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Levels of Cadmium Contamination of Domestic Animals (Cattle) in the Region of Warmia and Masuria

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Abstract

Liver and kidneys collected in 1998 from cattle bred in the region of Warmia and Masuria were analyzed for levels of cadmium, as well as copper and zinc. The mean concentration of cadmium in younger animals (<2 years) was 0.425 mg/kg in kidneys, and 0.159 mg/kg in liver, being much lower than the levels found in older (>2 years) cattle. Notwithstanding this, cadmium levels were not high enough to be dangerous from the toxicological point of view. The obtained data suggest that cadmium is gradually and progressively accumulated in animal tissues, especially kidneys. Content of copper and zinc in the organs remained at a physiological level. Data obtained for many individual liver and kidney samples also suggest that there might be a relationship between cadmium concentration and levels of copper and zinc. Higher cadmium concentrations were accompanied by lower levels of copper and zinc, or of one of these elements.

Keywords: cattle, cadmium, copper, zinc, liver, kidneys

Introduction

Cadmium and its compounds are defined as absolutely toxic substances [1-3]. Industry, the chemicalization of agriculture, contaminated food products, and (in the case of humans) cigarette smoke are the main sources of cadmium contamination that may be dangerous for people and animals [4-10]. Cadmium is found in water, soil, air, plant and animal tissues [1, 11-14]. It belongs to heavy metals characterized by the highest accumulation, mostly in kidneys and liver [15-17]. Once within the organism, it may cause many disorders, e.g. it intensifying osteoporosis, inducing secondary hyperthyroidism; showing an antagonistic effect on the accumulation of copper, zinc, selenium and other elements; decresing contraction ability of the heart; disturbing reproductive processes; and inducing neoplastic diseases [2, 18-22].

Cadmium mobility in the organism is so low that the established periods of half-life are often longer than the life-span of the organism. Due to harmful effects of cadmium in the environment and its accumulation ability, FAO and WHO have recommended systematic and multidirectional studies of this metal.

Generally, cadmium content in edible parts of animals in Poland do not exceed permissible levels [14, 23, 24]. As a rule, the highest concentrations of cadmium are found in kidneys and livers of domestic animals in regions with well developed industry [25]. In single cases, high concentrations of this metal were recorded especially in kidneys of horses and cattle [14].

In view of a relatively small amount of available original data on cadmium levels in the tissues of domestic and wild animals in Poland (especially in the region of Warmia and Masuria), studies were undertaken in order to determine these levels in liver and kidneys of Warmian and Masurian cattle, with attention given to hygienic and toxicological aspects.

This paper presents the results pertaining to cadmium

contents in liver and kidneys of cattle farmed in the region of Warmia and Masuria. In addition, copper and zinc levels were also determined. Taking into account the antagonistic effect of cadmium on copper and zinc, an attempt was also made to define the relationships between cadmium concentrations and levels of the other two elements.

Material and Methods

Liver and kidney samples were collected from 60 animals randomly selected in the region of Warmia and Masuria. The animals were slaughtered in July and August in slaughter houses of the region. All tissue samples were stored in a freezer until examination, at -18°C. The tissues were chopped, thoroughly mixed, and a definite amount of the biological material was weighed (about 10 g) and subject to analyses. The procedure consisted of two stages: mineralization (ashing in 450°C) of the material and its preparation for the quantitative analyses [26, 27] and determination of metals using a Unicam 939 Solar atomic absorption spectrophotometer. Optimization of the analytic conditions was performed according to the recommendations supplied by the firm [28].

Zinc and copper were determined directly in the mineralized samples as their concentrations were high enough to enable this.

It was assumed that concentrations of this element were low in the analyzed biological material, and that this may result in high analytical error due to interference in course of direct examination of the mineralized samples, so APDC/MIBK extraction of the samples was performed to the organic phase. An analytical procedure given by Zmudzki [27] was used in this case.

All results on heavy metal contents were recalculated into fresh tissue. They were analyzed statistically using Duncan's test for the significance of differences between the means [29].

Results and Discussion

Levels of cadmium, copper and zinc in liver and kidneys of cattle farmed in Warmia and Masuria are presented in Table 1 and Figs. 1 and 2.

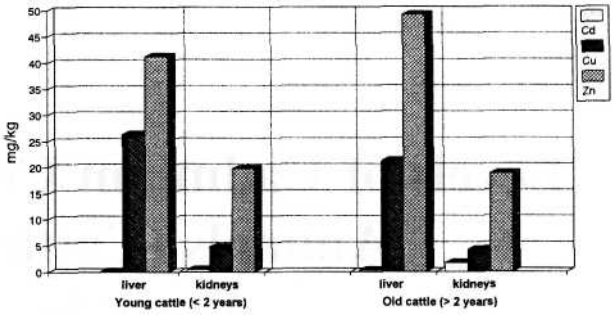

Fig. 1. Mean concentrations of cadmium, copper and zinc (mg/kg) in liver and kidneys of cattle in the region of Warmia and Masuria.

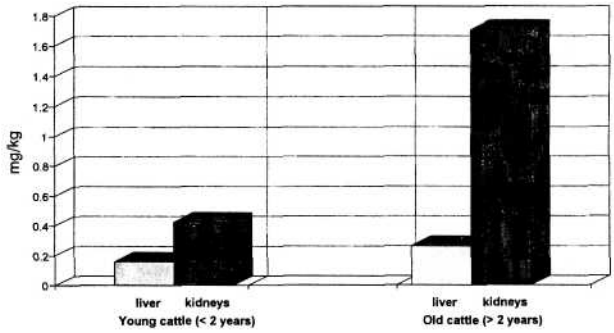

Fig. 2. Mean concentrations of cadmium (mg/kg) in liver and kidneys of cattle in the region of Warmia and Masuria.

One kidney sample collected from an old and emaciated cow contained very high levels of cadmium (10.692 mg/kg). The cow weighed 271 kg, while average animal weight for the whole group was 468 kg. It originated from the vicinity of Ełk. This sample was discarded as the cow in question was originally raised in an another region of Poland.

As results from the data presented in Table 1 show, cadmium was present in all samples. Liver and kidneys of young cattle (<2 years) in the region of Warmia and Masuria contained much less cadmium than those of older animals (>2 years). These data suggest gradual and progressing accumulation of cadmium in the tissues as the animals aged. They also reveal increasing contamination of the environment with cadmium, and show that elimination

Table 1. Content of cadmium, copper and zinc in liver and kidneys of cattle in the region of Warmia and Masuria in 1998 (mg/kg fresh weight); arithmetic mean, standard deviation, and range.

Animals	Tissue	Cadmium	Copper	Zinc
Young cattle (< 2 years) n = 44	liver	0.159 ± 0.098 (0.060 – 0.487)	26.377 ± 19.221 (2.351 – 66.967)	41.295 ± 8.501 (22.243 – 68.466)
	kidneys	0.425 ± 0.195 (0.104 – 0.937)	4.801 ± 1.344 (2.111 – 9.182)	19.699 ± 2.393 (15.764 – 29.649)
Old cattlee (> 2 years) n = 15	liver	0.263 ± 0.166 (0.081 – 0.672)	21.184 ± 15.682 (3.344 – 55.455)	49.152 ± 15.639 (30.887 – 77.973)
	kidneys	1.703 ± 1.106 (0.590 – 4.275)	4.198 ± 0.315 (3.795 – 4.740)	18.761 ± 2.614 (15.528 – 22.749)
Significance of the differences		Pwbm-wbs < 0.01 Pnbm-nbs < 0.01		Pwbm-wbs < 0.05

Explanations: wbm - liver of young cattle; wbs - liver of old cattle; nbm - kidneys of young cattle; nbs - kidneys of old cattle.

of this element from the tissues is very slow. Mean levels of cadmium in the kidneys of older cattle were about 4 times higher than in younger animals, and in the liver - about 1.5 times higher (Tab. 1, Fig. 2). Although the upper limit of 4 mg/kg [24] was exceeded only in one sample collected from an older animal, levels exceeding 1 mg/kg were recorded in as many as 70% of the kidney samples. Some Western countries assume that 1 mg Cd/kg is the maximum permissible level, and administrative steps are taken if this level is exceeded [cit. after 14]. In younger cattle the highest cadmium concentration in kidneys did not exceed 1 mg/kg. Mean levels in these animals were 0.425 ± 0.195 mg/kg, reaching maximally 0.937 mg/kg. In 73% of the samples collected from young cattle cadmium levels were below 0.5 mg/kg.

The limit for liver has been established at 2.0 mg Cd/kg of the tissue [24]. It was not exceeded in any sample, whether old or young cattle (Tab. 1). In 93% of liver samples collected from older animals, cadmium concentrations did not exceed 0.5 mg/kg, and only one sample contained 0.672 mg/kg. Liver samples collected from young cattle all contained less than 0.5 mg of cadmium/kg, the maximal level being 0.487 mg/kg. It should be emphasized that cadmium concentrations of less than 0.2 mg/kg were found in as many as 82% of the liver samples collected from young animals.

The high ability of cadmium to migrate from the soil to plants is the main cause of cattle exposure to this element in the region of Warmia and Masuria. The region is typically agricultural, so cadmium in the soil can originate mostly from chemical substances used in agriculture, in this also from mineral fertilizers (cadmium levels in superphosphate may reach 46.6 mg/kg) [30]. Other sources of contamination are also possible (e.g. motor vehicles, emissions from local industrial premises, soil fertilization with sludge, dumping of industrial wastes, etc.), which may contaminate soil, water, air and plants.

Copper and zinc levels in animal tissues (Tab. 1, Fig. 1) were within physiological limits and did not deviate from those found by the other authors [23, 31-33]. Many liver and kidney samples lower copper and zinc levels, or of one of these elements, were observed at higher concentrations of cadmium.

According to the data obtained by Zmudzki and Szkoda [14] in the course of a monitoring survey performed in 1993, cadmium levels in liver and kidneys of young cattle from the whole country were 0.146 and 0.580 mg/kg, respectively, and in older animals - 0.204 and 0.829 mg/kg. Other data collected in agricultural regions of Poland, but with no distinction between young and old animals, showed that cadmium concentration in cattle liver and kidneys in northern Poland was, respectively 0.100 and 0.450 mg Cd/kg [31], while the respective values in eastern Poland were: 0.160 and 0.230 mg Cd/kg [33], and in industrial regions they were 0.292 and 1.735 mg Cd/kg [25].

The above data show that cadmium levels in liver and kidneys of young cattle in Warmia and Masuria did not differ from those recorded on a national scale in 1993, while cadmium levels in older cattle were similar as those noted in 1990 in the region of Kielce [14].

Levels of cadmium in cattle kidneys in some countries of the European Union were of the same magnitude, e.g. 0.450 mg Cd/kg in Austria (1991) and 0.231 Cd/kg in Holland (1993) [34, 35], while values recorded for cattle liver were 0.061 mg/kg in Finland (1991), 0.070 mg/kg in Sweden (1991), and 0.105 mg Cd/kg in Holland (1987) [cit. after 36].

Cadmium levels found in the tissues of cattle from Warmia and Masuria, especially of young animals, are quite safe from the toxicological point of view. However, 70% of kidney samples collected from older cattle contained more than 1 mg Cd/kg. They are high enough to become unsafe for certain consumer groups, exposing people to increased cadmium levels. Due to high accumulation of cadmium and its long half-life, it may induce some diseases in the human organism (e.g. osteoporosis, decrease of heart contraction ability etc.), especially in smokers consuming higher levels of cadmium in cattle meat products.

The results obtained in the course of this study suggest the need for continuous control of domestic animals that are to be slaughtered, especially as regards contamination with cadmium. The data can also be used in subsequent estimates and comparisons related to environmental monitoring. They also illustrate exposure of domestic animals, and - indirectly - of humans, to the toxic element. The paper contributes to the inventory of cadmium concentrations in domestic animal tissues, and more specifically - to the data on actual levels of this element in cattle bred in Warmia and Masuria.

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