Cadmium and lead in the tissues and organs of livestock from an industrially polluted area

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Abstract

The occurrence of cadmium (Cd) and lead (Pb) from industrial emissions was determined in the muscle and liver of cattle from agricultural farms near an industrial plant in Eastern Slovakia. In this study, cows were slaughtered and the concentrations of Cd and Pb analysed by the Unicam Solar 939 atomic absorption spectrometer. The highest levels of Cd and Pb were recorded in the muscle (0.300; 0.854 mg·kg^{-1}) and the liver (0.865; 2.324 mg·kg^{-1}). It was concluded that exposure to an industrial plant can result in a significant increase in levels of contaminants in the muscle tissues and organs of cattle.

Atomic absorption spectrometer, cadmium, cattle, lead, liver, muscle

Introduction

Monitoring levels of mineral concentrations in animal tissues is important for assessing the effect of contamination on animal health and the safety of products of animal origin in human nutrition (Miranda et al. 2005). Increasing concerns about pollution in the environment call for advanced and rapid methods to estimate ecological toxicity (Nota et al. 2008). Toxic metals are metals that are not required in the diet and that have chronic negative effects at low concentrations and lethal effects at high concentrations. Xenobiotics, including heavy metals, exist in nature as complex mixtures of compounds with possible interactions (Stawarz et al. 2009). Animal studies on the toxicity of heavy metals have been widely used as a model to simulate the impact of environmental pollution on human health (Al-Johany and Haffor 2009). The effects of heavy metals on pigs (López-Alonso et al. 2007), hens (Arpášová et al. 2007), rabbits (Roychoudhury and Massanyi 2008), and cattle (López-Alonso et al. 2002) were examined.

Cadmium is an environmental contaminant unique among metals because of its diverse toxic effects, extremely protracted biological half-life, low rate of excretion from the body, and predominant storage in soft tissue, primarily in the liver and kidneys (Lukáč et al. 2007). Lead is a heavy metal that is distributed in environmental, natural and anthropogenic sources. The concentration of lead in biological tissue corresponds to environmental pollution levels and varies significantly with geographic area and demographic factors (Skalická et al. 2002). The aim of this study was to examine the concentrations of certain heavy metals in the muscle of cattle from a polluted area.

Materials and Methods

Samples of muscle and liver were obtained from cattles (n = 25) at the age of 3 – 5 years. The studied cattles came from farms in an area polluted by a metallurgical plant in Eastern Slovakia. The samples were collected at slaughter and immediately frozen and stored at -20 °C until analysis. The analysis consisted of digestion in a microwave oven (MLS-1200 Mega, Milestone) using 5 mL HNO_3 and 1 mL HCl per 1 g of sample. The digestion programme was as follows: step 1 – 250 W, 2 minutes; step 2 – 0 W, 2 minutes; step 3 – 250 W, 5 minutes; step 4 – 400 W, 5 minutes; step 5 – 500 W, 5 minutes; and step 6 – 600 W, 2 minutes. The digested samples were analysed for the presence of Cd and Pb using an atomic absorption spectrometer (Unicam Solar, 939) in a graphite furnace. The used operating parameters were recommended by the instrument manufacturer for Cd and Pb

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(wavelength 228.8 and 283.3 nm respectively, band pass 0.5 nm). The detection limits for Cd and Pb were 0.01 and 0.08 mg·L[1], respectively. The graphite furnace was optimised for maximum absorbency and linear response while aspirating a known standard. The reproducibility of the method was tested by analysing reference materials (MBH Anal. Ltd., U.K.) The standards were prepared from the individual 1 000 mg·kg^{-1} standard (Merck, Germany), 100 ml of five combined standards were prepared in 0.1 N HNO_3. The lamp current used was 75%. The signal type was transient for cadmium and lead. Measurement time was 3 seconds. The recovery of the method was 96 – 98% and reproducibility was better than 1.0%. Metal concentrations are expressed on a wet weight basis. The computer program Microsoft Excel was used to compare data as a mean, maximum of level and standard deviation.

Results and Discussion

Samples of cattle muscle and liver were taken from an area located in Eastern Slovakia (Fig. 1).

Fig. 1. The location of Slovakia and the area of sampling

The mean concentration of cadmium in the muscle of cattle was relatively low (0.054 mg·kg^{-1}) in the polluted area. On the other hand, the mean concentration of Cd in the liver (0.245 mg·kg^{-1}) was significantly higher than in the muscle (Fig. 2). The maximum level of Cd (0.865 mg·kg^{-1}) in the liver was higher than the maximum amount of Cd (0.300 mg·kg^{-1}) in the muscle (Table 1).

Table 1. Concentration of trace elements in meat (n = 25) from polluted area

Metal ions	Statistical parameter	Concentration of metal (mg·kg^{-1}) wet weight Muscle	Liver
Cadmium	X	0.054	0.245
	X max	0.300	0.865
Lead	X	0.424	0.672
	X max	0.854	2.324

X – average; X max – maximum values

The obtained results were compared with the maximum permissible hygiene limits for Cd in meat (0.05 mg·kg^{-1}) and internal organs (0.5 mg·kg^{-1}) according to Commission Regulation (EC) No. 629/2008. Levels reaching the highest permissible hygiene limit for Cd were recorded in 3 out of 25 samples of liver and in 6 out of 25 samples of muscle.

The mean values of Cd determined in our work were comparable with those published by Tahvonen and Kumpulainen (1994). The mean Cd content in the muscle and liver found in the study was (0.052; 0.066 mg·kg^{-1}). The decrease is due to current low Cd emissions in Finland and abroad and due to improved analytical methods. The mean Cd concentration found in our study was slightly greater in bovine meat and lower in liver than the values recorded in Slovenian cattle (0.004 and 0.373 mg·kg^{-1}, respectively) by

Doganoc (1996). Cattle from the industrialised area of Eastern Slovakia were older than the cattle reported in other recent studies. Miranda et al (2005) found in animals aged 9 – 12 months, from polluted areas of Asturias (Spain), that concentrations of heavy metals were ranged from 0.04 to 1.11 mg·kg^{-1} for lead and 3.4 x 10^{-4} to 0.66 mg·kg^{-1} for copper.

The mean concentration of lead in the liver (Fig. 3) was higher (0.672 mg·kg^{-1}) than the mean concentration of Pb in the muscle (0.424 mg·kg^{-1}). The maximum level of Pb (2.324 mg·kg^{-1}) in the liver was higher than the maximum amount of Pb in the muscle (0.854 mg·kg^{-1}). The results obtained were compared with the maximum permissible hygiene limits for Pb in the muscle (0.1 mg·kg^{-1}) and the internal organs (0.5 mg·kg^{-1}) according to the Commission Regulation (EC) No. 629/2008. In our study, levels reaching the highest permissible hygiene limit for Pb were recorded in 15 of the 25 samples of liver and in 22 of the 25 samples of muscle.

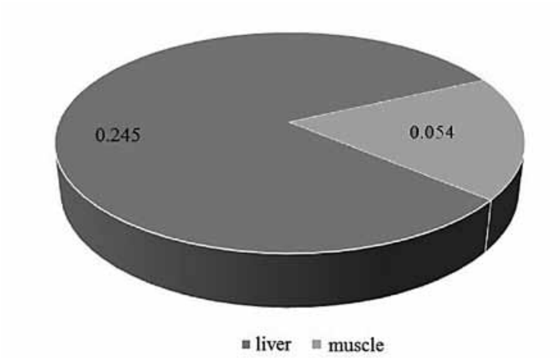

Fig. 2. The average levels of cadmium in the liver and in the muscle of the cattle (mg·kg^{-1})

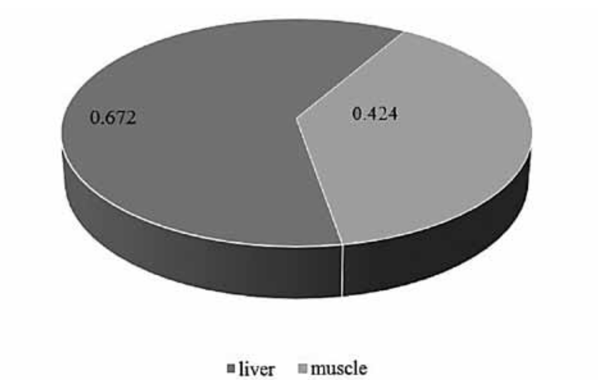

Fig. 3. The average levels of lead in the liver and in the muscle of the cattle (mg·kg^{-1})

The Pb concentrations in the cattle muscle found in our study were greater than the values recorded by Falandysz (1993), Tahvonen and Kumpulainen (1995) and Doganoc (1996), who found mean Pb values in the ruminant muscle (0.040, 0.010 and 0.050 mg·kg^{-1} wet weight, respectively) and mean Pb values in the liver (0.160, 0.037 and 0.100 mg·kg^{-1} wet weight, respectively) in Poland, Finland and Slovenia.

Jorhem et al. (1996) suggested that the main reason for the apparent widespread decrease in muscle Pb levels is probably the improvement in analytical methods and quality control programmes rather than any true reduction in muscle Pb concentration. The mean concentrations of Pb in the liver and muscle observed in our study (0.672, 0.424 mg·kg^{-1}, respectively) were markedly higher in comparison to studies referred (0.028, 0.0145 mg·kg^{-1}, respectively) López Alonso et al. (2002).

Conclusions

The livestock from the observed area polluted by a metallurgical plant mostly showed higher tissue levels of toxic metals such as Cd and Pb than cattle from polluted areas in other studies. Occurrence above the permitted limit in samples of cattle in the studied industrial area was as follows: Cd – 25% in the muscle and 12% in the liver, Pb – 88% in the muscle and 60% in the liver.

Acknowledgments

The study was supported by VEGA 1/0373/15.

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