Bull Environ Contam Toxicol (2009) 83:265–268
DOI 10.1007/s00128-009-9704-x

Distribution of Toxic Metals in Organs of Local Cattle, Sheep, Goat and Poultry from the West Bank, Palestinian Authority

K. M. Swaileh · A. Abdulkhaliq · R. M. Hussein · M. Matani

Received: 8 November 2008 / Accepted: 26 February 2009 / Published online: 17 March 2009

Abstract Graphite furnace atomic absorption spectrophotometry was used to measure the concentrations of Cu, Cd, Pb, and Zn in muscles and internal organs (liver, kidneys, heart, and lungs) of cattle, sheep goat and poultry sampled from local markets in the West Bank, Palestinian Authority. Mean levels of metals (dry weight basis) during this study were as follows: Cd: 0.34–0.57 μg/g, Pb: 0.2–4.7 μg/g, Cr: 0.44–3.62 μg/g and Cu: 1.03–217.9 μg/g. Muscles and internal organs of each species were found to have statistically different metal levels. Generally, livers and kidneys were found to have the highest levels of metals and muscles the lowest levels. When compared to each other, the four animal groups either did not show any significant differences or no clear trends. Compared to results reported in the literature, our results were comparable to or less than most of the studies reported from clean sites in different countries.

Keywords Metals · Meat · Organs · West Bank

Environmental pollution with heavy metals is a dangerous problem that is recognized worldwide. Metals can be found in water, soil, air, plant and animal tissues. Monitoring their levels is of great importance for the wellbeing of all life forms. As, metals tend to bioaccumulate in the environment and biomagnify in food chains (Caggiano et al. 2004), their levels might reach toxic limits even when found in low concentrations in environmental samples. Metals can interfere with the functions of enzymes and are responsible for many diseases, especially cardiovascular, renal, nervous and even bone disorders (Freiberg et al. 1986). Besides, some metals are considered as being carcinogenic, mutagenic and teratogenic in experimental animals (Pitot and Dragon 1996). Metal levels in animal tissues are organ specific. Highest levels of heavy metals are usually found in the liver and kidneys (Abou-Arab 2001; Lazarus et al. 2005; Villar et al. 2005). In many Middle Eastern countries, internal organs (liver, kidneys, heart, and lungs) are sold and consumed as a valuable food source. Therefore, evaluating heavy metal levels in internal organs is important for safety and health purposes.

In the West Bank, because of the long unstable political situation in the country, environmental issues were completely neglected and many areas of the country became contaminated especially with wastewater and solid wastes. Cattle, goats and sheep herds are usually seen grazing in and around contaminated areas. Their meat or dairy products reach the local market without any monitoring with regard to heavy metal levels. In addition, local standards for metal levels in meat or internal organs of animals are lacking. Therefore, the present study aims at evaluating levels of metals (Cu, Cd, Pb, and Cr) in muscles, liver, kidney, heart and lung of cattle, goat, sheep and poultry from Palestinian markets.

Materials and Methods

A total of 140 organ and muscle samples from cattle, sheep, goat, and poultry were collected from markets in the West Bank during 2007. Samples were kept in plastic bags in an ice box before being transferred to the laboratory at Birzeit University. Samples were oven-dreid at 60°C till

K. M. Swaileh (✉) · A. Abdulkhaliq · R. M. Hussein · M. Matani
Department of Biology and Biochemistry, Birzeit University, P.O. Box 14, West Bank, Palestinian Authority
e-mail: kswaileh@birzeit.edu

constant weights were reached. Thereafter, samples were ground to powder using a grinder with stainless steel knife, then stored in clean glass vials for later analysis.

Sub-samples (about 0.2 g tissue powder) were digested in a mixture of 1:1 nitric: perchloric acids (Suprapur, Merck) (Swaileh et al. 2004). At the end of digestion, volumes were adjusted to 10 mL using double distilled water. Blanks and reference material (Copepod Homogenate: MA-A-1^{TM} provided by the International Atomic Energy Agency and Mussel Tissue "CRM 278": provided by the Commission of the European Communities, Community Bureau of Reference-BCR-No 289) were run with the samples. Finally, concentrations of Cu, Cd, Pb, and Cr were measured as μg metal/g dry weight tissue by a graphite furnace atomic absorption spectrophotometer (Perkin–Elmer, AAnalyst 600). All accepted recoveries were within the two standard errors of the mean certified values shown in Table 1.

Data were analysed using Statistix 9.0 software (Analytical Software, Tallahassee, FL, 2008). Statistical differences between organs of the same species and between organs of different species were tested using one way ANOVA. Where significant differences were observed, Tukey HSD paiwise comparison test was applied. Differences were considered significant at p values ≤ 0.05.

Table 1 Mean certified metal concentration (μg/g dry weight) ± standard error (SE) and % recoveries of metals in the reference material used in the present study

Metal	Mean ± SE		% Recovery (≥)
	Copepod homogenate	Mussel tissue	
Cu	7.60 ± 0.20	9.60 ± 0.16	97
Cd	0.75 ± 0.03	0.34 ± 0.02	91
Pb	2.10 ± 0.30	1.91 ± 0.04	91
Cr	1.10 ± 0.20	0.80 ± 0.08	86

Results and Discussion

Different organs of the same species were found to have different mean metal concentrations (Table 2). Organs of all species were found to differ statistically in their mean metal concentrations except Cr in organs of goats and Cd in organs of sheep and goat. Generally, organs were richest in Cu followed by Pb, Cr, and Cd. Among organs of all species, mostly the liver was found to be the organ containing the highest levels of metals. Mean Cu concentrations in all organs ranged between 1.03 and 217.9 μg/g in poultry kidney and cattle liver, respectively. Mean Pb concentrations ranged between 0.2 μg/g (hearts of sheep and goat)

Table 2 Metal concentrations in organs of some locally-reared animals from the West Bank collected during 2007

Animal	Organ	Cd	Pb	Cr	Cu
Cattle	Liver	0.57 ± 0.03^{a}	3.28 ± 0.56^{a}	3.62 ± 1.24^{a}	217.90 ± 32.03^{a}
	Kidneys	0.55 ± 0.03^{a}	4.7 ± 0.55^{a}	1.33 ± 0.13^{ab}	9.97 ± 0.85^{b}
	Heart	0.44 ± 0.08^{ab}	0.27 ± 0.11^{b}	1.52 ± 0.37^{ab}	15.79 ± 2.11^{b}
	Lungs	0.34 ± 0.02^{b}	1.20 ± 0.12^{b}	0.52 ± 0.08^{b}	6.81 ± 1.26^{b}
	Muscles	0.48 ± 0.06^{ab}	0.51 ± 0.22^{b}	0.70 ± 0.14^{b}	2.71 ± 0.49^{b}
ANOVA (p value)		0.019	<0.0001	0.0062	<0.0001
Sheep	Liver	0.57 ± 0.03	2.42 ± 0.33^{a}	1.50 ± 0.27^{a}	136.65 ± 15.49^{a}
	Kidneys	0.49 ± 0.03	3.02 ± 0.27^{a}	1.46 ± 0.36^{ab}	6.46 ± 0.74^{b}
	Heart	0.48 ± 0.09	0.20 ± 0.05^{c}	0.53 ± 0.11^{c}	11.67 ± 1.65^{b}
	Lungs	0.35 ± 0.02	1.06 ± 0.14^{b}	0.61 ± 0.10^{bc}	10.23 ± 1.80^{b}
	Muscles	0.45 ± 0.09	0.25 ± 0.04^{bc}	0.49 ± 0.06^{c}	2.78 ± 0.45^{b}
ANOVA (p value)		0.5332	<0.0001	0.0014	<0.0001
Goat	Liver	0.53 ± 0.02	2.17 ± 0.37^{b}	0.94 ± 0.10	183.61 ± 46.21^{a}
	Kidneys	0.46 ± 0.01	3.49 ± 0.45^{a}	1.30 ± 0.23	5.90 ± 0.74^{b}
	Heart	0.43 ± 0.05	0.20 ± 0.04^{c}	1.12 ± 0.39	14.5 ± 1.35^{b}
	Lungs	0.43 ± 0.01	1.15 ± 0.25^{bc}	0.44 ± 0.07	8.23 ± 1.37^{b}
	Muscles	0.36 ± 0.06	0.37 ± 0.06^{c}	0.70 ± 0.17	3.97 ± 0.98^{b}
ANOVA (p value)		0.0581	<0.0001	0.0795	<0.0001
Poultry	Liver	0.63 ± 0.03^{a}	3.16 ± 0.50^{a}	0.82 ± 0.09^{b}	17.53 ± 3.05^{a}
	Kidneys	0.45 ± 0.01^{b}	3.52 ± 0.48^{a}	1.14 ± 0.18^{b}	1.03 ± 0.13^{b}
	Heart	0.41 ± 0.03^{b}	0.28 ± 0.11^{b}	3.34 ± 1.17^{a}	7.58 ± 1.31^{b}
	Lungs	0.35 ± 0.02^{b}	0.97 ± 0.17^{b}	0.50 ± 0.07^{b}	3.57 ± 0.98^{b}
	Muscles	0.45 ± 0.09^{ab}	0.28 ± 0.06^{b}	0.60 ± 0.08^{b}	7.34 ± 1.92^{b}
ANOVA (p value)		0.0022	<0.0001	0.0039	<0.0001

Values shown are means ± SE of seven samples expressed as μg/g dry weight basis

Different letters indicate statistical significant difference at $p \leq 0.05$

and 4.7 μg/g in kidneys of cattle. Mean Cr levels were found to be between 0.44 and 3.62 μg/g in goat lungs and cattle liver, respectively. Cd mean concentrations were not so variable between organs and species. Its mean concentrations ranged between 0.34 μg/g (lungs of cattle) and 0.63 μg/g (liver of poultry).

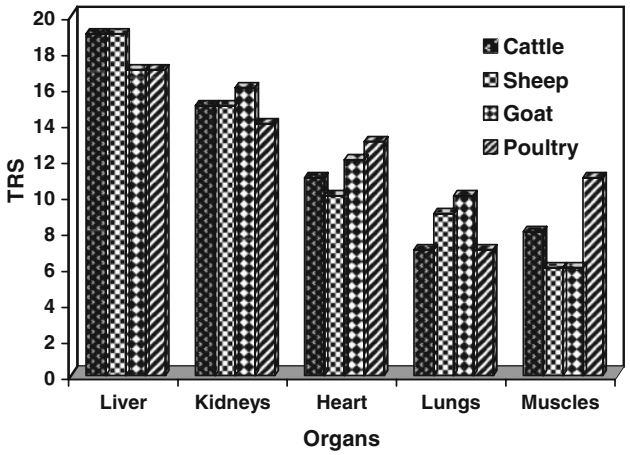

Fig. 1 Total rank scores (*TRS*) of organs of some locally-reared animals from the West Bank according to their capacity to concentrate Cu, Cd, Pb and Cr

Organs were ranked according to their capacity to concentrate different metals by calculating the total rank score (TRS) for each organ (Swaileh et al. 1994, 2004). The liver of all species was always the richest in metals, while the muscles were the least in their ability to concentrate metals in the four animal groups investigated (Fig. 1). According to metal richness and total rank score, organs followed the following order: liver > kidneys > heart > lungs > muscles. The liver and kidneys are target tissues for monitoring metal contamination in animals because both organs function in removing toxic metals from the body (Husain et al. 1996; Abou-Arab 2001).

Metal concentrations in the same organ from the four animal groups were compared and statistically analysed (Table 3). Statistical differences were observed for Cu in organs of all animal groups analysed. Besides, kidneys and lungs of the four animal groups were found to vary statistically in their metal concentrations. Hearts, of animal groups investigated were found to differ only in their mean Cr concentrations. Lead concentrations were homogeneous in the same organ from cattle, sheep, goat and poultry. Poultry liver, kidneys and heart contained significantly less Cu than other groups. However, their muscles contained significantly more Cu than cattle, sheep and goat. Cattle

Table 3 Comparison between metal concentration in similar organs of some locally-reared animals from the West Bank collected during 2007

Organ	Animal	Cd	Pb	Cr	Cu
Liver	Cattle	0.57 ± 0.03	3.28 ± 0.56	3.63 ± 1.24	217.90 ± 32.03[a]
	Sheep	0.57 ± 0.03	2.42 ± 0.33	1.50 ± 0.27	136.65 ± 15.49[a]
	Goat	0.54 ± 0.02	2.17 ± 0.37	0.94 ± 0.10	183.61 ± 46.21[a]
	Poultry	0.63 ± 0.03	3.16 ± 0.50	0.82 ± 0.09	17.53 ± 3.05[b]
ANOVA (*p* value)		0.1665	0.2444	0.3089	0.0004
Kidneys	Cattle	0.55 ± 0.03[a]	4.71 ± 0.44	1.33 ± 0.13	9.97 ± 0.85[a]
	Sheep	0.4 ± 0.03a[b]	3.02 ± 0.27	1.46 ± 0.36	6.46 ± 0.74[b]
	Goat	0.46 ± 0.01[b]	3.49 ± 0.45	1.30 ± 0.23	5.90 ± 0.74[b]
	Poultry	0.44 ± 0.01[b]	3.52 ± 0.48	1.14 ± 0.18	1.03 ± 0.13[c]
ANOVA (*p* value)		0.0185	0.0818	0.8328	<0.0001
Heart	Cattle	0.45 ± 0.08	0.27 ± 0.11	1.52 ± 0.37[ab]	15.79 ± 2.11[a]
	Sheep	0.48 ± 0.09	0.21 ± 0.05	0.53 ± 0.11[b]	11.67 ± 1.65[ab]
	Goat	0.43 ± 0.05	0.20 ± 0.04	1.12 ± 0.39[ab]	14.5 ± 1.35[a]
	Poultry	0.41 ± 0.03	0.28 ± 0.11	3.34 ± 1.17[a]	7.58 ± 1.31[b]
ANOVA (*p* value)		0.8932	0.8494	0.0312	0.0083
Lungs	Cattle	0.34 ± 0.02[b]	1.20 ± 0.12	0.52 ± 0.08	6.81 ± 1.26[ab]
	Sheep	0.45 ± 0.02[a]	1.07 ± 0.14	0.61 ± 0.10	10.23 ± 1.80[a]
	Goat	0.43 ± 0.01[a]	1.15 ± 0.25	0.44 ± 0.07	8.23 ± 1.37[ab]
	Poultry	0.35 ± 0.01[b]	0.98 ± 0.17	0.50 ± 0.07	3.57 ± 0.98[b]
ANOVA (*p* value)		0.0005	0.8092	0.4851	0.0178
Muscles	Cattle	0.48 ± 0.06	0.51 ± 0.23	0.70 ± 0.14	2.71 ± 0.49[b]
	Sheep	0.44 ± 0.07	0.25 ± 0.04	0.49 ± 0.06	2.78 ± 0.45[b]
	Goat	0.36 ± 0.06	0.37 ± 0.06	0.70 ± 0.17	3.97 ± 0.98[ab]
	Poultry	0.45 ± 0.09	0.29 ± 0.06	0.60 ± 0.08	7.34 ± 1.92[a]
ANOVA (*p* value)		0.7079	0.4618	0.5778	0.0254

Values shown are means ± SE of seven samples expressed as μg/g dry weight basis

Different letters indicate statistical significant difference at $p \leq 0.05$

Table 4 Published data on metal levels (μg/g dry weight) in organs of different animal groups from different regions of the World

Study/country	Animal	Organ	Cd	Pb	Cu
Liu (2003) China	Sheep	Liver	0.49	0.72	120.6
	(control)	Kidneys	1.83	0.96	11.8
		Heart	0.3	1.54	15.7
		Lungs	0.61	1.45	10.6
		Muscles	0.17	0.86	5.9
	Sheep	Liver	7.92	15.3	248.1
	(contaminated)	Kidneys	25.39	39.5	25.2
		Heart	0.38	4.3	28.8
		Lungs	3.02	4.35	23.2
		Muscles	0.62	1.85	8.0
Sedki et al. (2003) Morocco	Cattle	Liver	5.1	–	112
		Kidney	10.3	–	33
Husain et al. (1996) Kuwait	Sheep	Liver	0.044	0.125	–
		Kidney	0.301	0.145	–
	Goat	Liver	0.047	0.13	–
		Kidney	0.442	0.427	–
	Poultry	Liver	0.089	0.104	–
Villar et al. (2005) Philippines	Poultry	Liver	0.029	0.082	–
Caggiano et al. (2005) Italy	Sheep	Liver	0.33	1.5	–
		Kidneys	6.71	2.0	–
		Muscles	0.16	1.6	–

kidneys contained significantly more Cd than kidneys of other animal groups. Lungs in Sheep and goat contained significantly higher Cd levels than lungs of cattle and poultry. Generally, organs of poultry contained less metal levels than those of cattle, sheep and goat.

As compared to results of similar studies from other countries (Table 4), metal levels reported in the present study seem to be comparable to or less than those reported in organs of animals from clean sites. Results of Liu (2003) for metal levels in sheep organs sampled from contaminated sites in China are clearly higher than those found in our study. In addition, our results are clearly much less than those reported by Sedki et al. (2003) where he analyzed metal levels in liver and kidneys of cattle from Morocco. His results are more than 10 times higher than our results for Cd. Levels of Cd and Pb in poultry liver from our study are slightly higher than those reported by Husain et al. (1996) from Kuwait and Villar et al. (2005) from Philippines.

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