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Ecological Aspects of the Use of Bentonites as Detoxicants of Heavy Metals In the Body of Cows.

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ABSTRACT

As a result of the intensification of technological processes in agricultural production, the risk of contamination and accumulation of xenobiotics of various origins, including heavy metals, in the livestock production has increased. Their intensive and long-term effects on animals and humans damage the work of the immune system, disrupt the hormonal balance and function of the enzymes, and also lead to a decrease in the systems of adaptive processes of homeostasis of the organism. One of the effective methods of detoxication therapy can be the use of sorbents from the group of natural aluminosilicates - bentonites, which have long been used in the treatment of poisoning in animals with oral intake of toxic substances. The use of bentonitefrom the Kantemirovskoye field of the Voronezh region by down-calving cows 60 days before calving in a dose of 50.0 g per animal reduces the accumulation of lead in the blood of cows by 7.8%, cadmium – by 4.2%, nickel – by 9.4%, respectively, being a highly efficient, economical and affordable method of reducing the transport of Pb, Cd, Ni in the food chain. At the same time, bentonites, the metabolic activity of which is due to the content of a wide range of macro- and microelements and physico-chemical structural features, provide correction of such essential trace elements as Fe, Zn and Cu in the animal organism.

Keywords: animal husbandry, aluminosilicates, bentonites, enterosorption, ecology, heavy metals, cattle

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INTRODUCTION

The current state of animal husbandry poses great and complex problems for scientists, managers, specialists and workers of the agro-industrial complex. The organization of large industrial enterprises, and most importantly - the tendency to obtain the maximum possible livestock products without a clear and strict observance of the developed technological regulations for breeding, feeding and keeping are the main factors of destabilization of this branch of agriculture.

The intensification of technological processes in agricultural production has resulted in the increase of the risk of contamination and accumulation of xenobiotics of various origins – pesticides, radionuclides, heavy metals, nitrates, bacterial cells, mold fungi and their toxins, which, retaining their toxic properties, get into the organism of animals and poultrythrough the feed chains [1].

Toxic elements polluting the atmosphere, as well as agricultural raw materials and livestock products are heavy metals, which are "a critical group of substances-indicators of atmospheric stress." At the same time, their intensive and prolonged impact on animals and humans damages the work of the immune system, disrupts the hormonal balance and the function of the enzymes, and also leads to a decrease in the systems of adaptive processes of the body's homeostasis [2].

The toxic effect of pollutants is manifested in a negative effect, primarily on the liver, since one of the main functions of this organ is barrier - neutralization of poisons and toxins. Modern environmental conditions, increasing intensity of exposure to chemical-physical and biological factors, as well as excessive prescription of medical preparations, including antibiotics and hormones, create preconditions for the growth of hepatopathies [3].

In connection with the foregoing, the current issue of pharmaceutical science is the development of methods and means for reducing the intake of toxicants, both in the animal's organism and in livestock products. One of the effective methods of detoxification therapy is the use of sorbents, which have long been used in the treatment of poisoning in animals due to the oral intake of toxicants [4].

The group of natural sorbents includes bentonites, which, due to their high sorption, catalytic, binding activity and excessive surface negative charge, are the most effective natural compounds capable of accumulating not only heavy metal ions, but also a large number of different toxicants [5].

They are crystalline aluminosilicates formed from two structural elements assembled into laminated packets. In most cases, montmorillonite occupies a leading position (60-70%), so bentonites are often called montmorillonite clays [6].

Montmorillonite clays are formed during the decomposition of volcanic ash, and also due to weathering of igneous rocks in marine lagoons during hydrothermal processes and are formed mainly in alkaline medium, which greatly increases their chemical activity. At the same time, a number of macro-and microelements, which are biologically active substances, capable of exerting a strong effect on various physiological processes of the body, are found in their composition. That is why, at the initial stages of studying the effect ofbentonites on the organism of animals and humans, they were considered as a natural polymineral additive. However, this is not the only and, perhaps, not the main function of bentonite clays.

Due to the peculiar composition of the structure of the crystal lattice, bentonites are able to effectively bind and remove toxic substances from the body. When they come into contact with live biological tissue, a fundamentally new biomineral environment consisting of particles of bentonite, toxin molecules and lymphoid cells clustering around them arises in the intestinal cavity. The source of lymphoid cells for such artificial anatomical formations are the sinuses of the villi of the small intestine, in the lumen of which there are lymphocytes, which begin to migrate actively through the intercellular gaps to the surface of the epithelium upon contact of the intestinal mucosa with the sorbent particles. At the same time, they assume the detoxification and immune functions. During the adsorption of toxic products in the intestine, the cellular immunity activates, the trigger mechanism of which is the introduction of an absorbent substance - bentonite into the body [7].

At the same time, the efficiency of the formation of such bonds depends on the ion sorbent capacity index. Bentonites having a capacity of more than 60 mg / eq per 100 g of dry matter actively attract and retain the polar functional groups of toxin molecules, creating on their basis new structural compounds that, due to their increase in size, cannot be sorbed by the intestinal walls of the intestine. Bound toxins are fixed on the surface of the sorbent particles, which prevents their absorption and spread through the body and then are excreted with feces [8]. In addition, the crystal lattice of bentonite clays is electrically unbalanced, which creates an excessive negative charge on the surface of the adsorbent, significantly increasing its ability to accumulate ions with positive charges. That is why they excellently remove from the intestine under-oxidized metabolism products, harmful gases, actively extract ammonium nitrogen, heavy metal ions, radionuclides. Due to the mobile lattice, large active surface, exchange capacity and the range of change of these parameters, the sorption activity of bentonites can increas 10-15 times, which makes them one of the most effective adsorbents. Therefore, it is bentonites that are unsurpassed sorbents, easily binding both organic bases and their salts and inorganic compounds, forming clay-organic complexes - bentons [9, 10].

In this connection, the purpose of the experiments was to study the detoxification properties of bentonites with respect to heavy metals.

METHODOLOGY OF RESEARCH

The object of the research is a natural aluminosilicate mineral – bentonite of the Kantemirovsky deposit of the Voronezh region.

Scientific and production experiment was conducted on down-caving cows 60 days before calving, of which two groups of 10 animals were formed according to the principle of paired analogues. The keeping and feeding conditions of cows were identical. The difference was that, in addition to the basal diet, the animals of the experimental group received bentonite in a mixture with concentrated feeds at the rate of 50 g per animal before calving. The second group of cows was an intact control (Table 1).

Table 1 – Scheme of scientific and production experiment

Groups	Number of animals in the group	Feeding conditions
1–control	10	Basaldiet (BD)
2 – experimental	10	(BD) + bentonite 50 g/head

Blood samples of all animals were taken for laboratory testsin the dynamics - before the experiment, after 30 days and at the end of it. The content of lead, cadmium and nickel in the samples was determined by atomic-absorption spectroscopic analysis in the acetylene-air flame. The digital data obtained in the experiments were subjected to biometric processing using the software of Mikrosoft ® company, CarlZeiss ®. The reliability criterion was determined according to the Student's table.

RESULTS

It has been experimentally found out that the pharmacological activity of bentonite is manifested by a decrease in the content of heavy metals in the blood of experimental animals (Table 2).

Table 2 – Dynamics of changes in the level of heavy metals in the blood of cows with bentonite application (n=10; M±m)

Items	Background	Experimental		Control	
		after 30 days of experiment	after 60 days of experiment	after 30 days of experiment	after 60 days of experiment
Lead, mg/kg	0.13±0.01	0.08±0.01	0.07±0.02	0.137±0.01	0.149±0.02
Cadmium, mg/kg	0.048±0.02	0.032±0.01	0.03±0.01*	0.049±0.03	0.051±0.01
Nickel, mg / kg	0.053±0.02	0.039±0.03	0.034±0.02	0.05±0.03	0.057±0.01

Degree of reliability:P≤0.01

So, after 30 days from the beginning of the experiment, the lead concentration decreased from 0.13±0.01 to 0.08±0.01 mg/kg, or by 38.4%, cadmium - from 0.048±0.02 to 0.032±0.01 mg/kg, or by 33.3%, nickel – from 0.053±0.02 to 0.039±0.03 mg/kg, or by 26.4%, respectively. By the 60th day, the difference with the background indicators for the level of heavy metals in this group was within the range of 46.2%, 37.5% and 35.8%.

At the same time, the most intensive changes in the dynamics of heavy metals occurred in the first month of application of bentonite. Subsequently, lead content in the blood of experimental cows decreased by 7.8%, cadmium by 4.2%, nickel - by 9.4%, respectively. Thus, the sorption of these elements from the body by bentonites directly depended on their concentration in the blood, at the same time, the aluminosilicates provided regulation of the levels of heavy metals in the body of animals within the limits of biological safety.

Against the background of a decline in a number of indicators in the experimental group, their increase was found in control cows. Moreover, the accumulation of lead in the blood of animals occurred more intensively, which was characterized by an increase of 14.5%, while the concentrations of cadmium and nickel increased by 6.2% and 7.5%.

It should be noted that the use of bentonites contributed to the simultaneous increase ofconcentrations of certain essential elements (such as iron, copper, zinc) in the blood of cows of the test group.

Already on the 30th day of application of bentonite in experimental animals, there was an increase in the concentration of iron by 19.5%, zinc by 11.7%, copper by 9.7% (Table 3).

Table 3 – Dynamics of changes in the level of trace elements in the blood of cows after application of bentonite (M±m; n=20)

Items	Background	Experimental		Control	
		after 30 days of experiment	after 60 days of experiment	after 30 days of experiment	after 60 days of experiment
Iron, μmol/l	22.1±1.4	26.4±2.0	29.2±2.1*	23.0±1.7	20.9±1.5
Copper, μmol/l	13.4±0.56	14.7±1.1	15.2±0.8	13.5±0.6	13.7±1.0
Zinc, μmol/l	14.5±1.6	16.2±2.1	17.0±2.4	14.1±0.9	13.8±2.3

Degree of reliability: P≤0.01

The subsequent use of bentonites confirmed the positive dynamics in the content of trace element levels, which by the end of the studies amounted to 29.2±2.1 μmol/l in iron against 22.1±1.9 μmol/l of baseline values (with P≤0.01 reliability), for copper – 15.2±0.8 μmol/l against 13.4±0.5 μmol/l and zinc – 17.0 ± 2.4 μmol/l against 14.5±1.6 μmol/l, respectively.

It should be noted that the most significant increase was in the amount of serum iron (by 32.1%). And this increase with the greatest values was noted in the first month of the experimental period (Figure 1).

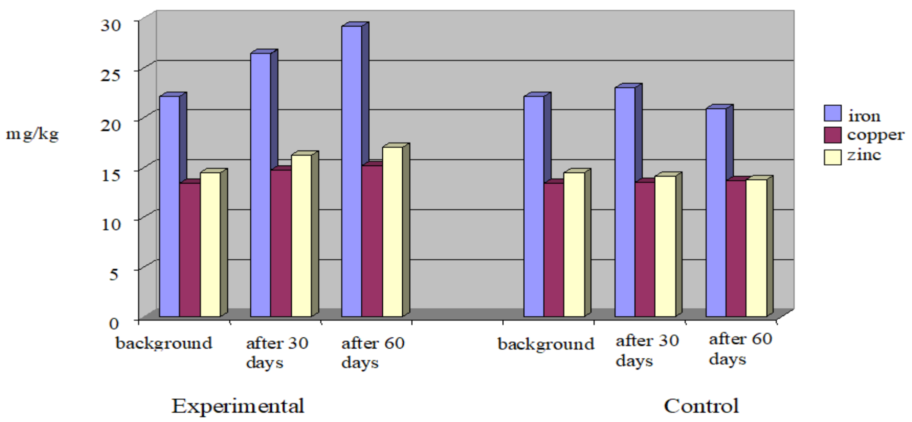

Figure 1. The dynamics of changes in the level of trace elements in the blood of cows after the application of bentonite

In the control group, the concentration of the studied minerals did not undergo significant changes. And if an unreliable increase (by 2.2%) was noted by the amount of copper, then the level of iron at the end of the experiment relative to the background indicators decreased by 5.4%, zinc - by 4.8%. The difference in groups on the 60th day of the study was 39.7% for iron, for copper – 10.9%, for zinc – 23.1%, respectively.

It should be noted that the mechanism of correction of mineral deficiency in cows with the application of bentonites is associated, on the one hand, with the presence of a complex of macro- and microelements, as well as better assimilation of mineral substances from the components of the feed due to lengthening of the passage of intestinal contents and normalization of digestion. On the other hand, the detoxification and adsorption effect of bentonites indirectly normalizes the mineral metabolism due tothe decrease of the toxicity of the feed, activation of hormones and enzymes, and improvement of liver function.

CONCLUSION

Thus, it was found that the use of bentonite reduces the accumulation of heavy metals in the body of down-calving cows and is a highly effective, economical and affordable method of reducing the transport of Pb, Cd, Ni in the food chain. Being excellent ion exchangers, aluminosilicates act as donors to provide the body with macro and microelements in an available and easily digestible form, ensuring correction of the mineral component of the blood of animals.

Consequently, the use of preparations of this group is promising in terms of maintaining animal health and producing environmentally safe livestock products.

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