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Distribution of Lead, Cadmium, and Zinc in Tissues of Hens and Chickens from Slovenia

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Lead (Pb) and cadmium (Cd) are environmental contaminants which are present in almost all living organisms and are non-esential for plants, animals and human beings. Zinc (Zn) is an essential element which occurs together with Cd and is linked with it.

There exists little information about the contamination of tissues of hens and chickens with these elements. Recent reports mostly deal with the contamination of meat, kidney and liver (Korsurd et a1.1985; Cibulka and Sova 1986; Falandysz 1987; Geert et al. 1989; Vos et a1.1990). Other tissues and eggs have not been examined thoroughly enough to deal with the distribution of Pb, Cd and Zn in the body of hens and chickens.

The primary aim of this study was to investigate the distribution of Pb, Cd and Zn in the different tissues of poultry and eggs in Slovenia.

MATERIALS AND METHODS

From 1989 to 1993 we analyzed 108 hens, 77 chickens and 127 eggs collected from 120 locations in Slovenia. Chickens, male and female animals 1 to 6 months old, were from domestic, free-range breeding stock and from extensive breeding stock on farms. Hens, adult female animals, were from domestic breeding stock only and were 6 to 144 months old. Eggs were collected only from free-range breeding hens.

The pectoral and femoral muscle, liver, kidney, spleen, gizzard, skin, heart, femural bone, egg-yolk and egg-white were taken and were separately stored in plastic containers at -18° C. Tissues, except bone, kidney, spleen and heart, which were taken whole, were homogenised and 10g of the fresh homogenates were weighed into quartz dishes. Samples were dried and dry-ashed in the muffle-furnace at 450° C over-night.

Concentrations of elements were measured by flame atomic absorption spectrometry on a Varian AA 175. Zinc was measured directly from solutions prepared by dissolving ashes in diluted hydrochloric acid at wave-length 213.9 nm (AOAC 1990). Lead and cadmium were measured as diethylammonium-N,N-diethyldithiocarbaminat (DDDC) complex in organic solvent methylisobutylketone (MIBK) at wave-length 217 nm for Pb and 228.8 nm for Cd (AOAC 1990;Snodin 1973). The calculations were carried out by the standards additions method. Analytical quality assurance was performed by analysing certified reference materials (BCR 184 bovine muscle, 185 bovine liver, 186 pig kidney) and by recovery tests. Recoveries for Pb ranged from 87 to 106 % and for Cd from 85 to 94 %. Mean recovery for Zn was 95 %. The limit of Zn determinations was 0.01 mg/kg, of Pb 0.05 mg/kg and of Cd 0.003 mg/kg. Statistical analyses were performed by using the SPSS-X program package.

RESULTS AND DISCUSSION

The Pb, Cd and Zn concentrations in tissues of hens, eggs and chickens and the relations of the concentrations of these elements in particular tissues as compared to pectoral muscle are shown in Tables 1 to 6. Where the element concentration was lower than the detection limit, a value of half the limit of detection was assigned for the purpose of calculating the mean (arithmetic average).

Table 1. Lead concentrations in tissues of hens from Slovenia (mg/kg wet weight)

Tissue	Number of samples	Range	Mean	standard deviation	Relation [a]
Femoral muscle	108	* – 1.15	0.06	0.13	1.2
Pectoral muscle	107	* – 1.09	0.05	0.11	1.0
Liver	108	* – 4.62	0.30	0.67	6.0
Kidney	108	* – 7.56	0.62	1.08	12.4
Spleen	108	* – 3.34	0.21	0.52	4.2
skin	108	* – 2.69	0.21	0.39	4.2
Femoral bone	108	* –10.26	2.90	2.43	58.0
Gizzard	108	* – 0.96	0.08	0.13	1.6
Heart	43	* – 0.05	*	0.00	0.5
Egg yolk	127	* – 1.68	0.06	0.16	1.2
Egg white	127	* – 0.09	*	0.01	0.5

*-concentration under limit of detection

[a] -relation was calculated from mean of the particular tissue and mean of pectoral muscle content

Table 2. Lead concentrations in tissues of chickens from Slovenia (mg/kg wet weight)

Tissue	Number of samples	Range	Mean	standard deviation	Relation [a]
Femoral muscle	68	* - 0.07	*	0.01	1.0
Pectoral muscle	60	* - 0.09	*	0.01	1.0
Liver	77	* - 0.25	*	0.04	1.0
Kidney	77	* - 0.46	0.07	0.09	2.8
Spleen	51	* - 1.05	0.08	0.17	3.2
skin	51	* - 1.47	0.13	0.31	5.2
Femoral bone	51	* - 5.74	0.56	0.95	22.4
Gizzard	51	* - 0.15	*	0.03	1.0
Heart	38	* - 0.11	*	0.02	1.0

* and [a] see Table 1

Table 3. Cadmium concentrations in tissues of hens from Slovenia (mg/kg wet weight)

Tissue	Number of samples	Range	Mean	standard deviation	Relation [a]
Femoral muscle	108	* - 0.85	0.04	0.10	1.2
Pectoral muscle	107	* - 0.43	0.03	0.07	1.0
Liver	108	0.04 - 6.64	0.70	0.98	20.6
Kidney	108	0.16 -12.20	2.63	2.16	77.4
Spleen	108	* -13.95	0.48	1.63	14.1
Skin	108	* - 0.78	0.07	0.13	2.1
Femoral bone	108	* - 0.85	0.04	0.10	1.0
Gizzard	108	* - 4.26	0.34	0.54	9.9
Heart	43	* - 0.15	0.01	0.02	0.4
Egg yolk	127	* - 0.03	0.00	0.00	<0.1
Egg white	127	* - *	*	0.00	<0.1

* and [a] see Table 1

The highest mean Pb concentrations were present in the bones of hens ($P<0.000l$), with a 5-times lower concentration in the kidney followed by spleen, liver and skin (Table 1). In liver Pb was about two times less than in kidney, corresponding to information from similar investigations by Honda et al. (1985) and Lee et al. (1989). Egg-yolks contained more Pb than whites and about the same as meat. The highest mean Pb

Table 4. Cadmium concentrations in tissues of chickens from Slovenia (mg/kg wet weight)

Tissue	Number of samples	Range	Mean	Standard deviation	Relation [a]
Femoral muscle	68	* – 0.02	0.003	0.00	2.2
Pectoral muscle	60	* – 0.02	*	0.00	1.0
Liver	77	* – 0.22	0.03	0.04	22.7
Kidney	77	* – 0.70	0.09	0.12	62.7
Spleen	51	* – 0.13	0.02	0.04	10.7
Skin	51	* – 0.08	0.01	0.02	6.7
Femoral bone	51	* – 0.02	0.003	0.00	2.0
Gizzard	51	* – 0.18	0.03	0.04	22.7
Heart	38	* – 0.03	0.005	0.01	3.3

* and [a] see Table 1

Table 5. Zinc concentrations in tissues of hens from Slovenia (mg/kg wet weight)

Tissue	Number of samples	Range	Mean	Standard deviation	Relation [a]
Femoral muscle	108	6.6– 38.9	17.7	5.76	3.9
Pestoral muscle	107	1.8– 23.1	4.5	2.45	1.0
Liver	108	11.3–160.3	34.3	20.69	7.6
Kidney	108	8.1– 56.0	22.2	8.39	4.9
Spleen	108	* –130.9	18.6	13.91	4.1
Skin	108	2.1– 21.8	8.0	4.38	1.8
Femoral bone	108	3.2– 87.9	38.8	14.74	8.6
Gizzard	108	9.7– 54.4	22.8	7.98	5.1
Heart	43	2.1– 30.6	17.9	4.81	4.0
Egg yolk	127	4.6– 40.9	23.0	7.84	5.1
Egg white	127	* – 2.8	0.1	0.28	<0.1

* and [a] see Table 1

concentrations were found also in the bones of chickens ($P<0.000l$), with skin, kidneys and spleen having lesser amounts (Table 2).

The highest mean Cd concentrations were found in kidneys of hens and chickens ($P<0.000l$) (Tables 3,4). Cadmium concentrations in liver were about 3 times lower, corresponding to information reported by Honda et al. (1985) and Lee et al. (1989), followed by spleen

Table 6. Zinc concentrations in tissues of chickens from Slovenia (mg/kg wet weight)

Tissue	Number of samples	Range	Mean	Standard deviation	Relation [a]
Femoral muscle	51	6.4–27.8	15.9	5.07	3.8
Pectoral muscle	60	1.6–8.1	4.2	1.42	1.0
Liver	60	12.6–76.4	28.5	12.08	6.9
Kidney	60	10.1–42.9	19.8	5.76	4.8
Spleen	51	* –52.7	17.0	6.98	4.1
Skin	51	2.9–25.6	8.6	4.13	2.1
Femoral bone	51	16.8–68.2	31.1	9.60	7.5
Gizzard	51	8.7–30.8	22.2	5.41	5.3
Heart	38	3.0–68.6	17.3	9.69	4.2

* and [a] see Table 1

Table 7. Portions of samples of hens which exceeded official tolerance levels for Pb and Cd

Tissue	Number of samples	unsuitable samples (%)		official tolerance levels (mg/kg)	
		Pb	Cd	Pb	Cd
Femoral muscle	108	1.8	7.4	0.5	0.1
Pectoral muscle	107	0.9	7.4	0.5	0.1
Liver	108	7.4	38.9	1.0	0.5
Kidney	108	17.6	77.8	1.0	1.0
Egg yolk	127	3.1	18.9	0.25*	0.005*
Egg white	127	0.0	0.8		

* for the whole egg

and gizzard. Cadmium was not detectable in egg-yolks and whites of chickens.

The highest Zn concentrations were present in the bones of hens ($P<0.000l$) and chickens (Tables 5,6), followed by liver, kidney, spleen and red meat. Egg-yolks contained 200-times more Zn than whites and 5-times more than white meat.

In hens there were individual samples of meat, liver, kidney and egg that exceeded our official tolerance levels for Pb and Cd (Uradni list SFRJ 1987). On the basis of these results (Table 7) we considered that kidneys of laying hens (but not chickens) from some industrial contaminated areas (as Celje and Koroška

region) have to be judged as unfit for human consumption.Veterinary directorate of Slovenia accepted our purposal in year 1990 which is still valid.

At the same time we also tried to establish the positive correlation between Cd and Zn concentrations in livers and kidneys of poultry described in the literature by Honda et al. (1985) and Lee et al. (1989). On the basis of our results we established only that when Cd concentration in liver increased the percentage of samples with higher Zn concentrations also increased. Such correlation was not established with kidneys.

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