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1. Introduction

Meat is an important part of the human diet as well as an important source of a wide range of nutrients, but it may also carry certain toxic substances. Although the level of these toxic substances in muscle is generally low, the offal such as liver and kidney, showed higher concentrations of toxic substances than most other foods. Chemical residues in meat may present a hidden but they represent a serious threat to public health. Because residues generally cannot be seen, smelled or tasted, they are difficult to detect. The monitoring of raw meat for chemical residues is necessary to ascertain that approved compounds are not being misused and are not presenting a danger to consumers (***Pullen 1990***). All heavy metals are toxic at certain levels of intake, as lead and cadmium play no useful role and pose a risk for animal and human health. Heavy metals detected in muscle, liver and kidney of cattle by ***Akan et al. (2010); Khalafalla et al. (2011); Ambushe et al. (2012); Bala, et al. (2013); AbdEl-Salam et al. (2013) and Badis et al. (2014).***Many investigators were detected the heavy metals in meat and edible offal (liver and kidney) in camel ***(Eltahir et al., 2010 and Badis et al., 2014***), sheep (***Akan et al., 2010; Abd El-Salam et al.,2013; Badiset al., 2014andAkoto et al., 2014***) and buffalo tissues (***Abd El-Salam et al., 2013 and Mehmood et al., 2014).*** Heavy metal causes many symptoms as hepato toxic effects and increase in liver function test parameters in lead **(Adeyemi *et al.*, 2009),** While various cardiovascular disorders such as hypertension and cardio myopathy and both carcinogenic and anti-carcinogenic activities in cadmium were reported by **Dong *et al.* (2009)**. The copper, in high doses causesoxidative damage in liver in forms of granular degeneration, necrosis of hepatocytes (**Emin *et al.*, 2010)**. Zinc causes (in high dose) "metal fume fever"; which causes fever, depression, malaise, cough, vomiting, salivation and headache **(Abd EI-Salam, 2013)**. A frequently found harmful feature of human diets is the simultaneous presence of toxic substances in food stuffs.

Therefore, this study was carried out, to determine heavy metal residues in meat, liver and kidney in carcasses of (cattle, camel, sheep and buffalo) at retail butchers shops in Beni-Suef Governorate. The public health significance of such residues was discussed.

2. Material and method

Collection of samples:

A total of 300 samples were collected from cattle, camel, sheep and buffalo carcasses from butcher´s shop in Beni-suef City. Each carcass represented by 75 samples from each liver and kidney and muscles. The collected samples were identified and rapidly transported in ice box to the laboratory, for examination.

Preparation of samples:

The samples were prepared according to the wet digestion method recommended by Graig and Wayne (1984).

Quantitative determination of heavy metal (cadmium, lead, copper, zinc) residues in the examined sample was conducted using UNICAM 969 Atomic Absorption Spectrophotometer. All results were statistically analyzed using Knapp and Miller, 1992 SPSS statistics 17.0 software program.

Result and discussion

The residual level of lead was observed in muscle samples of different animals (cattle, camel, sheep and Buffalo), each constituting 3.135±0.35, 1.402±0.52, 0.94±0.81 and 1.31±0.31 respectively. 46%, 84%, 100% and 88% of the examined muscle samples of cattle, camel, sheep and buffalo, respectively, were exceeded the limit (0.1 ppm) of ***Egyptian Organization for Standardization "E.O.S." (1993).*** Nearly similar values were detected by ***Dallatuet al. (2013); Badis et al. (2014)***; ***and Mehmood et al. (2014).***On the other hand 100%, 28%, 8% and 20% of the examined liver samples of cattle, camel, sheep and buffalo,respectively exceeded the permissible limit (0.5ppm) reported by ***"E.O.S." (1993)***. These results were similar to those recorded by ***Akan et al. (2010); Bala et al. (2012); Abd El-Salam et al. (2013) and Badiset al. (2014).*** Regarding lead residual level in kidney samples, 96%, 92% of cattle and camel sample sand all kidney samples of sheep and buffalo were exceeded the maximum residual limit (0.5 ppm) recorded by ***E.O.S. (1993)***. These results are in close agreement with those reported by ***Akan et al. (2010); Abd El-Salam et al. (2013); Akotoet al. (2014) and Mehmood et al. (2014)***. There were significant difference ($p \leq 0.05$) between examined liver and kidney samples of different animal species, while the muscle samples were not significantly different. Statistical analysis of different organs (muscle, liver and kidney) within the same species revealed that, the concentration of lead in liver were significantly ($p \leq 0.05$) higher than muscle and kidney in cattle and camel, while in sheep and buffalo the kidney samples were significantly ($p \leq 0.05$) higher than muscle and liver.

Table. Statistical analytical results of heavy metals residues in similar tissues of examined animal species.

Metal	Organ	Cattle	Camel	Sheep	Buffalo
Lead	Muscle	3.135±0.35^{aA}	1.402±0.52^{Aa}	0.94±0.81^{aC}	1.31±0.31^{aC}
	Liver	3.99±0.1^{aB}	3.4±0.31^{bB}	1.8±0.85^{bA}	0.174±0.07^{bA}
	Kidney	1.76±0.30^{aA}	1.41±0.23^{aC}	2.94±0.18^{bB}	3.47±0.14^{Bb}
Cadmium	Muscle	0.2±0.01^{aA}	0.2±0.03^{bB}	0.7±0.03^{cC}	0.91±0.02^{dC}
	Liver	0.25±0.043^{aB}	0.46±0.09^{bA}	0.35±0.02^{cA}	0.00±0.00^{cA}
	Kidney	0.11±0.019^{aA}	0.85±0.26^{bA}	0. 21±0.1^{aB}	0.2±0.2^{aB}
Copper	Muscle	0.79±0.18^{aB}	1.29±0.14^{aB}	1.9±0.19^{aB}	1.16±0.75^{aB}
	Liver	56.09±10.55^{Aa}	71.56±8.48^{aA}	109.81±13.5^{bA}	26.12±3.82^{bA}
	Kidney	4.2±2.02^{aA}	1.77±0.9^{aB}	7.92±5.19^{aB}	1.02±0.11^{aB}
Zinc	Muscle	53.23±1.37^{aC}	57.64±1.46^{aC}	43.84±1.35^{bC}	53.3±2.1^{aC}
	Liver	36.74±1.16^{aA}	51.71±2.46^{aA}	38.06±1.56^{aA}	22.12±1.25^{cA}
	Kidney	16.41±0.79^{aB}	17.49±0.6^{aB}	22.9±0.99^{bB}	14.11±0.96^{aB}

a, b, c and d indicate significant difference between similar organs in different species, while A, B and C indicate significant difference between different tissues within species at $p \leq 0.05$. Results expressed as means± S.E.

Kidney is considered as the target tissue of lead accumulation. Lead is frequently the cause of accidental poisoning in domestic animals, especially cattle. Absorbed lead is stored mainly in the liver and kidney, and like cadmium, it accumulates in tissues of animals. Lead is a wide spread environmental contaminant from largely airborne sources, such as industrial emissions and the combustion of fuel containing lead additives. The fallout from these sources is a particular problem to grazing animals this held the view reported by ***Humphreys (1991)***. Exposure to lead can occur from many sources but usually arises from industrial use. Lead and its compounds can enter the environment at any time during mining, smelting or processing. Major sources of lead contamination in other developing countries, result from metallurgical industries, lead-acid battery processing, lead wire and pipe factories, metal foundries, metal recyclers, leaded gasoline, lead water pipes in old houses, and scrap and smelter solid wastes**.** The main uses of lead are in batteries, pigments, plumbing, and gasoline, solder and steel products, food packing, glassware, ceramic products and pesticides reported by **(De Madureira *et al.*, 2009).** However **Lin *et al.* (2009)** stated that exposure to lead chemicals can occur. Through inhalation, ingestion or occasionally dermal Lead affects humeral immunity (perhaps through interference with macrophage function) and may or may not affect cellular immunity. The lead provide adjuvant signals to promote lymphocyte proliferation and enhance adaptive immune responses to unrelated antigens, enhance allergic and hypersensitivity reactions to environmental antigens and can activate neo antigen-specific T cells **(Ohsawa, 2009)**.

Regarding cadmium residual level the tabulated data illustrated that none of the examined muscle samples of cattle and camel exceeded the permissible limit (0.5 ppm) recommended by ***FAO/WHO (2000)***, while 96% and 100% of Sheep and buffalo muscle samples, exceeded the permissible limit with mean value of 0.7±0.03 and 0.91±0.02ppm. Nearly similar findings were detected by ***Khalafalla et al. (2011); Ambushe et al. (2012); Abd El-salam (2013) andBadis et al. (2014).***None of the examined liver samples of sheep exceeded the permissible limit(0.5 ppm) of ***FAO/WHO (2000)***, all the examined liver buffalo samples were below limit of detection, while 12% and 48% of examined liver sampled of cattle and camel, exceeded this limit. Nearly similar findings were detected by ***Khalafalla et al. (2011);Bala et al. (2012); and Mohamed (2014).***None of the examined kidney samples of cattle, sheep and buffalo exceeded the permissible limit (1.0 ppm) reported by ***FAO/WHO (2000)***, while 16% of camel kidney samples were exceeded this limit in relation to cadmium residual level. Nearly similar results were recorded by ***Khalafalla et al. (2011); Bala et al. (2012) and Mohamed (2014).*** There were a significant difference ($p \leq 0.05$) between muscle and liver samples of different animal species (cattle, camel, sheep and buffalo), while camel kidney samples were significantly ($p \leq 0.05$) higher than kidneys of cattle, sheep and buffalo. On the other hand there were significant difference ($p \leq 0.05$) between examined muscle, liver and kidney samples of each animal spices (cattle, camel, sheep and buffalo). Cadmium is widely distributed throughout the environment and the traces of cadmium can be detected in all plants, animals and foodstuffs. The application of phosphate fertilizers every year deposits considerable amount of cadmium in farmlands, thus increasing its level in soil. Additionally, acid rain may increase the amount of cadmium in soil and expand the concentration of metal in agricultural products, this reported by **(Busceme *et al.*,1997).** Some of waste materials may contain some heavy metals such as Lead, cadmium, arsenic and others that are dangerous to both human and animal health. Cattle and other ruminants graze freely on such environment and drink water from ponds, streams, rivers and other possible contaminated water sources. Animals in the process may be exposed to high levels of these metals in the environment, this agrees with that reported by **Nwude *et al.*(2010).** Results recorded in the table revealed that none of examined muscle samples of cattle, camel, sheep and buffalo exceeded the limit of ***Egyptian Organization for Standardization "E.O.S." (1993)*** whichis 20 ppm. Nearly similar values were detected by ***Abd El-Salam et al. (2013); Purnama et al. (2014) and Badis et al. (2014).***Regarding liver samples 76%, 92%, 84% and 52% ofexamined samples of cattle, camel, sheep and buffalo, respectively, exceeded the permissible limit (20 ppm) of ***"E.O.S." (1993)***. Nearly similar findings were detected by ***Eltahir et al. (2010); Abdelrahman et al. (2013); AbdEl-Salam et al. (2013) and Akoto et al. (2014).*** None of examined buffalo kidney samples exceeded the limit (20ppm) of ***EOS (1993)***, while 4% of examined kidney samples of cattle, camel and sheep were exceeded that limit. The liver samples of sheep were significantly ($p \leq 0.05$) higher than livers of other animal species (cattle, camel and buffalo), while the kidney and muscle examined samples of different animal spices were not significantly different. Residual level of copper in liver of (cattle, camel, sheep and buffalo), were significantly ($p \leq 0.05$) higher than its level in muscle and kidney. High Copper levels in liver can be caused by contamination of pasture and by industrial emissions, this agrees with that reported by ***Tokarnia et al. (2000)***. Major man-made releases of copper to the environment are from metal producing industries and other significant sources include sewage treatment processes. Since copper is also a naturally occurring element in the earth crust. It is also naturally present in rocks, soils, sediments and certain natural waters. This agrees with hypothesis reported by ***United Stated Environmental Protection Agency,(2003).*** The Copper is an essential component of various enzymes and it plays a key role in bone formation, skeletal mineralization and in maintaining the integrity of the connective tissues. Copper is essential for good health, but very high intake can cause health problems such as liver and kidney damage, that stated by**(ATSDR, 2004)**. Copper (cu) play an important role for farm animal health and productivity through their function as a main component of many essential metallo enzymes. These enzymes regulate the metabolism of carbohydrates and lipids and also function as antioxidant this is in agreement with (**Andrieu,2008).** The obtained results in the table indicated that the mean value of zinc residual level in muscle samples of cattle, camel, sheep and buffalo were 53.23, 57.64, 43.84 and 53.3 ppm, in which 96%, 96%, 72% and 92% of examined samples for respectively, exceeded the limit (40ppm) of ***FAO/WHO (1989).*** Nearly similar results were recorded by ***Dallatu et al. (2013) and Badis et al. (2014)***. None of the examined kidney samples exceeded the limit of ***FAO/WHO (1989)*** which is 40 ppm. On the other hand 28%, 80% and 36% of examined of cattle, camel and sheep liver samples, respectively, exceeded the limit (40 ppm) of ***FAO/WHO (1989)***, while none of the examined liver samples of buffalo exceeded that limit. Nearly similar results were recorded by ***Abdelrahman et al. (2013)*** and ***Purnama et al.(2014)***. Zinc residual level in muscle samples of sheep were significantly ($p \leq 0.05$) lower than other species (cattle, camel and buffalo), also liver samples of buffalo were significantly ($p \leq 0.05$) lower than other animal species (cattle, camel and sheep), while the kidney samples of sheep were significantly ($p \leq 0.05$) higher than other animal species. The zinc residual levels of muscle samples were significantly higher ($p \leq 0.05$) than liver and kidney in all examined samples (cattle, camel, sheep and buffalo), therefore, muscle is considered as the target tissue of zinc accumulation. Humans are exposed to small amounts of zinc in foods and drinking water each day. Levels in air are generally low and fairly constant. Occupational to zinc occurs in a number of mining and industrial activities, such as the manufacture of zinc-containing alloys, paints, and pesticides. This agrees with that reported by **Karen and Thomas (1996)**. Red meats, especially beef, lamb and liver have some of the highest concentrations of zinc in food. The concentration of zinc in plants varies based on levels of the element in soil. This substitutes the findings reported by **Malinowska and Szefer (2007)**. Zinc is an essential element in human diet. Too little Zn can cause problems; however, too much Zn is harmful to human health. (**ATSDR, 2004)**. Zn concentration in air over 15mg per cubic meter, result “metal fume fever”; which causes fever, depression, malaise, cough, vomiting, salivation and headache. Cadmium replaces Zn in many enzymes, therefore a higher amount of Zn is required to overcome the toxic effects of cadmium. That stated by **(Abd EI-Salam, 2013)**.

It could be concluded that, the concentrations of all metals in the muscle, liver and kidney of cattle, camel, sheep and buffalo were found to be significant at $p \leq 0.05$. Livers and kidneys were found to have the highest residual levels of lead and cadmium, while muscle have the highest residual levels of zinc. When compared to one another (cattle, camel, sheep and buffalo), there did show significant differences in the level of heavy metals. Hence, the residual levels of lead and zinc were exceeded from the permissible limit of detection in some of samples exception of cadmium and copper which were within the tolerance limits in most samples.

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