Preparation of Food Products of Animal Origin with a Reduced Content of Toxic Metals

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Abstract. Excessive concentrations of heavy metals in food we eat are among the current issues of food safety. This becomes especially evident if we consider highly toxic elements such as copper, lead and cadmium. With regard to the foregoing, it would be helpful to get information about use of novel sorbents in livestock farming and their effects on distribution of heavy metals in animal bodies. The drug we study is based on natural mineral raw materials and contains up to 60% of silicon dioxide. It has prominent sorption properties. The drug was introduced to diets of brood sows, growing piglets and finishing pigs in a dose 120 mg/kg of body mass. Lead concentrations in three-month-old piglets decreased by 17% in striated muscle tissue; and in the skin and hair covering of the piglets receiving sorbents there were just traces of lead. In striated muscle tissue of piglets in the control group the cadmium levels were 0.14±0.003 mg/kg, i.e. 2.8 times higher than the maximum permissible concentration. Sorbents introduces to the piglet diet caused decrease in concentrations of this metal by 35%. Use of the sorptive dietary supplement has certain prospects as a method of obtaining organic food.

1. Introduction

Today, conditions of agroindustrial production are characterized by powerful man-made impact on the environment, which is evident in intense plowing of virgin lands, application of plenty of mineral fertilizers, pesticides and herbicides to the soil, and industrial emissions of multiple toxic compounds to the environment. All the foregoing results in disturbance of natural processes taking place in the biosphere. Xenobiotics get involved into biogeochemical cycles and penetrate plants, food and animal and human bodies through the soil, air and water. Use of environmentally harmful foods entails increase in incidence of endogenous intoxication syndrome, which is characterized by systemic weakness, immunodeficiency, endocrine dysfunction, and blood disorders. Further, such food may cause allergies and malignancies. In this regard, ecological quality control of foods is of high priority in our current context. Salts of heavy metals pose a great threat to human health since they may trigger severe physiological changes in human and animal bodies [1].

Hazardous chemical compounds often found in food include salts of industrial pollutants such as cadmium and lead. These metals have properties of cumulative poisons and, thus, precondition their long-standing effects on the human body which they mainly penetrate with water and animal products.

In national cuisines of different countries, in addition to meat and liver people often use other parts of animal bodies, such as hearts, kidneys, brain etc. In this regard, at the present stage it is essential to try and find ways to remove cadmium and lead from livestock and to investigate distribution of these metals in organs and tissues.

Use of sorbents based on natural raw materials in animal food is one of the efficient ways to achieve this goal [2-6].

Findings of studies with analysis of metabolism and physiological status of pigs in different gender and age groups give evidence to development of metabolic disorders in farmed animals, which are caused by high contents of xenobiotics in their food and drinking water. Overdose of heavy metal cations and nitrate ions is especially hazardous. At certain stages of the metabolic process the said substances may trigger severe protein, carbohydrate, fat and mineral metabolism disorders and vitamin deficiency, and impair natural protection of the body. Brood sows and newborn piglets during the first 100 to 120 days of their life are most susceptible to such changes.

Studies on animals showed prospects of use of natural sorbents as dietary supplements in livestock farming and veterinary in order to normalize metabolism and immune status of animals, prevent toxicosis, and improve fertility of animals and quality of animal products. The drug under study is special in its ability to selectively affect cations of most toxic metals and chemical compounds that impact the body in a negative way. At the same time, the sorptive dietary supplement is mostly made up of silicon dioxide having some biologically active properties that help to inhibit degenerative processes in the body [7-11].

2. Object and methods

Experiments were carried out to study the influence of the sorbing additive on the physiological state and productivity of sows and piglets obtained from them while growing and fattening the latter under conditions of industrial complex technology.

Two groups of animals (I – control and II – experimental) of 50 animals each were formed. The sows were selected for these groups 40 days before farrowing. The sows of the second (experimental) group received in addition to the basic ration a sorbing additive in a dose of 120 mg/kg of body weight. Feeding of the preparation to sows continued until farrowing and within five days after. During this period the physiological state of experimental animals was studied. The sows of the second group of piglets received the preparation from the moment of feeding and up to nine months of age at the rate of 120 mg/kg body weight. Thus, the total duration of the experiment was 300 days. At the age of three months and nine months (at the end of the fattening cycle), pigs were slaughtered, during which tissue and organ samples were taken for morphological and biochemical studies.

The content of iron, zinc, copper, cadmium and lead in animal tissue samples was determined by atomic absorption spectroscopy.

3. Results

The drug did not have any negative effects on physiological status of pigs in different gender and age groups. This was evident in absence of any significant changes in complete blood count, hemoglobin levels and protein fractions. Moreover, the initial level of energy metabolism and the immune status were preserved. The metabolic status suggests that the sorptive dietary supplement mostly affected mineral metabolism in pigs, as evidenced by changes in volumes of heavy metal deposits in different tissues and organs.

Stool tests for brood sows showed that the new dietary supplement acted as an enterosorbent and, thus, reduced absorption of heavy metal cations. At the same time, it interfered with penetration of the hazardous substances into the circulatory system. However, the body has its own homeostatic mechanisms regulating blood levels of micronutrients, such as iron, zinc and copper. No such mechanisms were found for cadmium and lead; yet those were the only elements the levels of which dropped significantly. Most likely, their deposits were passively destroyed by a concentration gradient. After that the substances were removed with urine or by endogenous excretion.

If animal food lacks some essential elements, sorption of such elements causes some concern. We have already discussed the reasons of absence of clinical micronutrient deficiencies in animals in our experiment. The vitamin A level is one of the indicators of normal zinc metabolism, since its deficiency disrupts retinol-bonding protein synthesis in the liver, which is essential for vitamin transport in blood. And we are still facing this issue. In prospect, when appropriate, the sorbent can be used in combination with organic derivatives of some micronutrients and, thus, the issue of deficiency of metals essential to pigs will be solved.

Decrease in blood toxicant levels in brood sows results in mitigation of stressing effects on their bodies and on development of embryos. Reduction in deposits of xenobiotics in placenta tissues and colostrums is especially noteworthy. At the same time, it should be emphasized that changes in these factors made offspring of brood sows in the experimental group more viable and fertile.

Intensified calcium phosphate mineralization in cortical bones of piglets was another important indicator of activation of mineral metabolism triggered by the sorptive dietary supplement. Removal of some heavy metals (of cadmium and lead specifically) from bones facilitates active incorporation of calcium and phosphorus ions into bone tissue. This process intensifies formation of bone tissue in piglets, which is essential when piglets are raised on animal farms.

Analysis of distribution of heavy metals in tissues and organs of young growing and finishing pigs showed that the most significant changes caused by the sorbent occurred in cadmium and lead concentrations (table 1).

Table 1. Concentration of cadmium and lead in pigs' tissues and organs on fattening, mg/kg (*N=6, M±m*).

Organs and tissues	Cadmium		Lead	
	I – control	II – experiment	I – control	II – experiment
liver	0.15±0.002	0.13±0.003**	0.86±0.018	0.73±0.023*
muscle tissue	0.064±0.002	0.061±0.001	0.32±0.007	0.29±0.013
heart	0.11±0.001	0.09±0.002**	0.31±0.011	0.26±0.014
kidneys	0.61±0.035	0.52±0.041	0.54±0.011	0.53±0.033
spleen	0.075±0.001	0.073±0.002	0.606±0.028	0.536±0.024
brain	0.107±0.003	0.083±0.004**	0.29±0.007	0.25±0.015*
bone	0.24±0.003	0.21±0.004**	2.26±0.022	2.24±0.019
hair	0.07±0.004	0.05±0.002*	0.43±0.027	0.35±0.024

**p<0,01 (Mann-Whitney U-test).
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High toxicity of cadmium is associated with its ability to accumulate in tissues of mammals due to absence of homeostatic mechanisms regulating its concentrations. When absorbed, cadmium remains in the body, and just a minor amount of the element is excreted. It mostly accumulates in the liver and kidneys. Eighty percent of cadmium accumulated in these organs is bound with metallothioneins if protective detoxification mechanisms are activated. At the same time, the biological function of metallothioneins implies their engagement in homeostasis of essential elements such as zinc and copper. That is why cadmium in interaction with metallothioneins may disrupt homeostasis of biogenic zinc and copper. Therefore, the decrease in cadmium concentrations in the liver and kidneys of animals in the experimental group could facilitate normalization of zinc and copper homeostasis and mitigate antagonistic effects of cadmium.

Parameters of protein and carbohydrate and fat metabolism in pigs receiving the sorbent were within the physiological norm, and in some cases positive changes were observed. It should be noted that blood phospholipid levels in piglets increased, and such increase seemed to be associated with the liver function which came back to normal as soon as toxic compounds were removed from the liver. Phospholipids are the major components of the outer cellular membrane, and increase in their concentrations may activate biosynthesis processes in the body. At the same time, phospholipids are

one of the most reactive groups of substances, and any significant changes in their concentrations give evidence to positive effects of the sorbent.

Vitamin levels in pigs receiving the dietary supplement were important criteria of their physiological status. Use of various sorbents often gives rise to issues related to sorption of vitamins and their removal from the body. Findings of our studies allowed us to conclude that the sorbent had no negative effect on vitamin levels in pigs in different gender and age groups. Thiamine, riboflavin and tocopherol concentrations remained unchanged, and in some cases ascorbic acid and retinol levels improved significantly. We attribute the increase in levels of some vitamins to reduction of the general toxic load on the body. At the same time, the increase in ascorbic acid concentrations in blood of brood sows and piglets activated various biological processes in their bodies and also facilitated removal of iron from ferritin, which is essential for prevention of anemia.

In growing pigs the sorbent intensified protein metabolism. This was evident in significant increase in protein levels and tryptophan/oxyproline ratio in muscle tissue. Long-standing intake of the sorbent resulted in enhancement of general resistance of animals to effects of adverse factors. Decrease in cadmium concentrations unlocked processes of tissue protein synthesis and, therefore, increased bioavailability of the resulting meat.

4. Conclusion

Thus, findings of these studies give evidence to positive effects of the dietary supplement on physiological status of pigs in different gender and age groups. Further, the sorbent activated and facilitated metabolism and improved safety and bioavailability of pig farm products.

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