Heavy Metal Levels in Offals of Cow's Carcasses

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ABSTRACT

A total of 100 samples of the cow liver, kidney, rumen, intestine and lung (20 of each) were collected from Sharkia Governorate markets (Egypt) during autumn and winter 2008-2009 for detection and determinations of cadmium, lead, manganese and iron residues. The obtained results showed that the mean cadmium residues were 2.38, 1.81, 3.186, 2.09 and 0.913 ppm respectively in the examined liver, kidney, rumen, intestine and lung, respectively; while, the mean levels of lead residues in the mentioned samples were 8.618, 9.176, 11.0, 8.631and 7.104 ppm, respectively. The mean levels of the manganese residues were 7.912, 7.937, 5.10, 3.65 and 4.38 ppm in the examined cow liver, kidney, rumen, intestine and lung samples respectively, also; the average levels of the iron concentrations in the examined samples were 38.83, 49.28, 21.91, 11.245 and 27.08 ppm respectively. The most probable sources of these contaminations are feed and / or water rather than inhalation because the metal contents of the rumen and intestine were significantly higher than those in the lung.

Cadmium and lead residues exceeded the permissible limits in the most examined samples. Moreover, both manganese and iron exceeded the permissible limits in the most samples of liver and kidney; while, the converse result was recorded in the other three examined organs. From the obtained results, it could be concluded that most of the liver and kidney samples contained the tested heavy metals in levels above the permissible limits, this result explained by the role of liver and kidney for detoxifying the body toxins and the tendency of heavy metals to accumulate in these organs.

INTRODUCTION

The liver and kidneys are the main filters for detoxification the body from toxins, which come from foods, water and the environment. Thus, both liver and kidney were highly affected when exposed to the heavy metal contaminations rather than other tissues among the animal and poultry bodies *(1,2)*. On the other hand, offals are culinary term used to refer to the entrails and internal organs of a butchered animal. Offals in Egypt were widely used as a cheap and popular source of animal protein. The internal organs as lung, stomach and intestine receive the environmental pollutants as lead and cadmium via the contaminated air or food *(3)*; thus, these internal organs also exposed to the environmental contaminants rather than the skeletal muscles *(3,4)*.

Heavy metals constitute the most widely distributed group of highly toxic and long retained pollutants. The probable sources of the heavy metals may be industrial effluents discharged from rubber, paints, batteries and plants, or may be agricultural sources as fungicides, herbicides and phosphate fertilizers. Also, organic manure and decaying plant and animal residues are considerable sources of these pollutants *(5)*. Moreover, rocks and soil may be natural sources of these elements *(6)*. At the last few decades, heavy metals especially from man made pollution sources were continuously released into aquatic and terrestrial ecosystems and therefore, the concern about the effect of these pollutants on the ecosystem is growing *(7)*.

Cadmium is a non essential and relatively rare metal; it has a long biological half life, which is about 30 years in human *(8)*. It damages the proximal tubules of the kidney nephron, leads to leakage of low molecular weight proteins and essential ions like calcium into the urine, which leads to kidney failure *(9)*. Moreover, it causes calcium losses and leads to bone weakening resulting to itai- itai disease *(10)*. Furthermore, the cadmium and cadmium compounds were classified as class 1 human carcinogens *(11)*. On the other aspect, lead is a non essential heavy metal and it is widespread constitute of the earth's crust. It has always been present in soil, ranging in total content from 2 to 200 μg/gm with average 16 μg/gm, absorbed lead accumulate in animal tissues and mainly stored in liver *(12)*. The biological half life of lead in bone is about 27 year *(13)*. Chronic lead poisoning leads to mild anemia, mental deterioration, aggressive behavior, peripheral neuropathy and kidney damage *(14)*. Moreover, chronic lead exposure can produce chromosomal aberrations, cancer and birth defects *(15)*. In spite of the both manganese and iron are essential elements, these metals can be exhibited a serious hazardous effects if exceeded the permissible limits. Manganism (manganese toxicity) leads to decrease mental capability in children and causes symptoms identical to Parknson ′s disease in adults *(16)*. Although the iron poisoning is seldom, the symptoms of its toxicity are hemorrhagic gastroenteritis associated with diarrhea and vomiting *(17)*.

Because the available Egyptian studies about the heavy metal pollution in offals are scanty and insufficient; therefore, the aims of the present study were the detection and determinations of cadmium, lead, manganese and iron residues in liver, kidney, rumen, intestine and lung of the cow and evaluate their fitness for the human consumption depending on the results of this study.

MATERIAL AND METHODS

Collection of samples

A total of 100 samples of the cow liver, kidney, rumen, intestine and lung (20 of each) were collected from Sharkia Governorate markets (Egypt) during autumn 2008 and winter 2008-2009. Obtained samples were placed in polyethylene bag, identified and kept frozen till the analysis was conducted.

Preparation of Samples

The samples were prepared according to the cited method with modifications *(18)*. One gram of each tissue samples was macerated in screw capped bottle by sharp scalp. Five ml. of digesting solution (3 ml. of nitric acid + 2 ml. perchloric acid) were added to each sample. The bottles were tightly closed and the contents were vigorously shacked and allow to stand overnight at room temperature. The samples were placed for three hours in water bath at 70°C. (To ensure complete digestion). The bottles were cooled at room temperature and then diluted to 30 ml with deionized water and thoroughly mixed and the digest was filtered. The clean filtrate of each sample was kept at room temperature until analyzed for determination of the heavy metal contents.

Preparation of blank solution

Blank solution consists of 3 ml. of nitric acid and 2 ml. perchloric acid was subjected to digestion, dilution and filtration as previously mentioned in the preparation of the examined tissue samples to detect any trace of the studied metals in acids or deionized water used.

Quantitative determination of the examined metal residues

Quantitative determination of cadmium, lead, manganese and iron residues was conducted by using UNICAM 969 Atomic Absorption Spectrophotometer in Toxicology Unit, Animal Health Research Institute, Dokky, Giza. The concentrations of metals (ppm) in the examined samples were calculated according the following equation:

Concentration of metal in samples = $\frac{AxB}{W}$, where A= metal concentration (ppm) in the prepared sample from the digital scale reading of Atomic Absorption Spectrophotometer, B= the final volume of the prepared sample, W= weight of sample in gram.

Statistical analysis

Statistical analysis of data was conducted using "Statistic for animal and veterinary science" *(19)*.

RESULTS AND DISCUSSION

Table 1. Heavy metal concentrations (ppm, wet weight) in the examined cow liver, kidney, rumen, intestine and lung (n= 20 for each).

Examined Tissue \ Metal		Cadmium	Lead	Manganese	Iron
Liver	Minimum	1.2	6.5	5.5	12.4
	Maximum	3.5	11.0	9.5	56.5
	Mean ±S.E.	2.38 ±0.149^{b}	8.618 ±0.237^{b}	7.912 ±0.223^{a}	38.83 ±2.951^{b}
Kidney	Minimum	0.25	7.3	4.5	20.4
	Maximum	4.2	10.5	14.5	75.4
	Mean ±S.E.	1.81±0.265^{b}	9.176 ±0.202^{b}	7.937±0.687^{a}	49.28 ±3.57^{a}
Rumen	Minimum	1.3	7.6	2.3	7.2
	Maximum	4.6	14.5	9.4	38.0
	Mean ±S.E.	3.186 ±0.22^{a}	11.0 ±0.436^{a}	5.10 ±0.390^{b}	21.91 ±1.87^{c}
Intestine	Minimum	0.9	6.5	2.2	N.D.
	Maximum	4.3	10.4	5.2	34.0
	Mean ±S.E.	2.09 ±0.27^{b}	8.631±0.239^{b}	3.65 ±0.186^{c}	11.245 ±2.21^{d}
Lung	Minimum	0.55	N.D.	1.4	4.7
	Maximum	1.2	12.0	6.7	50.2
	Mean ±S.E.	0.913±0.042^{c}	7.104 ±0.899^{c}	4.38 ±0.306^{c}	27.08 ±2.81^{c}

N.B.: The difference between letters within the same category (lead, cadmium, manganese and iron) means the variation between the values of the examined tissue residues is significant at ($p \leq 0.05$) level.

Table 2. Frequency distribution of the heavy metal residues in the examined cow liver, kidney, rumen, intestine and lung (n= 20 for each).

Metal			Cadmium	Lead	Manganese	Iron
Permissible Limits (ppm)			0.5 *(20)* *(2)* &1.0 *(20)* *	0.5 *(20)*	5.4 *(21)*	30 *(22)*
Liver	Within P.L.	No.	0.0	0.0	0.0	5
		%	0.0	0.0	0.0	25
	Exceed P.L.	No.	20	20	20	15
		%	100	100	100	75
Kidney	Within P.L.	No.	6	0.0	6	3
		%	30	0.0	30	15
	Exceed P.L.	No.	14	20	14	17
		%	70	100	70	85
Rumen	Within P.L.	No.	0.0	0.0	11	17
		%	0.0	0.0	55	85
	Exceed P.L.	No.	20	20	9	3
		%	100	100	45	15
Intestine	Within P.L.	No.	0.0	0.0	20	18
		%	0.0	0.0	100	90
	Exceed P.L.	No.	20	20	0.0	2
		%	100	100	0.0	10
Lung	Within P.L.	No.	0.0	4	15	11
		%	0.0	20	75	55
	Exceed P.L.	No.	20	16	5	9
		%	100	80	25	45

: The permissible limits of cadmium in cattle liver and kidney are 0.5 and 1 ppm respectively(20)*, and in offal is 0.5 ppm according to Slovak Republic Standard of cadmium in edible offal, which mentioned in another study *(2)*.

The obtained results in Table 1 revealed that the mean concentrations of the cadmium residues in the examined cow liver, kidney, rumen, intestine and lung samples were 2.38 ±0.149, 1.81±0.265, 3.186 ±0.22, 2.09 ±0.27 and 0.913±0.042 ppm respectively. These levels were higher than those recorded in cattle liver, kidney and lung in Palestine *(23)*. Moreover, lower cadmium levels in organs and offals than those in the current study were recorded in Spain *(24)*, Greek *(25)* and Nigeria *(2)*.

Table 1 showed that the average values of the lead residues in the examined cow liver, kidney, rumen, intestine and lung were 8.618 ±0.237, 9.176 ±0.202, 11.0 ±0.436, 8.631±0.239 and 7.104 ±0.899 ppm respectively. These obtained levels were higher than those previously reported in sausage samples in Korea *(26)* and Egypt *(12)* in levels of 0.15 and 3.1 ppm respectively. Moreover, lower lead residues than those in the present investigation were estimated in internal organs in other recent studies in Palestine (0.2- 4.7 ppm) *(23)*, Romania (0.018-0.041 ppm) *(27)* and Nigeria (0.2- 0.65 ppm) *(2)*.

Regarding the manganese residues, the mean levels of this metal were 7.912 ±0.223, 7.937±0.687, 5.10 ±0.390, 3.65 ±0.186 and 4.38 ±0.306 ppm in the examined cow liver, kidney, rumen, intestine and lung samples respectively. These findings were coincided with those detected in pig offal in Spain (3.32 ppm) *(28)*. On the other hand, lower manganese levels than those in our study were detected in cattle organs and meat in Poland (0.11- 1.8 ppm) *(29)* and Uruguay (0.05- 0.17 ppm) *(30)*.

The average concentrations of the iron residues in the examined cow liver, kidney, rumen, intestine and lung samples were 38.83 ±2.951, 49.28 ±3.57, 21.91 ±1.87, 11.245 ±2.21 and 27.08 ±2.81 ppm respectively. Our estimations in liver were agreed with those detected in cattle liver in Poland (44 ppm)*(29)*; while, this study recorded higher iron levels in kidney (72 ppm) than those in the current investigation. On contrast, the results recorded in pig offals in Spain *(28)* coincided with our findings concerning iron residues in kidney; while, this study detected higher iron residues in liver than our figures. On the other hand, higher iron levels (27.2 ppm) than our findings in intestine (11.245 ppm) were detected in sausage in Korea *(26)*.

Regarding the statistical analysis of the obtained results, Table 1 showed that both cadmium and lead residues were detected in significant higher levels in rumen than those in other organs followed by liver, kidney and intestine without significant variations within them; while, the lung samples recorded the significant lower levels of these two metals. This result indicates that the ingested feed and / or water were the main sources of both cadmium and lead contaminations in the examined cow organs rather than air inhalations. On the other aspect, liver and kidney contained significant higher manganese levels than those in rumen which had significant higher levels of this metal than intestine and lung. Moreover, the iron residues distribution was nearly similar to manganese, the examined kidney contained the significant higher iron residues followed by liver and both rumen and lung; while, the intestine recorded the significant lower iron residues than those the other examined organs.

Concerning the comparison between the heavy metal levels in the present investigation and the maximum recommended permissible limits, the obtained results in Table 2 showed that all the examined samples contained both cadmium and lead residues in levels exceeded the recommended permissible limits except 6 (30%) kidney samples and 4 (20%) lung samples had cadmium and lead in residues within the permissible limits respectively. On the other hand, manganese residues exceeded the permissible limits in 20(100%), 14(70%), 9(45%), zero(0.0%) and 5(25%) of the examined liver, kidney, rumen, intestine and lung samples respectively; while, iron residues exceeded the permissible limits in 15(75%), 17(85%), 3(15%), 2(10%) and 9(45%) of the previously mentioned samples respectively. These results indicated that the cadmium and lead residues exceeded the permissible limits nearly in all the examined samples. Moreover, manganese and iron exceeded the permissible limits in the most liver and kidney samples; while, the converse result was recorded in the other three examined organs. From the obtained results, we could concluded that most liver and kidney samples contained the tested heavy metals in levels exceeded the permissible limits, this result explained by the charge of liver and kidney for detoxifying of the body toxins and the tendency of heavy metals to accumulate in these organs *(4)*.

In general, the examined cow liver, kidney, and offals contained considerable high levels of heavy metals especially cadmium and lead which exceeded the permissible limits in the most samples. The most probable sources of these contaminations are feed and water rather than air inhalation because the metal contents of the rumen and intestine significantly higher than those in lung.

Conclusion and Recommendations

1- Consumption of liver, kidney and offals must be limited to avoid the exposure to high levels of the metal contaminations.

2- Continuous monitoring of the internal organs and offals for detection of environmental contaminations is recommended.

3- Meat product plants and restaurants must be kept under continuous governmental control to avoid illegal using of offals and internal organs.

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الملخص العربي

مستويات المعادن الثقيلة في مخلفات ذبائح الأبقار

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تم إجراء هذه الدراسة لتقييم مستويات بعض المعادن الثقيلة في الكبد، الكلى، الكرش، الأمعاء و الرئة، تم تجميع عدد مائة عينة من الأعضاء المذكورة (٢٠ من كل نوع) من ذبائح ماشية الأبقار من أسواق محافظة الشرقية، و قد أسفرت الدراسة عن النتائج التالية. كان متوسط تركيزات الكادميوم في العينات المذكورة ٢,٣٨ ، ١,٨١ ، ، ٣,١٨٦ ، ٢,٠٩ ، ٠,٩١٣ جزء في المليون عل التوالي، في حين كان متوسط تركيزات الرصاص في نفس العينات السابقة ٨,٦١٨ ، ٩,١٧٦ ، ١١,٠٠ ، ٨,٦٣١ ، ٧,١٠٤ جزء في المليون علي التوالي، أما متوسط تركيزات المنجنيز فقد كانت ٧,٩١٢، ٧,٩٣٧، ٥,١٠ ، ٣,٦٥ ، ٤,٣٨ جزء في المليون في عينات الكبد، الكلى، الكرش، الأمعاء و الرئة علي التوالي، و كان متوسط تركيزات الحديد في نفس العينات السابقة ٣٨,٨٣، ٤٩,٢٨، ٢١,٩١، ١١,٢٤٥ ، ٢٧,٠٨ جزء في المليون علي التوالي.

كان مستوى كلا من الكادميوم و الرصاص في الرئة أقل بشكل معنوي عنها في باقي الأعضاء محل الدراسة مما يشير لأن المصدر الأساسي للتلوث بتلك العناصر يأتي عن طريق الغذاء و الماء من خلال الجهاز الهضمي أكثر منه عن طريق التنفس من خلال الرئتين.

كانت مستويات الكادميوم و الرصاص في معظم العينات تتعدى الحدود القصوى المسموح بها، أما مستويات المنجنيز و الحديد فقد تعدت الحدود القصوى في معظم عينات الكبد و الكلى و خلافا لذلك كان هذان العنصرين في مستويات أقل من تلك الحدود في أغلب عينات الكرش، الأمعاء و الرئة، و علي ذلك تكون عينات الكبد و الكلى هي الأكثر عرضه للتلوث بشكل عام و يرجع ذلك لطبيعة وظيفة هذين العضوين من حيث قدرتهما على استخلاص العناصر السامة من الدم.

من نتائج الدراسة الحالية نوصي بتقليل الاعتماد علي أعضاء و مخلفات ذبائح ماشية الأبقار كمصدر للبروتين الحيواني، و كذلك نوصي بتشديد الرقابة الحكومية لمنع استخدام تلك المخلفات كبديل للحوم في عمليات التصنيع و في المطاعم.