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Analyzing Physiological Metabolic Response of Sows to Gamavit

Yulia Gennadyevna Kropova, Igor Gennadievich Glamazdin, Svetlana Yuryevna Zavalishina*, Marina Mikhailovna Goryacheva, Elena Sergeevna Tkacheva, Maria Alexandrovna Vinichenko

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Abstract

The work was carried out on five groups of pregnant sows of the Duroc breed: one control and four experimental groups of 12 animals in each group. Seven days after successful insemination and up to 4 months of gestation, sows of groups 1, 2, 3, and 4 received gamavit intramuscularly three times a week at doses of 1.0; 0.5; 0.1; and 0.05 ml/kg live weight, respectively. Animals were weighed, plasma levels of malonic dialdehyde, reduced glutathione, oxidized glutathione, triglycerides, total cholesterol, total protein, lipoprotein fractions, glutathione peroxidase, and superoxide dismutase activity were estimated. It was found that when administered to sows in doses of 1.0; 0.5 and 0.1 ml/kg body weight gamavit has a positive effect on morphofunctional characteristics, showing its adaptogenic and stress-protective properties, providing the optimum conditions for the course of sows gestation. Administration of the drug accelerated the growth of pregnant sows and protected their organism from stress of any origin. The results show that gamavit optimizes lipid metabolism, the activity of the antioxidant system in sows during gestation, and has a beneficial effect on the reproductive ability of animals. In the course of the performed observation, it was possible to specify the most preferable dose of gamavit for pregnant sows, capable of optimizing their biochemical and physiological parameters. This allowed us to put forward proposals for pig breeding on effective strengthening of economically beneficial traits and to increase the level of viability of pregnant sows.

Keywords: Pigs, Gestation, Gamavit, Glutathione, Productivity

Yulia Gennadyevna Kropova
Institute of Natural Science and Sports Technology Moscow City University, Moscow, Russia.

Igor Gennadievich Glamazdin, Marina Mikhailovna Goryacheva
Department of Veterinary Medicine, Russian Biotechnological University, Moscow, Russia.

Svetlana Yuryevna Zavalishina*
Department of Pathological Anatomy, Russian State Social University, Moscow, Russia.

Elena Sergeevna Tkacheva
Department of Epizootiology and Microbiology, Vologda State Dairy Farming Academy named after N.V. Vereshchagin, Vologda, Russia.
Department of Normal Anatomy, Russian State Social University, Moscow, Russia.

Maria Alexandrovna Vinichenko
Department of Russian Language, Belgorod State National Research University, Belgorod, Russia.

***E-mail:** svetlanazsyu@mail.ru

Introduction

The overall breeding efficiency of any productive animals is determined by the success of reproduction (Glamazdin *et al*., 2021a; Medvedev, 2022). The use in practice of various methods to increase the reproductive capacity of animals, activation of the reproductive properties of each female can greatly increase the productivity of the entire breeding herd, ensuring the stability of high pork production and increasing its profitability (Lavoie *et al*., 2018).

In modern conditions, it is very important to further clarify the fundamental processes of realization of vital manifestations of a living organism and their application in production (Vorobyeva & Medvedev, 2020c; Kropova *et al*., 2024). Taking into account these parameters can provide opportunities for the development of new and existing animal breeding technologies, competently implementing the reproduction of livestock, strictly taking into account the regularities of growth and development of the organism of pigs (Charmandari *et al*., 2005; Medvedev *et al*., 2022). Modern animal breeding practice increasingly uses various optimization agents that stimulate metabolism and anabolic phenomena, as well as increase the general resistance and fertility of animals (Medvedev *et al*., 2022; Vorobyeva & Medvedev, 2023). For this purpose, several substances that have a favorable effect on the main physiological and biochemical characteristics of the organism are now used. They can accelerate the growth, development, and maturation of the animal organism, contributing to the profitability of measures on the farm.

The increase in stress resistance and organism viability achieved under these conditions can be considered a consequence of changes in lipid metabolism, peroxidation processes, biosynthetic mechanisms in cells and individual organs, and activation of humoral and nervous regulation of the organism (Medvedev *et al*., 2021).

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It is of interest to find out the effect of gamavit on the sow's organism, which may help to increase the efficiency of prevention of any dysfunctions in them with an increase of productivity, general health improvement, an increase of product quality, and decrease of costs for its obtaining. There are reasons to think that gamavit, which has adaptogenic action, can be a very effective means to rationalize the process of pork production.

The study aims to evaluate the tonic effect of gamavit on the organism of sows.

Materials and Methods

The work was carried out on 5 groups of re-pregnant Duroc sows with 12 animals in each group. There were 4 experimental groups and one control group, which were collected from completely healthy comparable animals. Animals of all groups were kept in individual machines to standardize housing and feeding conditions. The feed composition and the whole housing technology corresponded to that of the farm.

The sows in the experimental and control groups were in the same room as the rest of the farm animals. The feeding process was carried out in the same way. The composition of the applied ratio in the experimental and control groups is set out in **Table 1**.

Sows up to two years old were fed as a pig weighing 180-200 kg. The ration included grass meal 5-10%, green and succulent forages 15-35%, concentrated forages 45-65%, peas 20%, meat and bone meal 5-10%.

Table 1. Composition of the daily feed of observed sows

Composition of animals	1-half gestation	2-half gestation
Consumption of concentrated feed mix, kg	1.6-1.8	1.6-1.8
Consumption of succulent fodder, kg	8-10	8-10
Hay (grass) meal consumption, kg	1.1-1.6	1.1-1.6
Chalk consumption, g	40.0	40.0
Calcium, g	21.0	21.0
Phosphorus, g	20.0	20.0
Table salt,g	14.0	14.0
Cyanocobalamin (B_{12}), mg	38	46
Tryptophan, g	4.1	5.4
Lysine, g	23	31
Cysteine+methionine, g	17	23
Beta-carotene, mg	282.0	282.0
Ergocalciferol (D),IU	1250	1530
Riboflavin (B_2), mg	11	14
Pantothenic acid (B_3), mg	38	46
Nicotinic acid (PP), mg	38	46

Seven days after successful insemination, sows in the experimental groups were injected intramuscularly with gamavit in the form of a sterile solution three times a week. Pigs of the first group received gamavit at a dose of 1.0 ml/kg; pigs of the second group - 0.5 ml/kg; pigs of the third group - 0.1 ml/kg; pigs of the fourth group - 0.05 ml/kg. The control group of animals received the standard diet and did not receive gamavit.

All animals were weighed before the gamavit application. The weighing was repeated 1, 2, 3, and 4 months after fertilization. After one, two, three, and four months of gestation, blood sampling was performed. In blood we determined the amount of malonic dialdehyde, nmol/ml; the level of reduced glutathione, μmol/l; the content of oxidized glutathione, μmol/l; the biological activity of superoxide dismutase, U; the biological activity of glutathione peroxidase, U; triacylglycerol level, mmol/l; low-density lipoprotein cholesterol level, mmol/l; very low-density lipoprotein cholesterol level, mmol/l; high-density lipoprotein cholesterol level, mmol/l using standard research methods. Statistical processing of the results was associated with the calculation of the Student's criterion.

Results and Discussion

In general, it is possible to assess the well-being of the sow's gestation by the dynamics of the most common parameters. Body weight is recognized as one of these parameters. Its estimation in the present work was carried out at 1, 2, 3, and 4 months of gestation in all observed groups of animals, showing that in all cases it was within the normal limits **(Table 2)**.

Table 2. Body weight of gestating sows on the background of gamavit

Observation groups	1 month gestation, M±m	2 month gestation, M±m	3 month gestation, M±m	4 month gestation, M±m
1 group, kg	215.2±3.17	229.4±4.26*	251.3±4.36*	272.6±4.85*
2 group, kg	212.3±4.39	222.2±3.23	240.7±5.11	264.8±2.93*
3 группа, кг	206.4 ±4.80	212.6±3.27	227.2±4.63	248.0±3.86
4 группа, кг	205.3±2.65	207.3±3.40	234.7±2.75	242.6±4.18
Control, kg	202.6±5.23	208.5±4.36	227.7±5.02	236.4±4.27

Note. Differences with the control level: * - p<0,05.

The live weight of sows during the observation varied depending on the amount of gamavit administered to their organism. Growth during gestation was observed in all observed groups receiving the drug and in the control group. The most pronounced gain during gestation was observed in sows of groups 1 and 2, amounting to 26.6% and 24.7%, respectively. In groups 3 and 4 the gains were lower, amounting to 20.4% and 18.2%, respectively, while in the control group, this indicator was 16.8%.

The introduction of gamavit into the organism of sows contributed to the growth of their fertility in the gestation period in relation to the control **(Table 3)**. The highest number of piglets was observed in the first group. This indicator exceeded the control level by 62.3%. In the second group, this indicator was very close to that of the first group, while in the third group, the number of piglets produced was slightly lower and inferior to the first group by 12.6%, but exceeded the control level by 44.1%. In the first three groups of sows, all piglets were born alive. In the fourth group, the number of piglets produced was the lowest of all the experimental groups to the control, exceeding its level by only 5.2%. In addition, sows in this group had stillbirths, which, however, were 45.4% lower than in the control.

All born piglets were viable, with body weight corresponding to the norm. At the same time, the value of nest weight in sows receiving gamavit was higher than in the control group. This indicator was the highest in the first group, exceeding the control by 2.5 times.

The value of weight per head in piglets in the case of gamavit application was higher in all groups than in the control. This indicator reached its maximum level in the first group, exceeding the control values by 13.6%. In the fourth group, no differences with the control were found in this indicator **(Table 3)**.

Table 3. Reproductive performance of sows treated with gamavit

Observation groups	Piglets produced, heads			Birth weight, kg	
	total	living	stillbirth	nests	single head
1 group	12.5±1.22**	12.5±1.22**	0	26.9±1.38**	1.92±0.11*
2 group	12.3±1.34**	12.3±1.34**	0	24.4±1.85**	1.90±0.12*
3 group	11.1±1.45**	11.1±1.45**	0	21.8±2.06**	1.86±0.06*
4 group	8.1±1.23	7.0±1.73*	1.1±1.67**	12.2± 2.25*	1.72±0.05
control	7.7±1.82	6.1±1.64	1.6±1.25	10.9±1.98	1.69±0.08

Note. Differences with the control level: * - p<0.05, ** - p<0.01.

Lipid metabolism is extremely important for the realization of the pregnancy process in all mammalian species. In this regard, we evaluated the most important parameters of lipid metabolism in sows of all observation groups during gestation **(Table 4)**.

Table 4. Lipid metabolism parameters in sows

Observation groups	Triglycerides, mmol/l	Total cholesterol, mmol/l	High-density lipoprotein cholesterol, mmol/l	Low-density lipoprotein cholesterol, mmol/l
1 months of gestation				
1 group	0.81±0.42**	3.48±0.63	1.65±0.12**	1.46±0.22*
2 group	0.72±0.15**	3.45±0.38	1.60±0.28*	1.52±0.18
3 group	0.66±0.16*	3.37±0.45	1.45±0.14	1.62±0.16

4 group	0.58±0.19	3.30±0.57	1.35±0.49	1.69±0.20
Control	0.57±0.23	3.22±0.51	1.35±0.67	1.61±0.24
		2 months of gestation		
1 group	0.84±0.09**	3.65±0.31	1.73±0.29**	1.53±0.31**
2 group	0.76±0.10**	3.58±0.45	1.68±0.13**	1.55±0.34*
3 group	0.72±0.08**	3.51±0.38	1.61±0.22**	1.57±0.27*
4 group	0.62±0.19	3.41±0.48	1.31±0.24	1.81±0.38
Control	0.60±0.14	3.45±0.23	1.32±0.29	1.85±0.41
		3 months of gestation		
1 group	0.87±0.12**	3.78±0.61	1.86±0.12**	1.52±0.26**
2 group	0.80±0.10*	3.72±0.51	1.74±0.10**	1.61±0.34**
3 group	0.75±0.13*	3.60±0.42	1.55±0.28**	1.71±0.46*
4 group	0.65±0.18	3.59±0.57	1.30±0.19	1.99±0.35
Control	0.68±0.25	3.61±0.54	1.27±0.09	2.03±0.47
		4 months of gestation		
1 group	0.94±0.14**	3.96±0.47	1.96±0.16**	1.57±0.52**
2 group	0.86±0.11*	3.85±0.52	1.86±0.08**	1.60±0.44**
3 group	0.80±0.09	3.88±0.39	1.77±0.25**	1.74±0.39**
4 group	0.75±0.17	3.77±0.57	1.22±0.13	1.91±0.62
Control	0.78±0.19	3.81±0.48	1.20±0.09	2.25±0.58

Note. Reliability of differences of indicators with the control level: * - $p<0.05$, ** - $p<0.01$.

The study was conducted in all groups at 1 month, 2 months, 3 months, and 4 months of gestation, allowing us to trace the changes in lipid parameters as the gestation period increased. The dynamics of lipid parameters in the control group were associated with a gradual decrease in high-density lipoprotein cholesterol (total of 12.5%) an increase in triglycerides (total of 36.8%), an increase in total cholesterol (total of 18.3%), and increase in low-density lipoprotein cholesterol (total by 12.5%). In the fourth experimental group, which received the smallest amount of the drug, the dynamics of lipid parameters repeated the same in the control.

In the first, second, and third experimental groups, the dynamics of lipid parameters in sows during gestation were somewhat different. Not only triglycerides (total by more than 21%), total cholesterol (total by more than 15.0%) and low-density lipoprotein cholesterol (total by more than 7.0%) increased in their blood as in the other groups. At the same time in the process of gestation in the first three experimental groups, there was an increase in high-density lipoprotein cholesterol (total by more than 22.0%).

Lipid changes in the blood of sows during gestation are traditionally considered adaptive and necessary for the growth of fetuses in the sow's body but have a certain danger in relation to the state of its vessels. At the same time, the increase of high-density lipoprotein cholesterol in the blood of the observed sows contributed to the preservation of the morphofunctional optimum of the vessels of the animals receiving gamavit. The forming situation undoubtedly contributed to the longer maintenance of their full health and created conditions for the longest possible economic use.

The found increase in the amount of high-density lipoprotein cholesterol in the blood of animals with simultaneous unexpressed tendency to increase the content of low-density lipoprotein fraction indicates a physiologically favorable course of lipid metabolism in animals of the first three groups. Taking into account the importance of the cholesterol level of lipoproteins of different densities for the health of the organism, it is necessary to evaluate gamavit as a preparation having antiatherogenic capabilities associated with a positive effect on the hematologic lipid profile of gestating sows.

The state of redox balance in the organism is determined by donor-acceptor relationships, i.e. it is based on the balance of the degree of electron and proton withdrawal in one place and transfer to another place (Likidlilid *et al*., 2007; Medvedev & Vorobyeva, 2021). In this regard, the regulation of redox metabolism involves a highly dynamic balancing act between these fundamental processes. Fluctuations of this balance within the boundaries of the optimum are observed during the normal regulation of a large number of processes in the organism (Vorobyeva & Medvedev, 2020b).

In various disorders in the body leading to the appearance of oxidative stress, there is a decrease in the content of SH-groups and an increase in the number of SS-groups (Vorobyeva & Medvedev, 2020a; Glamazdin *et al*., 2021b). During pregnancy, the activity of antioxidant systems increases, ensuring the success of this condition while minimizing the risk of various disorders (Tkacheva & Medvedev, 2022b). During gestation, control sows showed a tendency to increase oxidized glutathione (by 4.6%) and a tendency to decrease reduced glutathione (by 2.3%). The level of malonic dialdehyde in the control during gestation increased by 11.6% with a tendency to weaken the capacity of the antioxidant enzymes taken into account **(Table 5)**.

Table 5. Activity of antioxidant system components in sows

Observation group	Reduced glutathione+cysteine, μmol/mL	Oxidized glutathione+cysteine, μmol/mL	Malonodialdehyde, nmol/mL	Superoxide dismutase activity, units	Glutathione peroxidase activity, units
1 months of gestation					
1 group	1.009±0.082	0.445±0.053*	5.86±0.56*	1122.6±182.4*	2452.0±186.0
2 group	0.995±0.087	0.460±0.045	6.05±0.47	1072.0±75.1	2382.0±162.1
3 group	0.952±0.071	0.480±0.080	6.28±0.52	1040.0±110.4	2291.0±115.7
4 group	0.947±0.056	0.490±0.069	6.35±0.33	1020.0±115.6	2260.0±117.8
Control	0.941±0.092	0.498±0.075	6.40±0.47	1016.0±126.0	2252.0±114.0
2 months of gestation					
1 group	1.015±0.058	0.429±0.036**	5.73±0.48*	1153.6±173.6*	2538.0±175.6*
2 group	1.007±0.067	0.447±0.045*	5.83±0.37*	1105.0±88.6*	2417.0±183.6
3 group	0.957±0.085	0.465±0.057	6.20±0.53	1050.0±93.5	2311.0±141.0
4 group	0.940±0.074	0.505±0.059	6.50±0.62	1006.0±98.5	2252.1±134.5
Control	0.938±0.082	0.508±0.068	6.58±0.61	1002.0±99.5	2247.0±122.6
3 months of gestation					
1 group	1.032±0.068*	0.422±0.092**	5.53±0.68**	1192.0±180.3**	2705.0±172.4**
2 group	1.014±0.071	0.432±0.087**	5.71±0.75**	1134.5±125.1*	2571.0±123.8*
3 group	0.968±0.054	0.451±0.084*	6.05±0.86*	1068.0±92.4	2361.0±100.2
4 group	0.935±0.066	0.514±0.090	6.82±0.63	1000.3±111.5	2240.0±87.6
Control	0.930±0.093	0.517±0.084	6.87±0.39	995.0±100.2	2231.0±115.4
4 months of gestation					
1 group	1.066±0.087*	0.402±0.071**	5.21±0.83**	1232.1±147.0**	2814.0±151.0**
2 group	1.019±0.075*	0.425±0.054**	5.52±0.74**	1178.0±154.6**	2620.0±122.3**
3 group	0.973±0.063	0.447±0.068*	5.82±0.66**	1100.0±91.8*	2420.4±88.5*
4 group	0.926±0.070	0.521±0.073	7.10±0.70	992.0±100.5	2220.0±92.6
Control	0.920±0.077	0.526±0.096	7.14±0.51	987.5±96.3	2215.6±133.4

Note. Reliability of differences of indicators with the control level: * - $p<0.05$, ** - $p<0.01$.

In the fourth observation group, the dynamics of these parameters were very similar to the control group and did not differ from it by the level of indicators. In the first three experimental groups, the dynamics of these parameters were different. In sows receiving significant doses of gamavit, reduced glutathione gradually increased. In the first group during gestation, its growth amounted to 5.6%, in the second 2.4%, in the third 2.2%, in all cases and at all stages of the study exceeding the control level. The level of oxidized glutathione in the first three experimental groups decreased during gestation, showing some dependence on the amount of gamavit administered to the animal. Thus, during gestation, the amount of oxidized glutathione in them decreased: in the first group by 10.7%, in the second group by 8.2%, and in the third group by 7.4%.

Attention to these indicators in the work carried out was caused by the fact that glutathione is a nodal component of the thiol-disulfide

system, being a tripeptide gamma-glutamyl-cysteinyl-glycine with a free sulfhydryl group (Charmandari *et al*., 2005; Mal *et al*., 2020). It is not found in protein hydrolysis products and therefore is synthesized by the body to perform specific functions. The reduced form of glutathione is the main sulfhydryl buffer in cells, maintaining in a reduced state the cysteine residues in all proteins containing SH groups in the active center (Tkacheva & Medvedev, 2022c). In addition, glutathione is able to participate independently in detoxification processes by reacting with hydrogen peroxide. For this reason, it belongs to the most important thiol antioxidants that preserve a large number of enzymes with sulfhydryl groups in the active center from oxidation and loss of catalytic activity (Vorobyeva & Medvedev, 2020a).

If glutathione is fed, its intramuscular or intravenous injections do not affect its activity in cells (Glamazdin *et al*., 2023). It is poorly transported across cell membranes, and only the reduced glutathione synthesized directly in the cell exerts its biological effect. In this regard, the administration of gamavit ensures the realization of reactions leading to the preservation of reduced thiol equivalents, which enhances the adaptive capabilities of the sow's organism and its resistance to adverse factors in pregnancy (Medvedev, 2021; Tkacheva & Medvedev, 2022c).

In the control group, the level of malonic dialdehyde increased by 11.6% during gestation. Similar dynamics were experienced by this indicator in the fourth experimental group. In the first, second, and third experimental groups, the level of malonic dialdehyde decreased: in the first by 12.5%, in the second by 9.6%, and in the third by 7.9%. The obtained facts confirmed the ability of gamavit to weaken the processes of peroxidation in the body of animals, the end product of which is considered to be malonic dialdehyde.

Traditionally, in this regard, a simple and generally recognized criterion of the ratio of antioxidant-prooxidant processes in all body systems is considered to be the content of malonic dialdehyde in the blood. An increase in its amount reflects the inability of the body's defense systems to restrain the phenomena of lipoperoxidation, in the course of which a mass of extremely reactive radicals arises (Tkacheva & Medvedev, 2020c). These underoxidized oxygen products weaken the nonspecific resistance of the organism (Tkacheva & Medvedev, 2020a). The use of gamavit in this study provided a decrease in the amount of malonic dialdehyde in the blood of experimental groups of gestating sows, which indicated a weakening of the intensity of lipid peroxidation and an increase in the general resistance of the sows' organism (Tkacheva & Medvedev, 2021a; Kropova *et al*., 2024).

One of the most important components of the antioxidant-antiradical defense system is considered to be superoxide dismutase, which converts highly reactive superoxide anion into ordinary molecular oxygen and hydrogen peroxide (Tkacheva & Medvedev, 2023). In addition, it has a high oxidizing capacity. The process of hydrolysis of organic hydroperoxides is provided by the enzyme glutathione peroxidase (Tkacheva & Medvedev, 2022a). Their main biological significance is the simultaneous protection of cellular biomembranes from oxidative processes at their initial stages (Tkacheva & Medvedev, 2020b; Vorobyeva & Medvedev, 2022a). It was found that in the control group, the activity of these two antioxidation enzymes tended to decrease during gestation: superoxide dismutase - by 2.9%, glutathione peroxidase - by 1.7%. The activity of these enzymes in the fourth experimental group repeated the dynamics of their activity in the control group during the observation of animals. In the first three experimental groups, there was an increase in biological capabilities of superoxide dismutase and glutathione peroxidase: in the first group by 9.8% and 14.7%, in the second group by 9.9% and 9.9%, in the third group by 5.8% and 5.6%, respectively. The obtained dynamics fully fits within the limits of natural biological fluctuations, which indicates a normal and biologically very advantageous state of redox processes that stabilizes the morphofunctional parameters of their cells at the state of optimum (Tkacheva & Medvedev, 2021b; Vorobyeva & Medvedev, 2022b), whereas in the control the existing state should be considered as a state closer to the lower boundary of the norm (Lavoie *et al*., 2018; Tkacheva & Medvedev, 2022a).

Conclusion

Quantitative characteristics of hematological parameters of productive animals are very important to ensure the productive capabilities of the growing stock. In this regard, the great biological necessity of competent application of effective variants of physiological stimulation of animal viability with control of blood parameters is clear. Gamavit in doses of 1,0; 0,5 and 0,1ml/kg when injected into the body was able to provide a clear adaptogenic and stress-protective effect in sows. Gamavit increased the level of nonspecific resistance of the organism, accelerated the growth of gestating sows, and weakened the manifestation of stress of any origin in animals. All these created conditions for the general strengthening of their organism, an increase of gains, and high safety of the herd of born piglets. The verification of applied doses of gamavit proved the fruitfulness of the chosen scientific direction and the possibility of providing with its help a very effective stimulation of the organism of animals and the level of their productivity. It is very promising to verify gamavit doses for piglets of different ages in the future.

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