CONCENTRATION OF SELECTED METALS IN LIVER, KIDNEY AND MUSCLE OF THE RED DEER (*CERVUS ELAPHUS*)

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ABSTRACT
Concentrations of cadmium, lead, chromium, zinc, copper and manganese in liver, kidney and muscle of red deer was investigated. For analysis of the content of these trace elements an AAS method was used. The concentration of cadmium is significantly ($p<0.05$) higher in kidney in comparison with liver and muscle. The level of lead is the highest in muscle ($p<0.05$). Lower values were detected in liver and in kidney. The concentration of chromium is very similar in all studied tissues. In zinc, we found higher concentration of this metal in muscle, followed by kidney and liver. The level of copper is significanlty higher in liver ($p<0.05$), and lower in kidneys and muscle. In evaluation of the concentration of manganese in red deer, the highest concentration of this element in liver was detected.

INTRODUCTION

Development in industry and agriculture produce reorganization of elements in the food chain. The amount of an element which accumulates in the organs depends on the interval of exposure, the quantity ingested, the production and reproduction phases of the animals, as well as their age and breed. Element toxicity upon the biological systems of animals is affected by the route and form of ingestion as well as by the interaction between essential and toxic elements[1]. Some metals are essential for life, others have unknown biologic function. Those causing poisonings are the ones, which accumulate in the body through the food chain, water and air [2, 3].
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 animal and 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 animals [4–7] as well as humans [8]. The purpose of this study was to determine cadmium, lead, chromium, zinc, copper and manganese concentration in selected organs of red deer (*Cervus elaphus*).

MATERIALS AND METHODS

The samples of liver, kidney and muscle (*m. longissimus dorsi*) were collected from 22 adult male red deer (*Cervus elaphus*), which were shot in the surroundings of the town Topolcany, West Slovakia. This is a hunting area with optimum soil and climatic conditions for this game species.
The digested samples were analysed for the presence of cadmium, lead, chromium, zinc, copper and manganese by using an atomic absorption spectrophotometer (AAS) Pye Unicam SP9. Analyzing reference materials tested the reproducibility of the method. The standards were prepared from the individual 1000 mg/kg standard, 100 ml of five combined standards were prepared in 0.1 N HNO_3. The lamp current used was 75%. Measurement time was 3 seconds. The recovery of the methods was 96 - 98% and reproducibility was better than 1.0% [9]. All metal concentrations are expressed on a wet weight basis in mg/kg.
For statistical analysis Student's *t*-test and Scheffe's test in PC programs SAS and Excel were used.

RESULTS AND DISCUSSION

Concentrations of cadmium, lead, chromium, zinc, copper and manganese in red deer are listed in Table 1.

Table 1. The Concentration of Selected Trace Elements in Liver, Kidney and Muscle in Red Deer

Organ	Median	Minimum	Maximum
	Cadmium (mg/kg)		
Liver	0.258	0.074	0.870
Kidney	2.387*	0.320	5.760
Muscle	0.232	0.010	1.320
	Lead (mg/kg)		
Liver	1.904	0.120	28.800
Kidney	0.561	0.100	1.303
Muscle	6.478*	0.150	104.873
	Chromium (mg/kg)		
Liver	0.138	0.030	0.368
Kidney	0.139	0.010	4.130
Muscle	0.246	0.040	0.584
	Zinc (mg/kg)		
Liver	26.235	20.370	34.096
Kidney	31.117	20.880	126.090
Muscle	54.760	17.797	109.120
	Copper (mg/kg)		
Liver	13.342*	2.890	34.260
Kidney	4.934	3.540	8.048
Muscle	2.489	1.190	5.340
	Manganese (mg/kg)		
Liver	3.470	1.310	5.150
Kidney	1.336	1.020	2.170
Muscle	2.033	0.820	5.790

*$p<0.05$

The kidney concentration of cadmium is significantly ($p<0.05$) higher in comparison with liver and muscle. The level of lead is the highest in muscle ($p<0.05$), which is more that 3-times higher than in liver and almost 12-times higher than in kidney. The concentration of chromium is very similar in all studied tissues. In zinc, we found higher concentration of this metal in muscle. The level of copper is significanlty higher in liver ($p<0.05$), and lower in kidneys and muscle. In evaluation of the concentration of manganese in red deer, the highest concentration of this element in liver was detected.

Cadmium mainly accumulates in kidney and liver in farm animals [9–11] as well as in wild animals [12, 13]. In this study we report significanly higher cadmium concentration in liver in comparison with liver and muscle. In the kidney of suburban foxes, cadmium concentrations increased from a median value of 0.73 mg/kg in juvenile animals to 1.82 mg/kg in adults. An age dependent storage of cadmium was also found in foxes from the rural surroundings [14]. In a study describing arsenic, cadmium, lead, copper and zinc in cattle from Galicia, Spain [15] has been reported that age did influence accumulation. The frequency of histopathologic changes as vacuolic degeneration, pycnotic nuclei, caryolysis, and necrosis is related to increased cadmium levels. Environmental cadmium exposure may be the cause for the histopathological alterations. It has been indicated that chronic cadmium poisoning may be an important cofactor in the pathogenic mechanisms of renal damage in roe deer [16].

Lead poisoning has been a part of history since 4,000 years before Christ. With increasing awareness of the toxicity associated with lead, it is one of the most common toxicants in large and small animals [17]. In our study we report significantly higher ($P<0.05$) accumulation of lead in muscles in comparison with liver and kidney. High lead-levels in muscles appear to be the most notable discovery of this survey. The average lead content in muscles of wild pigs was 4.342 mg/kg, roe 4.193 mg/kg and deer 0.201 mg/kg. The actual maximum limit for lead in meat was exceeded in 25% of the analysed samples [18].

In chromium, zinc and manganese we report very similar, non - significant values in all studied organs. Generally, it is interesting that elements with oxidation states II (cadmium, copper, lead, mercury, zinc,

nickel) all show a strong affinity for ligands such as phosphates, cysteinyl and histidyl side chains of proteins, purines, pteridines, and porhyrins. Hence, all these elements can act at a large number of biochemical sites. All inhibit many enzymes having functional sulfhydryl groups, all bind to and affect the confirmation of nucleic acids, and all disrupt pathways of oxidative phosphorylation, although in each instance the precise response depends upon the individual properties of the metal [19].
In copper we report significantly higher ($p<0.05$) concentration of this metal in liver in comparison with kidney and muscle (Table 1). Mean liver copper concentrations for farmed and feral yearlings were 267 and 889 μmol/kg, respectively, and for farmed and feral adults were 206 and 677 μmol/kg, respectively. Liver copper concentrations were lower for farmed than for feral deer and for feral adults than for feral yearlings [20]. Data that can be used to establish reference ranges for assessing trace element status in deer are limited. More robust reference values for farmed red deer need to be established through further studies relating biochemical data to health and performance.

CONCLUSIONS

Analysis of the concentration of cadmium, lead, chromium, zinc, copper and manganese in liver, kidney and muscle of red deer detected significantly ($p<0.05$) higher cadmium concentration in kidney in comparison with liver and muscle. The level of lead is the highest in muscle ($p<0.05$) and lower values are in liver and in kidney. The concentration of chromium is very similar in liver, kidney as well as in muscles. In zinc, higher concentration of this metal in muscle, followed by kidney and liver was observed. The level of copper is significanlty higher in liver ($p<0.05$), and lower in kidneys and muscle. In evaluation of the concentration of manganese the highest concentration of this element in liver was detected.

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