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## SELENIUM AS A MODULATOR OF BIOCHEMICAL RESPONSE OF ANIMAL ORGANISM

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Selenium derivatives have a multifaceted effect on blood biochemical parameters of various animal species. An increase in total protein and its fractions and a decrease in hepatic tension were noticed in the experiment. This showed the active role of selenium in the modulation of the biochemical response of the body to its introduction from the outside. The manifestation of the properties of the inorganic, organic and chelated forms of the microelement was tested on various types of mammals. It was of the same type, although in varying degrees, in rats, piglets and sows, calves and dairy cows. Selenopyran, an organic compound, had a more notable effect compared to an inorganic preparation and microelement-containing yeast. This phenomenon must be taken into account when growing a healthy animal under conditions of selenium deficiency in the biogeochemical provinces of the territory of Belarus and the western part of Russia.

Thus, selenium preparations should take their place both in the process of growing a healthy productive animal, and in the practice of modern therapeutic veterinary medicine.

**Key words:** selenopyran, sodium selenite, Selenium yeast, biochemical blood test, rat, pig, cattle.

### Introduction

In the current socio-economic conditions of human development, the problem of increasing the productivity and quality of agricultural products obtained is one of the main in veterinary science and animal husbandry practice [1, 7, 20]. The solution of the problem is possible due to the implementation of industrial production systems, which leads to the so-called metabolic reorientation of the organism, and, as a result, to clinically expressed metabolic disturbances. The imbalance of the metabolic status of an animal can not only be the cause of significant direct economic losses, but also significantly determine the level of productivity, as well as the biological value of finished livestock products [2, 3, 11].

Metabolic disorders caused by an imbalance of microelements are commonly referred to as microelementoses [4, 8]. Most of them are endemic diseases. Belarus, the northwestern part of Russia and the Baltic countries are among the regions where the selenium content in the soil, and, consequently, in cereal and other forage crops, is much lower than the physiological need, which leads to the insufficiency of this microelement in the animal ration [6, 9] .

Selenium is one of the most unique microelements: it is part of the active center of enzymes that participate in the detoxification process of numerous metabolic products, affect the synthesis of many hormones, control the activity of humoral and cellular immunity, and reproductive function [14, 15]. Against the background of selenium deficiency, a decrease in the concentration and a decrease in the activity of these enzymes is observed, which is manifested by an increase in the oxidation of lipids and sulfur-containing amino acids [18, 19].

Currently, in order to compensate for the deficiency of selenium in the body, its inorganic compounds can be used, which are highly toxic. The introduction of low-toxic selenorganic drugs is a very urgent task [11, 17].

Purpose of the study. The purpose of this work was to conduct a comparison of metabolic processes in the application of various forms of selenium compounds in different animal species as the basis for modulating the biochemical status.

**Methods and materials**

When conducting experiments, we evaluated various selenium compounds: mineral selenium, which is part of the preparation "Vit E-sel"; selenopyran (9-phenyl symm. octahydroselenoxanthen), which is an organic compound of selenium [13], and the drug SELENIUM YEAST, which is organic selenium in yeast, containing 0.1% of the microelement (manufacturer CENZONE TECH INC, USA).

***Characteristics of conducting experiments on animals***

For conducting experiments on laboratory animals male rats of the Wistar line were used. Animals received standard vivarium diet. For the experiment, three groups of rats were formed (ten animals in each group) with an average live weight of 100-110 grams. The first group, in addition to the basic ration, received the drug selenopyran at a dose of 1.25 mg per kilogram of dry matter of the feed, the second – 6.25 mg. The control group received the equivalent amount of sunflower oil.

Experiments on ***productive animals***: milk cows (100 heads), calves (30 heads), sows (16 heads), normotrophic piglets (30 heads) and hypotrophic piglets (30 heads).

In the conditions of the agricultural production co-operative “Koptevka” of the Grodno region (Belarus), where selenium deficiency amounts to 30–50% [17], an experiment was conducted to study the effect of organic selenium on ***sows*** (during periods of gestation and lactation) and ***young animals***. The way of keeping was close confinement, feeding was according to the ration adopted in farms. Sows of the first (control) group were once (25 days before farrowing) and the piglets obtained from them twice (with an interval of 10 days) treated with sodium selenite at 0.1 mg / kg. Animals of the second (experimental) group (sows and piglets) received the drug SELENIUM YEAST (CENZONE TECH INC, USA) at the rate of 250 g/ton of concentrates. The drug was meant to sows during pregnancy and feeding and to piglets from the 5$^{th}$ (start of feed input) up to the 30$^{th}$ day.

The experiment on piglets with a lag in growth was carried out in the conditions of the pig farm “Gorka” of the agricultural production co-operative named after Denshchikov of the Grodno district, Grodno region. For the experiments, three groups of pigs were selected, 10 heads in each group, aged 90-100 days. The control group were piglets with an average live weight of 45-48 kg (lag in growth and development compared to the norm by 10-20%), did not receive the test drug. The experimental group was formed from piglets selected on the principle of analogues pairs to the control (animals also had a lag in weight). Animals of the experimental group daily received inside (individually) a solution of selenopyran in vegetable oil at a dose of 1 mg / kg body weight (pure selenium content of 0.3 mg).

To study biochemical parameters at the end of the experiments, blood was taken from the orbital venous sinus of sows and piglets of all groups in the morning hours before feeding.

The experiment on dairy cows and calves was carried out on the basis of LLC Alexandriyskoye of the Shklovsky district of the Mogilev region.

The effectiveness of organic selenium (selenopyran) was tested against the background of the farm-adopted feeding and housing technology, as well as schemes for veterinary interventions.

There were created two groups of cows of 3-4 years of age, in the middle of lactation. The research lasted 30 days. The experimental group, in addition to the basic ration, received the drug selenopyran at a dose of 1.2 mg per 1 kg of dry matter of feed (compound feed) per day.

For research on calves, three groups of 3-4 months old were formed with ten heads in each. The first group (control group) received fodder yeast at a dose of 250 g per ton of feed and injections of selenium-containing preparation "Vit E-sel" according to the instructions. The second (1 experimental group) received (additionally with compound feed) the drug “SELENIUM YEAST” in a dose of 250 g per ton of compound feed. The third group (2 experiemental) received "Selenopyran" at a dose of 1 g per ton of feed and fodder yeast at a dose of 249 g per ton.

The blood of cows and calves was collected from the jugular vein 4 hours after feeding.

***Biochemical research methods***

Biochemical analyzes were performed on a DIALAB Autolyzer 20010D biochemical analyzer (Austria) using a P.Z. CORMAY diagnostic kit (Poland). The concentration of total bilirubin was determined using a sulfanilic acid diazonium salt. Total cholesterol was determined by the method based on the Liebermann-Burchard reaction modified by S.Ilca. Total protein was determined by the method of Lowry. The concentration of albumin in serum was determined by the reaction with bromocresol green.

The activity of alanine-aminotransferase (AlAT) and asparagin-aminotransferase (AsAT) was determined according to the principle of an optimized and modified method based on the recommendations of the International Federation of Clinical Chemistry (IFCC) without activation of pyridoxal phosphate [5]. The activity of γ-glutamyl transpeptidase (GTP) was determined on the basis of its ability to catalyze the reaction of transfer of the L-glutamine residue from the chromogenic substrate to glycylglycine.

Blood glucose was determined by the color reaction with orthotoluidine in an acetic acid solution [10]. The concentration of iron in the blood was determined colorimetric with ferene; the concentration of inorganic phosphorus – by a direct method without prior removal of the protein. Phosphorus ions in an acidic environment reacted with molybdate ions. Formed complex was determined by absorption at a wavelength of λ = 340 nm. It varied in direct proportion to the phosphorus content in the test sample. The calcium concentration was determined in an alkaline medium by reaction with α-cresolphthalein [5, 10, 12, 14, 19].

The research results were analyzed by the method of variation and non-parametric statistics using Student's t-test and the method of reliability of the difference of the compared values. The data were processed on a computer using the “Statistica 6.0” package.

**Results**

***The influence of selenopyran on the metabolic profile of rats bodies***

Dose dependence of selenium influence on biochemical parameters was studied in male Wistar rats. Selenopyran was used at the rate of 0.3 mg of pure selenium per kilogram of dry food for the first experimental group and 1.5 mg for the second group. In addition to the basic ration, the control group received sodium selenite in an equivalent dose. At the end of the drug administration biochemical blood tests were performed after decapitation of the rats.

From table 1 it can be seen that the administration of selenopyran significantly reduced the level of cholesterol and bilirubin, which indicated the beneficial effect of the drug on lipid and pigment metabolism. There was a tendency to an increase in the level of total protein, which also indicated a positive effect of selenium on protein metabolism.

*Table 1. Biochemical parameters of rats blood after applying selenopyran at a dose of 0.3 mg and 1.5 mg of pure selenium per kilogram of dry matter of feed*

| Group | Total protein, g/l | Albumin, g/l | Globulin, g/l | Bilirubin, μmol / l | Cholesterol, μmol / l | AlAT, u/l | AsAT, u/l |
|---|---|---|---|---|---|---|---|
| Control | 70.4 ± 3.1 | 37.1 ± 1.2 | 33.3 ± 1.9 | 0.187 ± 0.017 | 0.09 ± 0.001 | 85.1 ± 4.2 | 81.4 ± 6.9 |
| Experiment 1 (Se 0.3 mg) | 76.2 ± 2.2 % = 108 | 39.8 ± 1.7 % = 107 | 36.4 ± 1.4 % = 109 | 0.125 ± 0.019*# % = 66.8 | 0.07 ± 0.001* % = 77.7 | 57.4 ± 4.9 % = 67.4 | 61.4± 5.2 % = 89.1 |
| Experiment 2 (Se 1.5 mg) | 72.4 ± 3.4 % = 102 | 38.2 ± 2.7 % = 102 | 34.2 ± 3.1 % = 102 | 0.158 ± 0.021* % = 84.4 | 0.08 ± 0.001 % = 88.8 | 65.5 ± 1.9 % = 76.9 | 68.9 ± 4.1 % = 84.6 |

**Note:** * – $p < 0,05$ – relative to control
# – $p < 0,05$ – relative to 2 experimental group

The lower efficiency of selenopyran when prescribing it in a dose of 1.5 mg of pure selenium per kilogram of dry matter of feed was explained by the following circumstances. After isolation of the microelement from selenopyran, its excess part was bound by plasma proteins. Erythrocytes in this process played a leading role, since Se in the form of selenite extremely quickly penetrated their membranes. After 1-2 minutes, 50-70% of the total blood selenium was concentrated in red blood cells. Then, within 15–20 minutes, almost all of the selenium leaved red blood cells, contacting first with albumin, and then with blood plasma globulins [18].

In erythrocytes in humans and a number of animals there is a selenium "pump". Under the influence of the glutathione (GSH) – glutathione peroxidase system, an excess amount of selenium is converted to form a complex of selenium with GSH. During subsequent recovery, the microelement catalyzes the transport of electrons to oxygen. Coming out of the erythrocyte as a part of the selenoglutathione complex, it is fixed in plasma proteins [14, 16].

***The effect of organic selenium on the metabolic parameters of sows***

In the study of biochemical parameters of the sows blood prior to the administration of drugs, there were no differences between the experimental and control groups. All of them were within the physiological norm.

After one month of Selenium Yeast introduction to the sows, some changes in blood biochemical parameters were noticed (Table 2). In animals, the total protein content increased mainly due to albumin (by 16%). However, the most noticeable changes were observed in the hepatological profile: in the experimental group, the activity of AlAT de-

*Table 2. Blood biochemical parameters of sows and piglets treated with Selenium Yeast, (250 g / ton, 1 month orally with feed) (M ± m)*

| Indicator | Sows n = 16 | | Piglets n = 30 | |
|---|---|---|---|---|
| | Control | Experiment | Control | Experiment |
| Total protein, g/l | 70.1±4.2 | 74.7±4.1 | 55.7±6.6 | 55.2±3.4 |
| Albumin, g/l | 32.5±3.9 | 37.9±2.9 | 36.2±3.5 | 35.7±3.3 |
| Globulin, g/l | 37.6±3.1 | 36.8±3 | 19.5±7 | 19.3±4.4 |
| Ca, mmol/l | 3.12±1.12 | 3.14±1.24 | 3.02±0.54 | 5.27±2.43* |
| P, mmol/l | 1.93±0.24 | 1.95±0.52 | 2.83±0.24 | 2.94±0.22 |
| Ca/P | 1.6±0.7 | 1.6±0.5 | 1.1±0.2 | 1.8±0.8 |
| Fe, µmol / l | 19.4±5.2 | 17.1±2.2 | 26.1±1.2 | 16.8±3.3* |
| Glucose, mmol / l | 3.78±0.11 | 4.27±0.12* | 5.61±0.46 | 5.69±0.57 |
| Cholesterol, mmol/l | 4.22±0.17 | 2.48±0.11* | 4.28±0.81 | 3.55±0.14 |
| AlAT, u/l | 88.8±4.35 | 51.7±9.5* | 66.1±5.9 | 45.2±1.8* |
| AsAT, u/l | 76.7±2.5 | 65.7±3.3* | 88.4±9.5 | 71.3±8.4* |
| Total bilirubin, µmol / l | 4.90±0.96 | 3.17±0.24* | 24.4±2.5 | 13.9±2.2* |

**Note:** * – p < 0,05 – relative to control

creased by 42%, of AsAT – by 14% and the level of total bilirubin – by 35%. The level of cholesterol was statistically reduced (by 43%) and the amount of blood glucose increased (by 13%).

One month after administration of Selenium yeast, piglets also showed changes in blood biochemical parameters (Table 2). The concentration of Ca significantly increased, the activity of AlAT and AsAT decreased up to 71%, the level of total bilirubin up to 70%.

***The effect of selenopiran on the metabolic parameters of piglets with a growth lag***

When observing the piglets who had a lag in body weight and received additionally to the ration the preparation of organic selenium at the rate of 0.3 mg of pure selenium per kilogram of dry matter of the feed, in comparison with piglets who did not receive organic selenium, there was a tendency towards normalization of the general metabolism.

The analysis of biochemical blood parameters of piglets showed that during the study period in the group treated with organic selenium, total protein and albumin increased to the level of the norm. At the same time, in the control group, the indicators remained low, which indicates stimulation of the protein-synthetic ability with the introduction of organic selenium (Table 3).

***The influence of selenopyran on the biochemical profile of cows of the 3-4 lactation***

The next stage of research was to study the effect of selenopyran on the metabolic profile of cows of the 3-4 lactation. Before the beginning of the experiment, the biochemical parameters in all animals did not have significant differences. Total protein was 69.83 ± 4.9 g / l; bilirubin – 6.3 ± 0.74 µmol / l, glucose – 2.1 ± 0.95 µmol / l.

One month after the use of organic selenium at the rate of 1.2 mg of pure selenium in the form of selenopyran per kilogram of feed to dairy cows, several changes in biochemical parameters were observed: there was a tendency to decrease bilirubin, which indicated an improvement in the detoxification function of the liver due to the stimulation of xenobiotic conjugation processes (Table 4).

***The influence of selenium-containing compounds on the biochemical profile of calves of 3-4 months of age***

The dynamics of biochemical parameters of calves, as can be seen from table 5, manifested itself in bilirubin decrease in both experimental groups, which indicated the presence of hepatoprotective properties of selenium.

*Table 3. Blood biochemical parameters of piglets with a lag in weight at the age of five months after applying selenopyran (0.3 mg of pure selenium per kilogram of feed, one month) (n = 30, M ± m)*

| Animal group | Total protein, g/l | Albumin, g/l | Globulin, g/l | AlAT, u/l | AsAT, u/l | Bilirubin, µmol / l |
|---|---|---|---|---|---|---|
| Control | 73.9±2.1 | 34.8±2.8 | 39.2± 2.8 | 20.4±7.3 | 16.4±5.4 | 6.11±0.12 |
| Experiment | 79.7±2.2* | 38.6±3.6 | 41.1± 4.1 | 18.5±5.5 | 15.1±6.7 | 4.65±0.15* |
| Norm | 58.3-83.2 | 22.6-40.4 | 39.5-60 | 21.7-46.5 | 15.5-55.3 | 0.3-8.2 |

**Note:** * – p < 0,05 – relative to control

*Table 4. Biochemical indicators of dairy cows of the 3-4 lactation after application of selenopyran at a dose of 1.2 mg per kg of dry matter of feed per day (n = 100, M±m)*

| Indicator | Control | Experiment |
|---|---|---|
| Total protein, g/l | 93.6±7.45 | 94.81±5.82 |
| Albumin, g/l | 36.46±2.81 | 34.56±2.91 |
| Globulin, g/l | 58.34±1.78 | 59.05±7.97 |
| Ca, mmol/l | 4.17±1.19 | 4.13±1.41 |
| P, mmol/l | 2.01±0.33 | 2.12±0.76 |
| Fe, µmol / l | 17.34±6.1 | 19.22±5.2 |
| Glucose, mmol / l | 4.78±0.15 | 3.54±0.21* |
| Cholesterol, mmol/l | 4.76±0.47 | 4.32±0.83 |
| AlAT, u/l | 34.91±2.52 | 35.4±1.59 |
| AsAT, u/l | 78.82±2.06 | 79.9±6.55 |
| GTP, u/l | 20.63±6.28 | 19.21±4.11 |
| Total bilirubin, µmol / l | 12.59±0.89 | 10.12 ±1.61 |

**Note:** * – p < 0,05 – relative to control

*Table 5. Blood biochemical parameters of calves of 3-4 months of age after the use of selenium-containing drugs (0.3 mg pure selenium per kilogram of feed), (n = 30, M±m)*

| Indicator | 1 group (control) | 2 group (Selenium yeast) | 3 group (Селенопиран) |
|---|---|---|---|
| Total protein, g/l | 64.83 ± 2.29 | 68.81 ± 1.14 | 71.66 ± 1.61* |
| Albumin, g/l | 34.42 ± 1.62 | 35.40 ± 3.06 | 37.32 ± 1.13* |
| Globulin, g/l | 30.41 ± 4.13 | 33.41 ± 3.06 | 34.33 ± 1.23 |
| Total bilirubin, µmol/l | 7.64 ± 0.57 | 4.83 ± 0.62* | 3.58 ± 1.02*# |
| Glucose, mmol / l | 2.58 ± 0.23 | 1.01 ± 0.08* | 2.08 ± 0.17# |
| Mg, mmol/l | 1.03 ± 0.03 | 0.78 ± 0.15 | 0.93 ± 0.08 |
| P, mmol/l | 2.03 ± 0.18 | 2.13 ± 0.61 | 2.23 ± 0.18 |
| Ca, mmol/l | 1.50 ± 0.11 | 1.80 ± 0.04* | 1.78 ± 0.06 |

**Note:** * – p < 0,05 – relative to control
# – p < 0,05 – relative to 2 experimental group

An increase in total protein in the group treated with selenopyran could indicate its increased protein-stimulating ability in comparison with other derivatives of selenium compounds.

**Conclusion**

The results of studies conducted on rats, sows and piglets, dairy cows and calves, confirmed the conclusions about the distinct effect of selenium preparations on the biochemical status of animals. Preparations containing this microelement are able to stimulate protein synthesis, improve the functioning of the liver. The manifestation of the above biochemical properties of selenium-containing drugs increases in the series: sodium selenite <Selenium Yeast <selenopyran. In addition, selenopyran has the greatest cumulative ability and exhibits its protective properties even in situations of crisis for the animal organism.

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