Veterinary sanitary assessment of the quality of meat products and the morphofunctional characteristics of the muscle tissue of pigs fed a mineral adaptogen

V.M. Usevich*, *M.N.* Drozd, and *L.* Banda

Ural State Agrarian University, Yekaterinburg, Russia

Abstract: Pigs are the most susceptible to stress. Therefore, the **purpose of our research** was to assess the effect of the mineral adaptogen on animal health and the quality of meat products. **Research methods.** The studies were conducted on piglets of a large white breed. With the use of hematological, immuno-biochemical, morphological methods of research and veterinary and sanitary assessment of the quality of meat products obtained. **Results.** It was found that the mineral adaptogen has a positive effect on the immune system, metabolic processes, and the reduction of stress-dependent glucose and cortisol levels. **Scientific novelty**. For the first time, comprehensive studies have been conducted showing the effect of mineral adaptogen not only on immunocompetent organs and immune indicators, but also a complex effect on stress resistance, reduction of toxigenic activity of feed, stabilization of metabolic processes in animals, and veterinary-sanitary and micromorphological assessment of the quality of meat products.

1 Introduction

Today, pig farming is one of the fastest growing livestock industries. A feature of this species of animals is increased stress sensitivity and their early maturity during growth and development. Pig breeding complexes accumulate a very large livestock in a limited area, in this regard, an increased number of stress factors arises that act simultaneously. Modern pig breeding technologies are aimed at minimizing stress, but do not completely eliminate them. Therefore, until now, the search for means and methods to reduce the effect of stress and increase the resistance of animals remain relevant. There is a constant search for cheap and effective means to improve the productivity of pig breeding, as well as prevent stress, metabolic disorders, mycoses and mycotoxicosis. [1-4, 6-18] One of such agents is adaptogens. They refer to means aimed at stimulating biological processes in the body, contributing to the rapid adaptation of the body, capable of withstanding various stresses and other unfavorable factors of biological, chemical and physical nature.

* Corresponding author: vus5@yandex.ru

© The Authors, published by EDP Sciences. This is an open access article distributed under the terms of the Creative Commons Attribution License 4.0 (http://creativecommons.org/licenses/by/4.0/).

In addition, there is a growing interest in local sources of enterosorbents, micro- and macro elements. One of them is a mineral adaptogen belonging to the group of artificial zeolites, a feed mineral additive (FMA) "BSh-VIT" [18]. The drug possesses sorption and ion-exchange properties, in this regard, it is able to sorb enterotoxins in its crystal lattice that enter with food and is able to release individual ions and take others from the body, i.e., displace the ones that are not needed by the body and replace them with the necessary ones. Since the mineral adaptogen contains more than 30 macro- and microelements, while it contains the trace element iodine, which is vital in the zones of biogeochemical provinces, it provides the body with the necessary minerals most fully. The sorption properties of the mineral adaptogen provide an additional opportunity for the optimal function of the immune system.

The level of natural resistance and metabolic processes in fattening piglets is significantly influenced by the quality of feed, the balance of diets, compliance with the technological conditions of keeping, the individual characteristics of the animals themselves, the initial state of the immune system. Young animals are most sensitive to endo- and exogenous disturbances after weaning and throughout the entire period of fattening; a contributing factor is liver damage and a decrease in its detoxification function [1-18].

In case of errors in feeding, fattening young animals may develop pathological processes associated with a lack of micro- and macro elements. Intoxication of the body leads to a decrease in immunity to immunodeficiency, while secondary or other viral and bacterial infections can actively develop. Therefore, farms preemptively use specific immunization with hyperimmune sera and mono- and polyvalent vaccines [1-10]. The development of preventive schemes and the search for effective means of protection against adverse environmental conditions remains an urgent issue in practical veterinary medicine up to the present time [1-18].

The use of drugs with sorption properties leads to a decrease in the intoxication of the body, the conversion of feed increases, the absorption of nutrients, vitamins, micro- and macro elements increase, which contributes to the restoration of the functions of organs and systems. [1-21]

Aim and objectives.

In connection with the above, the aim of the study was to determine the effect of the mineral adaptogen on the immune-biochemical status of piglets during the fattening period and the quality of the resulting meat products.

The research objectives were:

- to assess changes in the clinical and immune-biochemical status of piglets during the period of active growth and fattening when using a mineral adaptogen;
- to determine the effect of the mineral adaptogen on the growth rate of piglets during the fattening period;
- to determine the veterinary and sanitary quality of the received meat products.

2 Methodology and research methods

To solve the research problems, scientific and production experiments were carried out in one of the pig farms in the Sverdlovsk region.

Object of study. The object of the study was large white piglets aged 4 to 7 months of age. In total, 40 heads were selected in this study.

Hematological, biochemical and histological studies were carried out in the laboratory of the Department of Infectious and Non-infectious Pathology of the Ural State Agrarian University and in the accredited laboratories of the Ural Branch of the Russian Academy of Sciences. General and immune-biochemical blood tests were determined according to

generally accepted methods. The hematological status was investigated using the "Abacus Junior Vet" hematological analyzer and a set of standard reagents. The leukocyte formula was determined by counting different forms of leukocytes in blood smears stained according to Romanovsky-Giemsa using a light microscope "Micromed R-1".

Immuno-biochemical studies were carried out on a "Chem Well-2910 Combi" biochemical analyzer with a set of "Vital Diagnostics Spb" reagents according to standard methods using kinetic, colorimetric and turbo metric methods. The number of T- and B-lymphocytes was determined by the reaction of spontaneous rosette formation in the modification of Smirnov PN *et al*. Phagocytic activity of monocytes and neutrophils was determined using latex by opson-phagocytic reaction Potapov S.G. *et al*. with a light binocular microscope "Micromed R-1." The amount of circulating immune complexes in blood serum was determined by PEG-precipitation on a spectrophotometer. The research results were processed statistically.

After the slaughter of piglets, a veterinary and sanitary examination of carcasses and internal organs was carried out. During the examination, we used organoleptic assessment and laboratory tests for compliance with fresh meat in accordance with Interstate Council for Standardization and Certification (ISC). For a comprehensive assessment of the quality of meat products after feeding with the mineral adaptogen, samples of the heart and skeletal muscles (femoral muscle group) were taken. The quality of the meat was determined by organoleptic indicators, cooking test and by the results of chemical tests with copper sulfate, the reaction to peroxidase and the acidity of the sample.

The selected material for histological examination was fixed in an aqueous 10% neutral formalin solution. The recorded material was further processed in the pathomorphological laboratory of the Yekaterinburg Cardiology Center. They were dehydrated in alcohols of increasing concentration. After dehydration, the prepared material was embedded in paraffin according to standard techniques. Histological sections were prepared on a rotary microtome and then stained using standard techniques with hematoxylin and eosin. The study of histological sections was carried out at the Department of Infectious and Non-infectious Pathology of the Ural State Agrarian University.

For the study, 40 large white breed piglets were selected for fattening, which were divided into two groups of 20 heads each. The average age of the piglets was 4 months. Management of piglets: group cage, feeding with feed manufactured at of the feed mills, "Bogdanovich feed mill" according to a standard recipe. Drinking from automatic drinkers *ad libitum*. Piglets of the experimental group were fed with a mineral adaptogen - FMA "BSh-VIT" at a dose of 0.5g per 1 kg of live weight per day in 2 courses of 14 days with an interval of 14 days between them. The control group of piglets was fed only the ration used at the farm. The duration of all studies was 60 days. The study design is presented in Table 1.

The health status of piglets in both groups was monitored daily during the entire study period. During the observation period, the body weight was monitored monthly and the average daily weight gain was calculated.

To assess the state of immunity, metabolism and stress resistance, blood was taken from piglets to determine the hematological and immune-biochemical status. Blood samples were taken in the morning, before feeding the animals, on an empty stomach.

Table 1. Study Design

Feeding ration	Control group	Experimental group
Basic diet, 14 days	+	+
+ mineral adaptogen Bsh-VIT 0.5g per kg of live weight per day, course 14 days	-	+
Interval 14 days, Basic diet	+	+

+ mineral adaptogen Bsh-VIT 0.5g per kg of live weight per day, course 14 days	-	+
Basic diet, 14 days and so on	+	+

3 Results

Changes in hematological and biochemical parameters are shown in tables 2-4.

Table 2. Hematological profile of piglets for fattening.

№ in sequence	Indicators, units of measurement	The standard interval	Background values, n=40	14 days after feeding the mineral adaptogen	
				Experimental group, n=20	The control group, n=20
1	Red blood cells, 10^{12}/l	6.0-7.5	8.17±0.3	8.2±0.1	8.1±0.1
2	White blood cells, 10^{9}l	8.0-16.0	22.2±5.9	22.0±1.1	21.7±1.1
3	Hemoglobin, g/l	90-110	135.7±9.2	143.7±10.4	138.4±3.9
4	Hematocrit,%	39-43	44.6±3.4	44.3±3.2	41.2±1.6
5	Basophils, %	0-1	2.8±1.5	3.7±0.6*	6.0±3.0*
6	Eosinophils, %	1-4	3.9±0.2	3.3±0.6	4.2±1.7
7	Young, %	0-2	1.1±0,8	1.0±1.0	1.7±0.6*
8	Stick-core, %	2-4	6.4±1.9	4.7±1.5*	8.3±6.3*
9	Segmented, %	40-48	28.9±8.3	34.7±11.2*	31.7±15.0
10	Lymphocytes, %	40-50	52.2±9.2	48.5±8.6	44.7±10.1*
11	Monocytes, %	2-6	3.0±1.7	2.3±0.6*	2.7±0.3

P<0,05*, P<0,01** the difference is reliable

From the data in Table 2, it can be seen that in piglets of the control group, 14 days after the start of feeding the mineral adaptogen, an increase was noted in: hemoglobin by 2%, basophils by more than 2 times, eosinophils by 8.3%, young neutrophils by 51%, young neutrophils by 29%, segmented neutrophils by 10% and a decrease in; hematocrit by 8%, erythrocytes by 1%, leukocytes by 2%, lymphocytes by 15% and monocytes by 11% in comparison with background values.

Lymphocytopenia is clear evidence of immunosuppression, and basophilia characterizes allergic syndrome or hypofunction of the thyroid gland.

In the experimental group, piglets have increased indicators: hemoglobin by 6%, erythrocytes by 1%, basophils by 32% and segmented neutrophils by 20%, and a decrease in: leukocytes by 1%, eosinophils by 14%, young neutrophils by 9%, stab neutrophils by 28%, lymphocytes by 7%, monocytes by 22% and hematocrit by 1% compared to background values.

Optimization of leukocyte formula indicators in the experimental group was more pronounced than in the control group. Indicators of hematocrit, hemoglobin and erythrocytes exceed the reference values, which is probably due to the activation of metabolic processes and increased hematopoiesis.

Table 3. Biochemical status of pigs in fattening.

№ in sequence	Indicators, units of measurement	The standard interval	Background values n=40	14 days after feeding the mineral adaptogen	
				Experimental group, n=20	The control group, n=20
1	Total Protein, g/l	55-85	70.1±3.2	74.0±3.2	70.4±3.3

2	Albumin, g/l	30-45	31.8±1.5	34.9±1.7	31.2±1.4
3	Globulins, g/l	15-35	38.4±1.5	39,1±0.1	39.2±1.8
4	Albumin/Globulin, c.u.	1.3-2,0	0.8±0.1	0.9±0.1	0.8±0.01
5	AST, U/l	До 36	71.0±2.8	48.5±0.2**	57.0±2.7*
6	ALT, U/l	До 30	72.0±2.9	52.4±2.5**	67.0±3.0
7	Alkaline phosphatase, U/l	37-41	161.2±6.5	146.4±7.1*	169.6±7.5
8	GGT, U/l	0-29.2	47.6±1.9	34.4±1.7**	40.5±1.7*
9	LDH, U/l	417-785	509.2±20.4	545.6±26.1	506.9±21.7
10	Total bilirubin, μmol /L	3-12	4.8±0.2	3.2±0.1**	3.8±0.2*
11	Total cholesterol, μmol/L	1.5-2.5	3.3±0.1	2.6±0.1*	3.1±0.2
12	Triglycerides, mmol/l	-	0.3±0.01	0.2±0.01*	0.26±0.01
13	Urea, mmol/l	3.33-6.99	4.9±0.2	5.3±0.3	5.4±0.2
14	Creatinine, μmol/L	40-90	122.1±5.3	124.6±5.7	123.7±5.3
15	Glucose, mmol/l	4.4-5.4	6.5±0.3	5.3±0.3*	7.4±0.3
16	CK, U/l	-	270.2±12.2	250.1±11.8	288.0±12.4
17	Cortisol, nmol/l	-	146.5±5.9	169.3±7.8*	219.5±10.5*

P<0,05*, P<0,01** the difference is reliable

The data in Table 3 showed that the piglets in the control group during the fattening period increased the amount of: globulins by 2%, alkaline phosphatase by 5%, triglycerides by 7%, urea by 9%, creatinine by 1%, glucose by 14%, CK by 7 %, and cortisol by 50%, and the following indicators are reduced: albumin by 4%, AST by 20%, ALT by 7%, GGT by 15%, LDH by 1%, total bilirubin by 20%, total cholesterol by 6%... Significant increases in cortisol and glucose are indicative of an increased stress response.

In the experimental group of piglets, an increase was noted: total protein by 6%, albumin by 10%, globulins by 2%, LDH by 7%, urea by 7%, creatinine by 2%, cortisol by 16%, at the same time AST indicators decreased by 32%. ALT by 27%, alkaline phosphatase by 9%, GGT by 28%, total bilirubin by 33%, total cholesterol by 20%, triglycerides by 21%, glucose by 18% and CK by 7%. A slight increase in cortisol with a simultaneous decrease in glucose, compared with the control group, is evidence of an increase in stress resistance in piglets of the experimental group during the fattening period. Decrease in indicators: AST, ALT, alkaline phosphatase, GGT, total bilirubin, total cholesterol and triglycerides - characterizes a decrease in the toxic load on the liver, an improvement in its metabolic and excretory functions, as well as restoration of optimal lipid metabolism, compared with animals of the control group, where these indicators changed minimally in relation to the background values.

Table 4. Mineral status in pigs during fattening.

№ in sequence	Indicators, units of measurement	The standard interval	Background values n=40	14 days after feeding the mineral adaptogen	
				Experimental group, n=20	The control group, n=20
1	Calcium, mmol/l	2.0-3.0	2.6±0.1	3.1±0.1**	3.1±0.1*
2	Iron, μmol/L	15-38	32.4±1.3	42.5±1.9**	34.3±1.6
3	Phosphorus, mmol/l	1.5-2.5	3.4±0.2	3.0±0.1*	3.4±0.1

4	Ca/P, c.u.	1.3-1.5	0.8±0.1	1.1±0.01*	0.9±0.1

P<0,05*; P<0,01** the difference is reliable

The data in Table 4 showed that the piglets in the control group increased the level of calcium by 19%, and iron by 6%, and the level of phosphorus decreased by 1%, but the calcium-phosphorus ratio did not reach the optimal value.

In the blood serum of piglets from the experimental group, the following increase were observed: calcium values by 21%, iron by 31%, and the phosphorus content decreased by 13%. The restoration of calcium-phosphorus metabolism is noted, which contributes to the active growth of piglets and the prevention of osteoarticular pathologies. Over the entire period of research, no cases of diseases were observed in piglets, incl. mycoses and mycotoxicosis, which persisted even after the termination of the feeding of the mineral adaptogen. This was reflected in the intensity of growth and development of animals and a decrease in the feed conversion rate. It was found that during the period of feeding the mineral adaptogen, the piglets of the experimental group fed better and more willingly, grew more actively and added to live weight, which is reflected in table 5.

Table 5. The effect of mineral adaptogen on the live weight gain of fattened piglets.

Group	6 months	8 months		10 months	
	Live weight, kg	Live weight, kg	% to control	Live weight, kg	% to control
Experimental	88.57	110.9	-	126.86	-
Control	88.17	115.3	5.77	131.83	8.65

The gain in live weight in piglets in the final period of fattening in the experimental group was higher than in the control by an average of 7%. The economic efficiency of using the mineral adaptogen was 6.88 rubles per 1 ruble of costs.

When slaughtering piglets after fattening, a veterinary and sanitary examination of carcasses was carried out in the slaughterhouse for organoleptic indicators. The carcasses of piglets of both groups had similar characteristics without obvious signs of pathology. On the conveyor, the veterinary and sanitary assessment of the liver was carried out. At the same time, it was noted that from the piglets of the experimental group, the liver was practically not culled, signs of damage to the gastrointestinal tract were not noted, the liver and heart were released without culling. After the veterinary and sanitary examination of the internal organs from the piglets of the control group, it was noted: about 5% of the total number of examinations, intestinal lesions and 2% - the liver, which were sent to industrial processing. When calculating economic efficiency, this also reduced the economic efficiency of the basic feeding and prevention scheme adopted at the enterprise.

According to organoleptic indicators, it was found that the appearance is good; color - uniform; the smell is pleasant; aroma - strong; consistency - delicate; meat is juicy; the general assessment of the quality of meat practically did not differ in the experimental and control groups and had an assessment of 7 - 8 points. The reaction with copper sulfate - the transparency was preserved, the reaction to peroxidase was positive (the extract changed color from blue-green to brown within 1 minute) and the acidity of the samples of both groups was also at the same level (pH 5.6-5.8). When conducting a study on the quality of meat products, the broth was transparent, aromatic with a small amount of fat on the surface of the broth with a sample of cooking from the piglets of the experimental group. When evaluating meat samples from piglets of the control group, the broth was fragrant, transparent, slightly opalescent, on the surface of the broth there were more large fat drops. Studies have shown that meat samples from piglets of both groups meet the requirements of veterinary and sanitary examination for fresh meat (Table 6).

Table 6. Comparative veterinary and sanitary assessment of the quality of meat while using a mineral adaptogen

Indicator of VSE	Femoral muscle	
	control group	experience group
Appearance on inspection	good - 7	very good - 8
Color from the surface and on the cut	uniform - 8	uniform - 8
Smell, aroma meat	pleasant and strong - 8	pleasant and strong - 8
Consistency of meat	mild - 8	mild - 8
Juiciness of meat	juicy - 8	juicy - 8
Overall assessment of the quality meat	7.8	8
Reaction with copper sulphate	Clear broth	Clear broth
Reaction with peroxidase	Positive (from blue-green in 1 min to brown)	Positive (from blue-green in 1 min to brown)
pH	5.6	5.8
Cooking test (evaluation of broth)	transparent, the smell is specific to this type of fresh meat	transparent, the smell is specific to this type of fresh meat

At the microscopic level, the state of the striated skeletal muscles in the thigh area of piglets in the control group, the muscle fibers of the skeletal muscles have signs of degenerative-dystrophic changes and fatty layers between the muscle fibers and perivascular.

Microscopically visible: destruction of the membrane of muscle fibers, areas of destruction of the cytoplasm and degenerative changes in the nuclei of muscle fibers with signs of destruction at different stages: vacuolization, karyorrhexis, karyolysis and karyopyknosis. Individual muscle fibers are defragmented and have areas with immature muscle elements. In this condition, the muscle tissue cannot fully perform the musculoskeletal function. Probably, in the future, this can affect the value of the amino acid composition and the quality of meat. In the femoral muscle group in piglets of the control group, the structure is generally well expressed, but along with mature muscle fibers, there are immature ones (Fig. 2, 3). In piglets of the experimental group, muscle fibers had a characteristic structure, both in longitudinal and in transverse sections. The structure of muscle fibers has a transverse striation, the nuclei also have a characteristic functionally active structure. There is less adipose tissue in the intermuscular spaces. Muscle fibers are collected in bundles and fit tightly to each other (Fig. 2, 4).

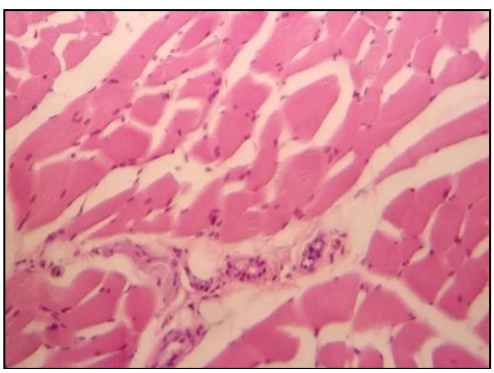

Fig. 1. Control group. Skeletal muscle in a cross section. Magnification x 200.

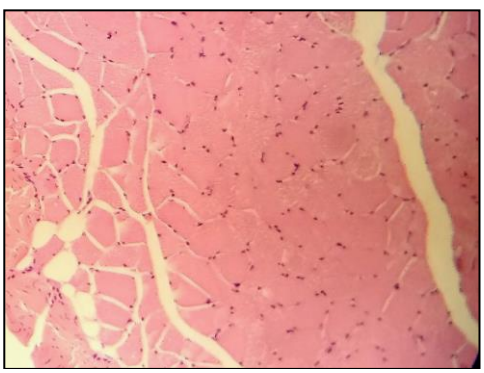

Fig. 2. An experienced group. Skeletal muscle in a cross section. Magnification x 200.

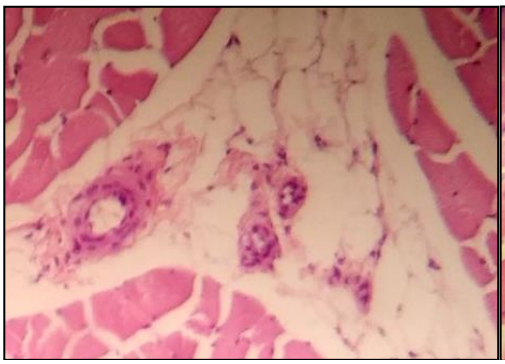

Fig. 3. Control group. Intermuscular connective tissue. Magnification x 200.

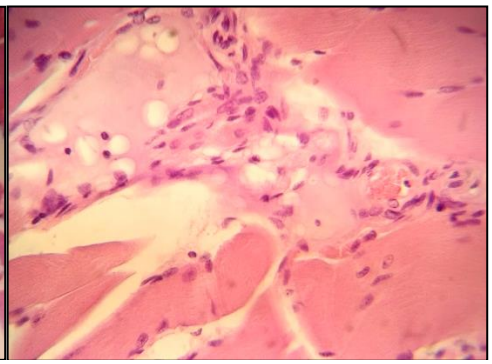

Fig. 4. An experienced group. The formation of the layer of fat intermuscular. Magnification x 400.

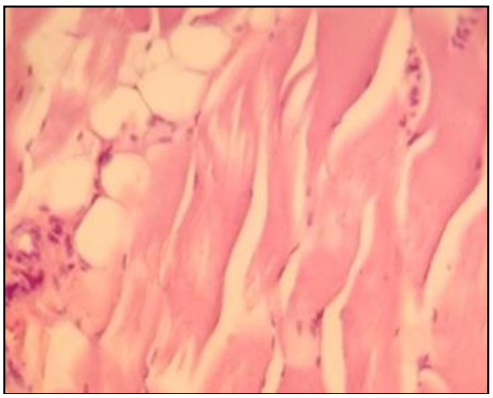

Fig. 5. Control group. Cardiac muscle tissue. Magnification x 200.

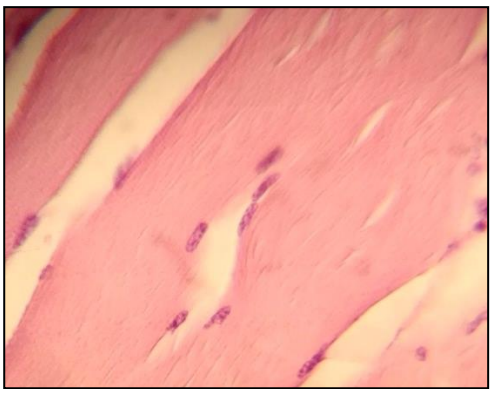

Fig. 6. An experienced group. Cardiac muscle tissue. Magnification x 400.

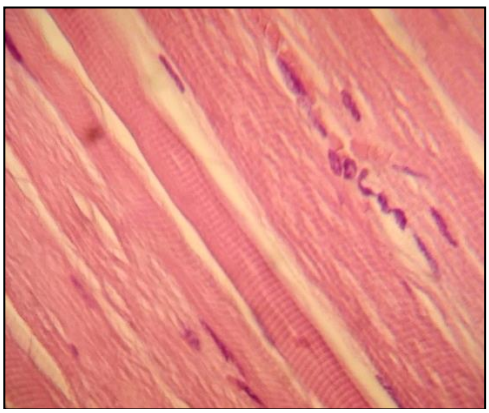

Fig. 7. Control group. Cardiac muscle tissue. Magnification x 600.

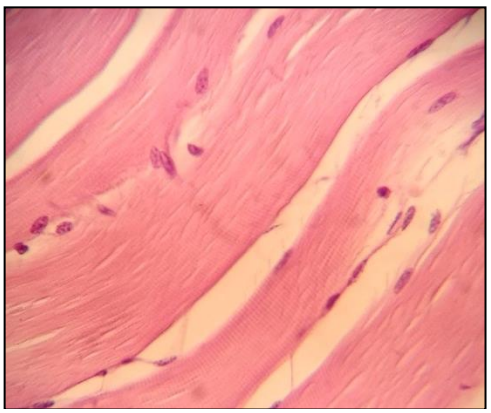

Fig. 8. An experienced group. Cardiac muscle tissue. Magnification x 600.

When studying histological sections of the heart muscle from piglets of the control group, dystrophic and degenerative changes in muscle fibers (defragmentation and loosening of muscle fibers, loss of striated striation), perivascular edema of the myocardial stroma were noted (Fig. 5, 7). Fatty infiltration in the stroma of the organ is noted in places.

When examining the microstructure of the muscle tissue of the heart muscle, the piglets of the experimental group noted (Fig. 6, 8) the preserved structure of muscle fibers. They retained a typical striated appearance, and the cell nuclei corresponded to a functionally active state, in which accumulations of euchromatin and heterochromatin are clearly visible.

4 Discussion of research results

Enteric properties are aimed at removing endo- and exotoxins from the piglets' body, and the contained minerals are needed to replace the necessary elements on the basis of an ion-exchange mechanism. The bulk of minerals is important in maintaining natural resistance, stimulating the processes of erythro- and leukopoiesis, as well as maintaining homeostasis in the body.

All the conducted macro- and micromorphological studies made it possible to track the morphological changes developing in the piglets' body during the final period of fattening. Histological studies of skeletal muscles and the heart have shown that the structure of cells when fed with a mineral adaptogen contributes to the preservation of their structure and function, respectively, metabolism is stabilized, and natural resistance increases. Feeding the poly-mineral adaptogen to broilers during the period of intensive fattening reduces histopathological disorders and the manifestation of immune reactions in the liver tissue.

A comprehensive study of the effect of FMA on the quality of meat products of pig breeding allows us to recommend it as a mineral adaptogen and enterosorbent, which has a positive effect on the restoration, maintenance and activation of metabolic processes in the body of piglets to obtain more meat products of high veterinary and sanitary quality.

5 Conclusions

After analyzing the results obtained, the following conclusions can be drawn:

1. When feeding the mineral adaptogen to fattening piglets, stress and resistance to technological and other types of stress increases.
2. The use of mineral adaptogen during the fattening period in piglets helps to reduce the feed conversion rate. Piglets grow faster and gain live weight.
3. Feeding the mineral adaptogen reduces the toxic load on the liver, improves its metabolic and excretory functions, and also restores optimal lipid metabolism.
4. The use of the mineral adaptogen during the fattening period of piglets promotes the activation of metabolic processes and hematopoiesis.
5. Feeding piglets during the fattening period with a mineral adaptogen prevents the development of mycoses and mycotoxicosis.
6. After slaughter, veterinary and sanitary examination of meat and by-products from piglets of the experimental group, testifies to the morphological usefulness of muscle tissue in terms of organoleptic and laboratory quality indicators and corresponded to the Russian Interstate Council for Standardization and Certification (ISC) requirements for fresh poultry meat.
7. A comprehensive study of the effect of a mineral feed additive on the quality of pig meat products allows us to recommend it as a mineral adaptogen and an enterosorbent that has a positive effect on the restoration, maintenance and activation of metabolic processes in the body of piglets during the fattening period, in order to obtain a larger amount of meat products of high veterinary quality and sanitary quality.
8. The economic efficiency of using the mineral adaptogen was 6.88 rubles per 1 ruble of costs.

6 Conflict of interest

The authors of the article confirm that the data provided by them does not contain any conflicts of interest.

References

1. N.A. Bezborodova, A.S. Krasnoperov, G.M. Shulaev, V.N. Afonyushkin, L.N. Ivashkina, BIO, **5 (224)**, 28-32 (2019)
2. P.O. Busygin, I.A. Shkuratova, N.N. Bespamyatnykh, L.I. Drozdova, T.M. Melnikova, BIO, **6 (201)**, 12-14 (2017)
3. N.A. Vereshchak, S.V. Malkov, O.Yu. Oparina, N.V. Israilova BIO, **2 (221)**, 32-38 (2019)
4. N.A. Vereshchak, O.Yu. Oparina, L.S. Vaganova, E.D. Karnaukhova, Issues of legal regulation in veterinary medicine, **3**, 115-118 (2017)
5. N.A. Vereshchak, A.P. Poryvaeva, I.A. Shkuratova, A.S. Krasnoperov, O.Yu. Oparina, L.S. Vaganova, Issues of legal regulation in veterinary medicine, **3**, 168-170 (2017)
6. I.M. Donnik, M.G. Balykhin, I.G. Blagoveshchensky, M.M. Blagoveshchenskaya Storage and processing of agricultural raw materials, **4**, 126-138 (2018)
7. A.G. Isaeva, A.S. Krivonogova, E.N. Bespamyatnykh, N.B. Musikhina, A.I. Belousov, Issues of legal regulation in veterinary medicine, **3**, 173-175 (2016)
8. A. Isaeva, A. Krivonogova, Veterinary of agricultural animals, **7**, 43-47 (2017)
9. A.G. Isaeva, A.S. Krivonogova, N.B. Musikhina, A.I. Belousov, Issues of legal regulation in veterinary medicine, **3**, 171-173 (2016)
10. A.S. Krasnoperov, S.V. Malkov, N.A. Vereshchak, Issues of legal regulation in veterinary medicine, **4**, 234-239 (2018)
11. S.V. Malkov, A.S. Krasnoperov, N.A. Vereshchak, A.P. Poryvaeva, Effective animal husbandry, **2 (150)**, 72-74 (2019)
12. V.M. Usevich, A.D. Ustyugov, M.N. Drozd, I.M. Milstein, R.V. Chus, Veterinary and sanitary assessment of the quality of pig meat products with a concentrate type of feeding, In the book: Institutional transformations of the Russian agro-industrial complex in the context of global challenges. Collection of abstracts based on the materials of the III International conference,64 (2019)
13. I.A. Shkuratova, N.A. Vereshchak, S.V. Malkov, BIO, **11 (218)**, 31-34 (2018)
14. I. Shkuratova, I. Lebedeva, M. Ryaposova, I. Konopleva, P. Busygin, Effective animal husbandry, **8 (156)**, 94-95 (2019)
15. I.M. Donnik, I.A. Shkuratova, Herald of the Russian Academy of Sciences, **87(2),** 139-142 (2017)
16. A.G. Isaeva, A.S. Krivonogova, I.M. Donnik, I.A. Shkuratova, L.I. Drozdova, E.N. Bespamyatnykh, Indo American Journal of Pharmaceutical Sciences, **4(11)**, 4130-4136 (2017)
17. A.S. Krasnoperov, S.V. Malkov, N.A. Vereshchak, A.P. Poryvaeva, Agrarian Bulletin of the Urals, **11(190)**, 66-70 (2019)
18. I.M. Tributary, I.A. Shkuratova, Bulletin of the Russian Academy of Sciences, **4**, 362 (2017)

19. A.D. Ustyugov, V.M. Usevich, I.M. Milshtein, K.O. Lukashova, Morphobiochemical indicators of vietnamese pot-bellied pigs with concentrate type of feeding, *In the collection: Digital agriculture - development strategy. Proceedings of the International Scientific and Practical Conference (ISPC 2019)*, 486-490 (2019)
20. A.G. Isaeva, I.A. Shkuratova, I.M. Donnik, A.S. Krasnoperov, A.P. Poryvaeva, A.S. Krivonogova, E.N. Bespamyatnykh, A.I. Belousov, A.S. Romanova, Invention patent RU 2692918 C2, 28.06.2019. Application No. 2017138254 dated 02.11.2017. Piglet breeding method
21. A.A. Kotelnikova, O.Yu. Chernykh, V.A. Bannov, I.M. Donnik, A.A. Lysenko, R.A. Krivonos, V.N. Shevkoplyas, A.G. Koschaev, L.A. Daibova, Invention patent RU 2700479 C1, 17.09.2019. Application No. 2018134639 dated 01.10.2018. Method for determining the species belonging to chicken and pig tissues in food raw materials, feed and food products.