The content of cadmium and lead in muscle and liver of laying hens housed in a copper industry region

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Summary

The research was carried out on material sampled from 20 laying hens, one year old, housed in free range system (FRS) and 20 laying hens housed in a battery system (BS), in the region of the copper industry impact (Lower Silesia). Thigh muscles and livers were sampled to determine the content of Cd and Pb by an ICP-MS method. The concentrations of cadmium and lead in part of the FRS-liver samples exceeded the permissible limit: 0.5 mg·kg^{-1} of wet weight for both elements. The maximum value for Cd was 3.09 and the minimal value was 0.20 mg·kg^{-1} of wet weight. The Pb values were respectively 1.36 and 0.04 mg·kg^{-1} of wet weight. In poultry meat, the permissible level of Cd is 0.05 and of Pb 0.1 mg·kg^{-1} of wet weight. In FRS-muscle, Cd concentrations ranged between 0.01 and 0.15 mg·kg^{-1} and for Pb from 0.007 to 0.38 mg·kg^{-1} of wet weight. In BS-muscles and BS-livers, , the values were, with one exception, not above the limit.

Introduction

Farm animals, housed in regions with a high level of industrialization and urban development, are exposed to various toxic chemical compounds. The polluting substances contain heavy metals such as cadmium, lead, mercury but also other elements like zinc, copper or iron, which in minor quantities are essential in animal feeding (Jamroz, Potkański 2001).

The ecotoxicological significance of heavy metals is quite well understood, however biomonitoring studies are still carried out in Poland as well as abroad, particularly in urban areas, in industrial regions, in the proximity of motor traffic in order to assess degree of accumulation of the metals mentioned above in the soil environment, in plants, animals or products of animal origin (Bodak, Dobrzański 1997; Kabata-Pendias, Pendias 1999).

Aviculture in free range systems results in uncontrolled exposure of birds to all the kinds of environmental pollutants, since birds might accumulate elements not only from polluted soil, water, plants, geohelminths, but also from various non-edible wastes and substances containing i.e. heavy metal compounds. Housing laying hens in free range system might lead to increased morbidity and mortality of birds (Van Emous, Fiks-Van Niekerk 2004) and poultry products, such as eggs, meat or giblets polluted with toxic compounds (Kołacz *et al.* 2003).

In particular the exposure of poultry (and other animals) might occur in industrialized regions, such as mine-metallurgical industry, where there are significant emissions and imissions of toxic metals, including Cd and Pb (Schroeder 2003).

Many studies have shown that heavy metals might accumulate in eggs as well as in tissues and organs of galliformes (Dobrzański *et al.* 1996) and waterfowl (Jeng, Yang 1995), and the main route of their transfer is the digestive tract (Kan 1994).

The aim of the present work was to perform a comparative assessment of cadmium and lead accumulation in the tissues of hens housed in free range systems as well as in battery systems in a region polluted by copper industry.

Material and methods

The studies were performed on laying hens from the first production period (one year old) that were housed in a free range system (FRS) as well as in a battery system (BS) in the farms located in a region polluted by the copper industry (Legnica-Głogów Copper Region). In this region, mine industry coexists with copper metallurgy and with agriculture, in particular with livestock culture. Beside the activities resulting in reduced emissions of dusts and industrial gases, there still exists a risk of elevated accumulation of copper, zinc as well as lead, cadmium, chromium, arsenic, mercury, nickel etc. compounds (Schroeder 2003).

FRS hens were fed with various free range feeds, were free to use the aviary, where they could also consume soil, rainwater, plants. Laying hens from the BS group obtained compound feed and were under veterinary control.

Samples of liver and muscles (thigh), after previous decapitation, were taken from 20 clinically healthy laying hens both from the FRS and the BS systems. The samples were homogenized and after wet digestion with nitric acid in a high pressure microwave digestion system -2000 (CEM, USA). Chemical analyses of Cd and Pb concentrations were performed with the use of ICP-MS technique using a Varian Ultra Mass 700 in the Institute of Inorganic Technology and Mineral Fertilizers, Wrocław University of Technology (Górecka and Górecki 2000).

The results were analyzed statistically by calculating the average values ($\bar{x}$), standard deviation (SD) and significances of differences between the content of analyzed elements in FRS and BS groups (Microsoft Excel 2000).

Results and discussion

The obtained analytical results showed large differences in the concentrations of determined heavy metals. The Pb content in muscle and liver are shown in Table 1. The acceptable amount of Pb in meat is 0.1 and in liver 0.5 $mg \cdot kg^{-1}$ of wet weight (Decree of Health Minister 2003). Forty percent of the samples exceeded the acceptable limit of Pb in muscle in the FRS group (8 samples) and 15% (3 samples) in liver. The permissible level of Pb in muscle and liver was not exceeded in samples from the BS group.

The cadmium content in the organs is shown in Table 2. The permissible level of Cd was exceeded in 10% of the muscle samples and in 70% of the liver samples. One muscle samples from the BS system slightly exceeded the limit of 0.50 $mg \cdot kg^{-1}$ of wet weight (Decree of Health Minister 2003). Between the groups FRS and BS, the differences in the concentration of Pb and Cd in muscles and in liver were found to be statistically significant ($p < 0.01$).

In the available literature, there are few data to be found in this field. Only Kołacz *et al.* (2003), analyzed these metals in laying hens in an extensive housing system in the region polluted by mines and copper metallurgy. The results pointed to high levels of Pb in muscles and livers (0.250 and 0.577 $mg \cdot kg^{-1}$ of wet weight, respectively) and cadmium (0.014 and 0.601 $mg \cdot kg^{-1}$ of wet weight, respectively). However Żmudzki *et al.* (1995) monitored trace elements, including cadmium and lead in tissues of hens from free range system (FRS) and farming system (FS) in the territory of Poland. The average values of Pb were found in muscle to be 0.008 (FRS) and 0.010 (FS) and in livers 0.174 (FRS) and 0.024 (FS) $mg \cdot kg^{-1}$ of wet weight. For cadmium, levels of 0.010 and 0.003 in muscle and 0.614 and 0.139 $mg \cdot kg^{-1}$ of wet weight in liver were reported.

In the other studies (Libelt 2003) mechanically deboned broiler meat contained on average a Pb level of 0.1 – 0.28 $mg \cdot kg^{-1}$ of dry mass and a slightly lower level was found in slaughtered geese: 0.09 - 0.16 $mg \cdot kg^{-1}$ of dry mass. According to the latest findings of Szkoda and Żmudzki (2003), meat of broilers slaughtered in Poland contained an average Pb content of 0.021 (max. 0.088) and the mean content of cadmium was 0.001 (max.0.005) $mg \cdot kg^{-1}$ of wet weight. These values are relatively low when compared to our own studies. In this context, it should be noted that W ęgrzyn and Borys (2000) also determined the contents of Cd and Pb in muscle and liver of chickens and turkeys. The authors found that the concentration did not exceed the acceptable levels of these toxic metals and the highest levels were found in the territory of Lower Silesia, where industry, mining and power industry are concentrated.

Summarizing, poultry housing in an extensive (free range) system in the regions of environmental concern, creates the conditions that favour increased bioaccumulation of lead and cadmium, reducing thus the consumption acceptability of hen meat and giblets.

Table 1 Concentrations of lead (mg·kg^{-1} wet weight) in muscle and liver of laying hens from different housing systems.

Item	Free range system		Battery system	
	Muscle	Liver	Muscle	Liver
$\bar{x}$	0.165 ^{A}	0.513 ^{C}	0.058 ^{B}	0.140 ^{D}
SD	0.122	0.384	0.027	0.076
min.	<0.007 $^{*)}$	0.040	<0.007 $^{*)}$	0.038
max.	0.380	1.367	0.096	0.342

$^{*)}$ – below detection limit
A – B and C – D – $p < 0.01$

Table 2 Concentrations of cadmium (mg·kg^{-1} wet weight) in muscle and liver of laying hens from different housing systems.

Item	Free range system		Battery system	
	Muscle	Liver	Muscle	Liver
$\bar{x}$	0.056 ^{A}	0.980 ^{C}	0.019 ^{B}	0.254 ^{D}
SD	0.027	0.742	0.007	0.151
min.	0.010	0.200	0.008	0.195
max.	0.152	3.090	0.036	0.546

A – B and C – D - $p < 0.01$

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ROZPORZĄDZENIE Ministra Zdrowia z dn. 13.01.2003 r. (Dz. U. nr 37, poz. 326), w sprawie maksymalnych poziomów zanieczyszczeń chemicznych i biologicznych, które mogą znajdować się w żywności, składnikach żywności, dozwolonych substancjach dodatkowych, substancjach pomagających w przetwarzaniu albo na powierzchni żywność.

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