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Content of heavy metals in the muscle tissue of cattle

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Abstract. Muscle tissue to examine was taken from 31 Black-and-White bull-calves of West Siberia, aged 18 months. The concentration of 11 trace elements in the samples of the muscle tissue was determined with the method of atomic emission spectrometry with inductively associated plasma. The concentration of heavy metals (mg/kg) in the muscle tissue was equal to: Pb – 0.070; Cd – 0.015; As – 0.305; Sr – 0.255; Rb – 1.458; Cu – 1.571; Fe – 50.884; Zn – 52.99; Hg – 0.007; Ni – 0.069. Different correlations were revealed between the concentration of Cd in muscles and the level of Cu and Cr in hair (r = -0.349 and r = 0.374, respectively); Cu in muscles and Cd in hair (r = -0.377), Zn in muscles and Zn, Cd in hair (r = -0.558 and r = -0.470, respectively); Pb in muscles and Si in hair (r = -0.415); Hg in muscles and Cu, Cd in hair (r = 0.449 and r = 0.386). Correlations were revealed between the level of Cd in muscles and the concentration of Ba, Zn and P in blood serum (r = 0.574, r = -0.469 and r = -0.493 respectively); between Pb in muscles and Fe in serum blood (r = 0.535).

Keywords: Heavy metals, cattle, muscle, hair, blood serum.

Introduction

Chemical elements play one of the major parts in the organism, they are involved in a great many biochemical reactions controlling homeostasis. Changes in their concentration in certain organs can be of diagnostic character when detecting pathological processes. The study of the content of essential microelements (Zn, Cu, Fe, etc.) in organs and tissues of animals is of great importance. The composition of about 3000 proteins includes Zn and nearly 1000 proteins are enzymes with catalytic function of Zn [1, 2]. Iron (Fe) is an oxygen carrier and its role is great in releasing energy, fermentative reactions, immunity and cholesterol metabolism. There are well-known hereditary disorders such as iron deficiency anemia (IDA), hereditary hemochromatosis [3,4] and other diseases [5]. Copper is a part of many vitamins, hormones, respiratory pigments, myelin sheaths of nerves. The one is involved in metabolism and tissue respiration, it maintains bone and cartilage structures as well as elasticity of blood vessel walls, derma and so on. Copper facilitates Fe absorption. It is proved that accumulation of chemical elements is characteristic of organs and tissues [6]. Hence it is necessary to know the population level of their content in the organism taking into account natural and climatic conditions, species, breed and the period of ontogenesis.

Materials and Methods

Muscle tissue to examine was taken from 31 Black-and-White bull-calves of West Siberia, aged 18 months. In Analytical Geochemistry Laboratory of Joint Institute of Geology, Geophysics and Mineralogy of SB RAS, the concentration of 11 trace elements in the samples of the muscle tissue was determined with the method of atomic emission spectrometry with inductively associated plasma. The weight of up to 1g was taken from the pooled sample. The weight in a quartz cup was carried onto the oven (T~150 ºC), then, dried for 12 hours to obtain small pieces of coal. The dried weights were placed into a muffle furnace (T ~100ºC) with its door open. Every 30 minutes the temperature was to be up by 50 ºC, the furnace temperature reaching 480 ºC. The quartz cups containing the samples were added to with 5 ml of nitric acid and left for 12 hours. Then, the samples were heated to obtain a dry sediment (dross) and the each one was introduced with 1 ml of perchloric acid and 5 ml of nitric acid. 2 ml of scandium were added to each sample, the terminal Sc concentration being 2mcg/ml in the solution.

Results and Discussion

The highest Zn and Fe content was in muscle tissue (table 1). The concentration of copper was much lower. There are interspecies differences in the content of chemical

elements in organs and tissues. Thus, eg., the content of Zn, Fe and Cu was much higher in Siberia's Precocious Meat pigs than that in cattle [6,7].

Table 1. Heavy metals concentrations in muscle tissue (mg/kg)

Elements	$\bar{x}$ ± SE	lim
Zn	52.99±1.24	24.59 – 63.71
Fe	50.88±2.61	30.30 – 79.50
Cu	1.571±0.059	1.10 – 2.90
Ni	0.069±0.014	0.010 – 0.350
Co	0.015±0.009	0.001 – 0.089
Rb	1.458±0.053	0.936 – 2.473
Sr	0.255±0.026	0.080 – 0.650
Cd	0.015±0.001	0.009 – 0.036
Pb	0.070±0.013	0.024 – 0.200
As	0.305±0.050	0.000 – 0.940
Hg	0.007±0.0009	0.000 – 0.024

In muscles, the concentration of Hg, Cd and Co was minor. The highest phenotypic variability was characteristic of Co, Pb, Hg and As.

Correlations between different chemical elements in muscles were studied. High relations were identified between the content of Cr and Ca (r = 0.763), Fe and Mn (r = 0.639), Pb and Cu (r = 0.564), Cu and K (r = -0.677). As and Cd (r = -0.338), Zn and Ni (r = -0.572) correlated negatively.

The search for non- and low-invasive markers of HM accumulation tissues is of importance (table 2). The content of Cd and Cu in hair correlates to the accumulation of Hg in muscles (r =0.386 and r = 0.449 respectively). The content of Si and K in hair can be the marker of Pb accumulation in muscles (r = - 0.415 and r = - 0.390 respectively).

Table 2. Correlation of the content of chemical elements in hair and muscles.

Hair — muscle	r	Hair — muscle	r
B – Cd	- 0.372	Al – Hg	0.342
Cr – Cd	0.374	Cu – Hg	0.449
Cu – Cd	- 0.349	Cd – Hg	0.386
K – Pb	- 0.390	Cd – As	- 0.413
Si – Pb	- 0.415	Zn – Fe	0.330
		K – Rb	0.419

More closer relations were identified due to the accumulation of heavy metals in muscles and the content of different chemical elements in blood serum (table 3).

Table 3. Correlation of the content of chemical elements in blood serum and muscles

Blood serum - muscles	r	Blood serum - muscles	r
Ba – Cd	0,574	Ba – Fe	0,422
P – Cd	- 0,483	Cu – Fe	0,394
Rb – Cd	- 0,416	Rb – Fe	0,424
Zn – Cd	- 0,469	B – Rb	- 0,449
Fe – Sr	0,348	Cl – Rb	- 0,359
Cl – Pb	0,449	Cu – Rb	- 0,442
Fe – Pb	0,535	Rb – As	0,356
Rb – Pb	- 0,453		

Correlations of middle value were observed between the content of Cd in muscles and the concentration of Ba, P, Zn and Rb in blood serum (r=0.574, r=-0.483, r=-0.469 and r=-0.416, respectively). The association of the level of a series of chemical elements in blood serum with that of Fe and Rb in muscles was also observed. Thus, the content of some chemical elements in hair and serum can be used as indexes of the content of heavy metals in muscles.

Conclusion

Mean population levels of the content of heavy metals were determined in the muscles of Black-and-White cattle. Positive and negative relations were revealed in the level of a series of chemical elements in hair and blood serum to the accumulation of heavy metals in the muscle tissue of Black-and-White bulls. The content of a complex of chemical elements in the hair and blood serum can be used as lifetime indicators of HM accumulation in the muscle of cattle.

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