Concentrations of Cadmium, Lead, Nickel, Copper and Zinc in Various Muscles of Sheep

P. Massányi, P. Nad, R. Toman and J. Kováčik

Konzentrationen von Kadmium, Blei, Nickel, Kupfer und Zink in verschiedenen Schafmuskeln

1. Introduction

The presence of heavy metals in human and animal bodies always draws scientific concern as these are considered responsible for affecting health, especially in these days where the release of toxic wastes in the environment has been increased.

Development in industry and agriculture produces reorganization of elements in the food chain. Conditions also develop to promote uneven distribution of essential elements in the animal organism and to change their interaction. The inadequate intake of trace elements by ruminants and the interrelationships of copper and selenium are of interest (BIRES et al., 1991). From the viewpoint of husbandry and the predisposition of species, sheep appears to be the most endangered animal (BIRES et al., 1992).

Some metals are essential for life, others have unknown biological function, either favorable or toxic, and some others have the potential to produce disease. Those causing toxicity are the ones, which accumulate in the body through food chain, water and air (MORRIS and GREENE, 1970; LUCAS, 1975; TSOUMBARIS and TSOUKALI-PAPADOPOULOU,

Zusammenfassung

In dieser Arbeit haben wir die Konzentration von Kadmium, Blei, Nickel, Kupfer und Zink in 6 topographisch abweichenden Schafmuskeln untersucht, die nach AAS festgestellt wurden. Die größte Konzentration des Kadmiums haben wir im *M. triceps brachii* (0.035 ± 0.020 mg/kg) gefunden. Analog war auch die Bleikonzentration in diesem Muskel (0.347 ± 0.043 mg/kg) größer. Die größte Nickelkonzentration war im *M. quadriceps femoris* (0.470 ± 0.025 mg/kg), die des Kupfers im *M. psoas major* (2.127 ± 0.509 mg/kg) und die des Zinks im *M. triceps brachii* (37.745 ± 14.696 mg/kg). Wir haben keine Merkmalsunterschiede in der Konzentration der untersuchten Metalle zwischen ausgewählten Muskeln gefunden. Die Korrelationsanalyse hat gezeigt, dass es keine großen Korrelationsbeziehungen der Kadmium-, Blei-, Nickel-, Kupfer- und Zinkgehalte in den verschiedenen Muskeln gibt.

Schlagworte: Kadmium, Blei, Nickel, Kupfer, Zink, Muskel, Schafe, Schwermetalle.

Summary

In this study, concentrations of cadmium, lead, nickel, copper and zinc determined by AAS in 6 topographically different muscles of sheep are reported. The highest concentration of cadmium is reported in *m. triceps brachii* (0.035 ± 0.020 mg per kg of wet weight). Also the lead level was highest in *m. triceps brachii* (0.347 ± 0.043 mg/kg). Concentration of nickel was highest in *m. quadriceps femoris* (0.470 ± 0.025 mg/kg), copper in *m. psoas major* (2.127 ± 0.509 mg/kg), and the highest concentration of zinc was found in *m. triceps brachii* (37.745 ± 14.696 mg/kg). Any significant differences were found among the metal concentrations in studied muscles. Correlation analysis determined that, there are no high correlation relationships among the content of cadmium, lead, nickel, copper, and zinc in different muscles.

Key words: cadmium, lead, nickel, copper, zinc, muscles, sheep heavy metals.

1994). Cadmium and lead are not ubiquitous in the environment, but have been extensively used in industries. They are persistent in the environment once discharged, and they stay in the human body with long half-lives when absorbed. These behavioral characteristics make them good long-term markers of environmental pollution. Further, they are insidious intoxicants to humans (IKEDA et al., 1996).

The amount of an element accumulated in the organs of sheep depends on the interval of exposure, the quantity ingested, the production and reproduction phase of the animals as well as their age and breed (VAN DER SCHEE et al., 1983). Element toxicity upon the biological systems of animals is effected by the route and form of ingestion as well as by the interaction between essential and toxic elements (CHOWDHURY and CHANDRA, 1987).

The purpose of this study was to determine cadmium, lead, nickel, copper, and zinc concentrations in topographically different muscles and find whether there are differences in accumulation.

2. Materials and Methods

Ten improved Wallachian ewes 2 years of age were used for the analysis of cadmium, lead, nickel, copper and zinc in six topographically various muscles. Sheep were kept indoor and the nourishment was designed as normal without higher concentration of contaminants.

During necropsy following 1 cm^3 of muscles in the same middle region (venter) were obtained for analytical purposes: ***musculus psoas major*** (PM), *m. longissimus dorsi* (LD), *m. semitendinosus* (ST), *m. semimembranosus* (SM), *m. triceps brachii* (TB), and *m. quadriceps femoris* (QF). *M. psoas major* is the largest and most lateral of the sublumbar muscles, *m. longissimus dorsi* is the intermediate column of the erector muscles of the spine and is the largest and longest muscle in the body, *m. semitendinosus* is a long, fleshy, fusiform muscle, lying on the caudolateral aspect of the rump, *m. semimembranosus* is a long, thick, fleshy muscle which lies on the caudal aspect of the rump, *m. triceps brachii* is a large muscle which fills the angle between the caudal border of the scapula and humerus and is the major extensor of the elbow and *m. quadriceps femoris* occupies the area along the cranial, lateral and medial aspects of the thigh and is a strong extensor of the stifle joint. Generally two types of muscles were analyzed – muscles with lower motor activity (PM, LD) and muscles with high activity (ST, SM, TB, QF).

The samples taken were processed by means of a mineralization system MLS-1 200 MEGA of fy MILESTONE, using microwave decomposition technology and low-boiling acids (HNO_3, HCl). Digestion program: 1-st step – 250W, 2 minutes; 2-nd step – 0W, 2 minutes; 3-rd step – 250W, 5 minutes; 4-th step – 400W, 5 minutes; 5-th step – 500W, 5 minutes and 6-th step – 600W, 2 minutes. Muscles were analyzed by atomic absorption spectrophotometry as follows: copper and zinc were analyzed by graphite furnance using a Perkin-Elmer 306 instrument, whereas cadmium, lead and nickel were analyzed by the HGA 500 graphite cuvette using Perkin-Elmer 1100 and 4100 ZL. Concentrations of the individual elements were recorded in mg/kg wet matter.

From final data, basic statistical characteristics were calculated (mean, standard deviation), and an analysis of variance by Scheffe's test and correlation relationship were completed for each variable.

3. Results

3.1 Cadmium

The highest cadmium concentration was found in TB (0.035 ± 0.020 mg/kg). The level was lower in ST (0.033 ±

Table 1: Concentrations (mg/kg) of cadmium, lead, nickel, copper and zinc in studied muscles in sheep
Tabelle 1: Konzentrationen (mg/kg) von Kadmium, Blei, Nickel, Kupfer und Zink in untersuchten Muskeln bei Schafen

Element	Cd	Pb	Ni	Cu	Zn
Muscle	x ± s	x ± s	x ± s	x ± s	x ± s
PM	0.007 ± 0.007	0.346 ± 0.053	0.410 ± 0.051	2.127 ± 0.509	20.365 ± 7.072
LD	0.019 ± 0.008	0.244 ± 0.051	0.129 ± 0.043	1.795 ± 0.312	31.352 ± 7.633
ST	0.033 ± 0.013	0.259 ± 0.048	0.281 ± 0.036	1.338 ± 0.486	27.392 ± 7.910
SM	0.025 ± 0.009	0.321 ± 0.062	0.443 ± 0.053	1.705 ± 0.898	36.168 ± 22.178
TB	0.035 ± 0.020	0.347 ± 0.043	0.460 ± 0.027	0.713 ± 0.508	37.745 ± 14.696
QF	0.021 ± 0.005	0.343 ± 0.035	0.470 ± 0.025	1.009 ± 0.535	30.023 ± 12.752

PM – *m. psoas major*, LD – *m. longissimus dorsi*, ST – *m. semitendinosus*,
SM – *m.semimembranosus*, TB – *m. triceps brachii*, QF – *m. quadriceps femoris*

0.013 mg/kg), SM (0.025 ± 0.009 mg/kg), QF (0.021 ± 0.005 mg/kg) and LD (0.019 ± 0.008 mg/kg). The lowest cadmium concentration is reported in PM 0.007 ± 0.007 mg/kg (Table 1). Any significant differences were found. Correlation relationships among cadmium concentrations in studied muscles were very low. Middle relationship was found between ST – TB and was 0.4943.

3.2 Lead

Lead concentration was in all muscles in the range of 0.244 – 0.347 mg/kg (Table 1). The highest lead concentration is reported in TB (0.347 ± 0.043 mg/kg) and the lowest in LD (0.244 ± 0.051). The level of lead was in PM 0.346 ± 0.053 mg/kg, in ST 0.259 ± 0.048 mg/kg, in SM 0.321 ± 0.062 mg/kg, and in QF 0.343 ± 0.035 mg/kg. Differences among concentrations were not significant. Correlation analysis showed low relation. Middle correlation was found between PM – TB, PM – QF and TB – QF.

3.3 Nickel

The concentration of nickel was in all studied muscles 0.129 – 0.470 mg/kg (Table 1). The highest nickel concentration is in QF (0.470 ± 0.025 mg/kg) followed by TB (0.460 ± 0.027 mg/kg), SM (0.443 ± 0.053 mg/kg), PM (0.410 ± 0.051 mg/kg), and ST (0.281 ± 0.036 mg/kg). The lowest nickel concentration was found in LD (0.129 ± 0.043 mg/kg). We have found any statistic differences. All correlation relationships were very low.

3.4 Copper

Copper concentration is the highest in PM (2.127 ± 0.509 mg/kg) and the lowest in TB (0.713 ± 0.508 mg/kg). The copper level is in LD 1.795 ± 0.312 mg/kg, SM 1.705 ± 0.898 mg/kg, ST 1.338 ± 0.486 mg/kg, and in QF 1.009 ± 0.535 mg/kg (Table 1). There are no significant differences among copper concentration in various muscles.

Correlation analysis determined middle correlation relationship between LD and SM; all other relationships were low.

3.5 Zinc

The zinc concentration in muscles is in the range of 20.365 – 37.745 mg/kg (Table 1), with any significant differences among muscles. The highest zinc level is in TB (37.745 ± 14.696 mg/kg), followed by SM (36.168 ± 22.178 mg/kg), LD (31.352 ± 7.633 mg/kg), QF (30.023 ± 12.752 mg/kg), ST (27.392 ± 7.910 mg/kg), and the lowest zinc concentration was found in PM (20.365 ± 7.072 mg/kg). Middle correlation relationship was found between LD-QF (0.4393), and SM-TB (0.4434). Between zinc concentration in all other muscles low relation was determined.

4. Discussion

In this study concentrations of cadmium, lead, nickel, copper and zinc in six topographically different muscles were analyzed.

We report that the cadmium concentration in muscle is 0.007–0.035 mg/kg wet tissue. In our previous study we have analyzed cadmium content in *m. psoas major* and other organs in rabbits. Cadmium level in muscle was 0.01 ± 0.01 mg/kg wet weight and the highest cadmium concentration was found in kidney – 0.46 ± 0.11 mg/kg (MASSÁNYI et al., 1995). Similar values (TOMAN and MASSÁNYI, 1996) were found also in the *m. psoas major* of sheep (0.01 mg/kg wet weight) and fallow-deer (0.005 mg/kg wet weight). In beef meat the mean cadmium concentration is 52.5 ppb (TSOUMBARIS and TSOUKALI-PAPADOPOULOU, 1994). These data confirm that the cadmium accumulation is lower in muscles in comparison with kidneys, but there is unsignificantly higher concentration of cadmium in muscles with higher motor activity.

Concentration of lead is in different muscles in the range of 0.244–0.347 mg/kg. TSOUMBARIS and TSOUKALI-PAPADOPOULOU (1994) have reported the lead concentration in beef meat 160.0 ± 56.7 ppb. Very higher level of lead in muscles (1.68 ± 0.94 mg/kg) of improved Wallachian ewes have been reported in animals with copper intoxication (BIRES et al., 1995). Typical lead levels in meat are 0.05 mg/kg (GALAL-GORCHEV, 1991). Foodstuffs, which contribute most to the total intake of lead by adults vary from country to country, and have been identified as being alternatively drinking water, beverages, cereals, vegetables and fruits. In spite of high levels of lead that may be found in canned food, these foods, because of their relatively low consumption, were not identified as major contributors to the intake.

Nickel levels were in all studied muscles 0.129–0.470 mg/kg, with the highest level in *m. quadriceps femoris.* TSOUMBARIS and TSOUKALI-PAPADOPOULOU (1994) have reported in beef meat nickel concentration 75.2 ± 20.1 ppb. Food has been found to be the main source of nickel intake by man. Nickel was fairly evenly distributed throughout the various food groups examined but highest concentrations were found in the canned vegetables, sugars and preserves, and bread and cereals food groups, suggesting a contribution from food processing equipment and, possibly, food cans. Mean dietary nickel intake in the UK was between 0.14–0.15 mg/kg (SMART and SHERLOCK, 1987).

Determination of copper showed that the mean copper concentration in muscle is 0.713–2.127 mg/kg, with the highest value found in *m. psoas major.* Intoxication of sheep by copper compounds may be of different etiology. For ruminants, the fallout regions of copper producing plants present the major risk of increased copper intake (GUMMOV et al., 1991).

In this study we report that the zinc concentration in various muscles is 20.365–37.745 mg/kg. In comparison with beef meat (26.24 ± 4.19 mg/kg) they are very similar (TSOUMBARIS and TSOUKALI-PAPADOPOULOU, 1994).

From all our data it is evident that there are differences between topographically various muscles in the concentration of cadmium, lead, nickel, copper as well as zinc, but these differences are not significant. In comparison with liver and kidney these levels are much lower.

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Addresses of authors

Peter Massányi DVM, PhD, Robert Toman, Dr., Ing., Jaroslav Kováčik, Prof. Ing., PhD, University of Agriculture, Department of Physiology and Anatomy of Farm Animals, Tr. A. Hlinku 2, SK-94976 Nitra, Slovak Republic; e-mail: massanyi@afnet.uniag.sk

Pavel Nad, DVM, PhD, Research Institute of Veterinary Medicine, Hlinkova 1/A, SK-040 01Kosiče, Slovak Republic.

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