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Ascorbate Effect of Lithium on Protein and Lipid Metabolism in Pigs

K.S. Ostrenko*, V.P. Galochkina, I.V. Kutin, E.V. Koloskova, V.A. Yezersky

All-Russia Research Institute of Animal Physiology, Biochemistry, and Nutrition, Branch of Ernst VIZh Federal Science Center for Animal Husbandry, Federal State Badgetary Scientific Institution, Borovsk, Kaluga region, Russia.

***Email:** obbusin @ mail.ru*

ABSTRACT

The aim of the study was to investigate the effect of a new anti-stress drug on protein and lipid metabolism in the cultivation and fattening of pigs. The experiment was carried out on 5 groups of pigs of Irish Landrace breed (4 experimental and 1 control) with 10 heads in each in the period from 60 to 210 days of age. Animals of 1, 2, 3 and 4 experimental groups daily during the entire period of rearing and fattening received lithium ascorbate in the form of powder at a dose of 10, 5, 2 and 0.5 mg/kg of live weight, respectively. Weighing was carried out before the introduction of the drug, for the 4th month and before slaughter. Before setting the animals in the experiment and on the 180th day of the experiment, blood samples were taken. Triacylglycerols, total protein and globulins, and fractions of lipoproteins were determined in blood plasma. Acting on protein and lipid metabolism, lithium ascorbate activates the functions associated with the participation of α-, β - globulins in the transport of lipids, as well as in the performance of γ-globulins protective functions. Lithium ascorbate has a positive effect on lipid-cholesterol metabolism and, as a result, contributes to the increase in live weight and quality of meat. With the introduction of feed lithium ascorbate from the 60th day prior to slaughter at a dosage of 10, 5 and 2 mg/kg of body weight, lithium ascorbate exhibits a pronounced adaptogenic and stress-protection properties, prevents the accumulation of lipoproteins of low and very low density and activates the production of high-density lipoproteins. And in the control animals, it is is observed in the reverse reaction. The use of lithium ascorbate affects protein synthesis. Given that γ-and β-globulins serve as raw materials for the production of immunoglobulins, it can be noted that the animals treated with lithium ascorbate had the best opportunities for humoral specific protection for 180 days of experience, which contributes to the increase of nonspecific immunity and resistance. The revealed effects of lithium ascorbate indicate the prospects for the development of new effective ways to increase stress resistance, nonspecific resistance and productivity of animals using drugs based on organic lithium salts.

Key words: *antis-tress drugs, lithium ascorbate, lipid-cholesterol metabolism, protein metabolism, albumin, globulins, lipoproteins.*

INTRODUCTION

Keeping animals in conditions of large industrial complexes is due to the effects on the body of various stress factors [1]. This is due primarily to the specific conditions of industrial technology including lack of exercise, solar insolation, unbalanced diets for protein, vitamins and other components [2-4].

According to modern concepts, one of the least studied parts of the system of adaptation to the action of these factors is the processes of free radical oxidation [5]. Increased free radical lipid peroxidation (SPOL) and depression of antioxidant defense enzymes lead to the development of oxidative stress (OS), which in turn causes

damage to the internal organs of animals [6-8]. The condition of industrial technology for keeping animals remained clinically unnoticed for a long time, and therefore timely prevention of metabolic abnormalities in animals was not carried out [9-11]. A significant decrease in pig productivity is associated with technological operations in the growing cycle, such as regrouping, increased placement density, hypoxia, and changes in feeding [12, 13]. Ultimately, the combination of stressors is a deterrent to industrial pig production [14].
The aim of this study is to prevent the development of disorders of protein and lipid metabolism caused by the influence of stressors of different etiology. Reduction of the recovery period after stress, regardless of cultivation technology, climatic, feed and other factors is considered. A distinctive feature of this work is the possibility of using lithium ascorbate with feed, and not as injection forms as in the application of lithium salts with gamma-aminobutyric acid [15].

MATERIAL AND METHODS

Experiments were conducted in JSC "Sommatino" Maloyaroslavets district of Kaluga region in 5 groups of pigs of the Landrace at 10 goals each. Experimental and control groups were formed from 2-month-old piglets. The diet and technological process did not differ from the main technology of fattening and rearing of piglets. Lithium ascorbate was administered with feed in a dose (mg / kg body weight): group 1− 10, 2 – 5, 3 – 2; 4 – 0.5. The control group of piglets was on the main diet without the addition of the drug. During the experiment, feeding rations were made according to the norms of the VIZ when using the program complex feed Optima Expert, while the level of feeding was made up in the expectation of obtaining from 500 to 700 g of average daily live weight gain. The rations consisted of complete feeds of SK-5, SK-6, and SK-7. The animals were kept in the machines without playing games. The climate in the rooms was maintained automatically according to the zoo-hygienic requirements. Guinea pigs were fed with wet bags twice a day. Water was freely available. Total growing cycle was 210 days.
Primary weighing was carried out at formation of groups, and repeated weighing was performed at the age of 4 months, before slaughter, before the experiment and at the age of 180 days. The blood was taken from the external jugular vein into vacuum tubes with the addition of 10% solution of triplet. Plasma concentrations of triacylglycerols (mmol/ l), total cholesterol (mmol/ l), total protein (g / l), albumin (g/ l), globulins of different fractions (g/ l), low-density lipoprotein cholesterol (mmol/ ml), very low-density lipoprotein cholesterol (mmol/ l), and high- lipoprotein cholesterol (mmol / L) were determined.
Indicators characterizing lipid-cholesterol effects were analyzed using test systems of UNIMED company.

RESULTS AND DISCUSSION

The physiological role of lipids in the body is that they are a part of cellular structures and are used as rich sources of energy.
There are several classes of lipoproteins in the blood. These include low-density lipoproteins (LDL), very low-density lipoproteins (LDL), and high-density lipoproteins (HDL). The lipoprotein spectrum of blood can be changed under the influence of external stress factors; therefore, the determination of its biochemical status is an important factor in assessing the productivity of animals [16]. At the initial stage of the experiment, the level of lipoproteins of different fractions differed little in the experimental and control groups (Table 1).

Table 1. The indicators of lipid-cholesterol metabolism (M±m, n=5)

Group	TAG	OH X	X HDL	X LDL	X VLDL
	Age 60 days.				
1	0,50±0,04	2,52±0,12	0,89±0,13	1,15±0,19	0,48±0,041
2	0,49±0,06	2,53±0,18	1,01±0,46	1,12±0,24	0,40±0,014
3	0,52±0,04	2,76±0,21	0,93±0,51	1,37±0,31	0,46±0,024
4	0,48±0,09	2,69±0,26	0,99±0,24	1,28±0,21	0,42±0,032
control group	0,48±0,02	2,82±0,24	1,09±0,31	1,31±0,18	0,42±0,021
	Age 180 days.				
1	0,88±0,10*	3,92±0,54*	1,71±0,24*	1,67±0,46*	0,26±0,043*
2	0,82±0,06	3,81±0,73	1,67±0,37	1,75±0,39	0,28±0,039
3	0,75±0,12	3,73±0,67	1,64±0,31	1,86±0,54	0,34±0,050

4	0,60±0,09	3,62±0,47	1,49±0,18	1,95±0,73	0,46±0,076
control group	0,58±0,16	3,57±0,96	0,83±0,09	2,17±0,31	0,57±0,092
Notes: TAG-triacylglycerols, mmol/l; HO − cholesterol total, mm/l; x HDL − cholesterol of high density lipoproteins, mmol/l; X LDL − cholesterol of low density lipoproteins, mmol/l; X LDL − cholesterol of very low density lipoproteins, mmol / l. *P<0.05 by t - criterion when compared with the control.					

The changes in the experimental groups were recorded in terms of lipid-cholesterol metabolism. Cholesterol levels were higher in experimental animals than in controls. Cholesterol is a vital substance, as it is involved in the formation of bile acids which in turn plays an important role in the process of digestion and absorption of fat.

HDL consists mostly of protein and cholesterol. Their main function is to transfer excess cholesterol to the liver, from where they are released in the form of bile acids. Therefore, HDL cholesterol is also called "good cholesterol" [17]. In our studies, HDL was more in animals of the experimental groups compared with the control (106, 101, 98, and 79%, respectively) indicating a more intense lipid metabolism in animals of these groups.

Low-density lipoproteins (LDL) and very low-density lipoproteins, or "bad" fat, transfer the cholesterol they need to tissues. The animals of the experimental groups in blood serum for 180 days experienced their content slightly increased relative to 60 days, but significantly lower than in the control group (in group 1 by 23%, in 2 by 19, in 3 by 14, and in 4 by 10%). It is noteworthy that by the end of fattening in the animals of the experimental groups, there was an increase in the concentration of HDL and a decrease in the concentration of LDL and VLDL, and in control animals, there was a reverse reaction.

The most common lipids are triacylglycerols (TAG), which in the body perform a reserve role in the form of spare fat or protoplasmic fat cells. In the blood serum of pigs of the experimental groups, the content of TAG in the blood varied from 3.45 to 51.7; and in the control group, an increase in the level of TAG indicated a more intense fat deposition.

The use of lithium ascorbate did not contribute to an increase in the content of phospholipids in the blood. In the contrary, it tended to decrease to the lower limit of the physiological norm by 54.4; 50.9; 40.3; 19.3%, respectively in the groups lower than the control.

Proteins perform a variety of functions in the body. They are used to build cells, tissues and organs; they are used to encode hereditary information and memory; they are a part of enzymes, and hormones, catalyze biochemical reactions; change their dimensions; provide movement; in an acidic environment, they behave as a basis, and in an alkaline environment, as an acid, i.e. they perform a buffer homeostatic function.

The content of total protein in the blood serum of pigs of the experimental groups was increased with age. This is quite understandable from the point of view of the law of energy conservation, the values of the material energy carrier, and the total protein of blood serum corresponded to large body mass indices. A significant increase in this parameter of vital activity in pigs treated with lithium ascorbate was observed on 180 days of fattening. It is possible to assume that under stress; the body is forced to use proteins for energy purposes. As is known, α1-globulins are a complex comprising high-density lipoproteins and bilirubin. In animals of the control group, the content of α1-globulins by the end of the observation was significantly increased, compared with the initial period of the experiment which created prerequisites for toxicosis of the body with indirect bilirubin [18]. In the experimental groups, this indicator was characterized by a decrease. Since the composition of β-globulins includes transferrin, ceruloplasmin and prothrombin, the animals which introduced lithium ascorbate during the entire period of observation created more favorable conditions for the transport of iron, copper and the functioning of the blood coagulation system. The content of γ-globulins in the serum of pigs of the experimental groups was higher than in the control group; therefore, these animals had better opportunities for humoral specific protection. The total protein content in the serum of pigs of all groups was increased with age, reaching a maximum of 180 days of age. In the experimental groups, there was a steady trend of increasing the level of total protein compared to the control (respectively, in group 1 by 18%, 2 by 15%, and 3 by 11% as shown in Table 2) apparently due to the optimization of protein-synthetic liver function in terms of reducing stress and reducing free radical oxidation.

Table 2. The indicators of protein metabolism in the blood (M±m, n=5)

Groups	Total protein g/l	Albumin %	α1-globulins, %	α2-globulins, %	β-globulins, %	γ-globulins, %
	Age 60 day.					
1	62,2±2,09	25,34±1,35	3,9±0,43	7,3±0,43	10,76±0,34	14,89±0,42
2	60,3±1,24	24,71±2,03	4,2±0,72	6,9±0,29	9,47±0,41	15,02±0,24
3	63,2±0,94	25,98±2,64	4,4±0,51	8,1±0,74	10,21±0,35	14,51±0,42

4	62,9±2,71	26,14±1,99	4,6±0,37	8,5±0,56	10,61±0,54	14,05±0,36
Control group	63,8±1,19	26,12±0,98	4,4±0,29	8,5±0,52	10,54±0,27	14,24±0,24
	Age 180 day.					
1	85,4±5,30*	34,61±2,69	3,4±0,18*	7,4±0,59*	15,6±1,09*	24,4±1,94*
2	83,1±2,69	34,89±3,24	3,4±0,24	7,2±0,34	15,2±0,94	22,41±0,81
3	80,6±4,29	32,47±0,98	3,6±0,31	7,8±0,67	14,7±2,14	22,03±1,64
4	74,1±3,41	30,04±4,25	3,6±0,24	8,0±0,73	13,6±1,42	18,86±2,04
Control group	72,4±3,52	30,03±1,92	8,4±0,29	10,5±0,52	8,97±0,73	14,49±2,42

*P<0.05 by t - criterion when compared with the control

During the observation of the blood serum of the pigs of the experimental groups, globulin was predominant. The share of fine proteins of blood serum-albumins accounted for 1-16% more in the experimental groups. A stable trend was observed in the experimental groups for all globulin fractions. The share of α2-globulins decreased to 180 days age. It is known that α2-globulins, by binding to renin, give rise to angiotensin II, which controls the tone of the diverting arterioles of the renal glomeruli, facilitating diuresis at the ultrafiltration stage [19-21].

Β-globulins accounted for an average of 18% of the total amount of proteins, with variations depending on the dose of lithium ascorbate. The fraction of γ-globulins of blood serum accounted for about 1/4 part, and compared with the control group their concentration was higher by 2 times (Table 2). Given that γ-and β-globulins serve as raw materials for the production of immunoglobulins, it can be noted that animals treated with lithium ascorbate had the best opportunities for humoral specific protection for 180 days of experience [22, 23]. α1-globulins are a complex comprising high-density lipoproteins and bilirubin. In animals of the control group, the content of α1-globulins by the end of the observation was significantly increased, compared with the initial period of the experiment which creates prerequisites for toxicosis of the body with indirect bilirubin. In the experimental groups, this indicator was characterized by a decrease. Since the composition of β-globulins includes transferrin, ceruloplasmin and prothrombin, in the groups of animals treated with lithium ascorbate during the entire period of observation, more favorable conditions for the transport of iron, copper and the functioning of the blood coagulation system were created. The content of γ-globulins in the blood serum of the pigs of the experimental groups was higher than in the control group; therefore, these animals had better opportunities for humoral specific protection.

In a balanced lipoprotein system, the increased content of chylomicrons, VLDL and LDL determine the risk of excessive cholesterol deposition in the endothelium of co-vessels. In the same vein, an increase in the concentration of HDL accelerates the withdrawal of cholesterol from the endothelium and the body [24]. The leading way of chemical transformation of lipoproteins (LP) is excessive peroxidation of lipids included in their composition. Peroxide-modified LDL, on the one hand, is subjected to be captured by macrophages and smooth muscle cells of the arterial wall, which leads to a massive accumulation of cholesterol esters in them. On the other hand, the peroxide modification of LDL is accompanied by a significant increase in their immunogenicity. The formation of autoantibodies to altered LDL, captured by the cells of the arterial wall is an additional factor of arterial damage (destruction under the influence of immune complexes).

The physical, chemical and biological properties of LP depend, on the one hand, on the ratio between protein and lipid components of these particles, and on the other, on the composition and properties of proteins and lipids [25]. The largest particles, consisting of 98% of lipids (mainly TAG– 84-87%) are chylomicrons (XM). They are formed in the cells of the small intestine mucosa and are a form of transport for food neutral fats. Delivering lymph current to the lungs and then to the liver, they turn into LDL and VLDL containing about 60% of plasma cholesterol. HDL is also formed in the liver, partially-in the intestine and blood plasma as a result of degradation of HDL. LDL is the most atherogenic for a number of reasons. They transport about 60% of the total plasma cholesterol and are able, along with HDL, to penetrate the vascular wall through the endothelial barrier, but, unlike HDL which are easily removed from the wall, contributing to the excretion of excess lipids, LDL are retained in it [26].

Exaggerated under stress antigenic stimuli come from modified LDL lipid peroxidation, they are considered as the main factors of structural-functional cell membranes, which are the main cause of pathologic conditions of blood vessels.

In recent years in zootechnical science the characteristic of diets on criteria of atherogenicity and anti-atherogenicity has more and more been approved in the rights of the citizenship. We are interested in the status of lipid-cholesterol metabolism in animals in connection with the quality of food supplied by these animals to humans. In other words, we are talking about a comprehensive assessment of the potential adequacy of the diet for both animal and human. Without such an assessment, it is difficult to expect to receive healthy food products suitable for children, dietary and functional nutrition.

In recent years, interest in the use of pigs for medical and biological research has been increased significantly in many countries of the world. This is explained by the fact that the structure, functioning of the cardiovascular, digestive and other systems, as well as metabolism in pigs are largely similar to those in humans. Pigs are rightly considered to be one of the most convenient objects for studying atherosclerosis, as the anatomical and histological structures of the inner shell of the aorta and coronary vessels in humans and pigs are very similar. In pigs, spontaneous atherosclerotic lesions of the aorta and coronary arteries are often noted, pathogenetically very close to atherosclerotic vascular lesions in humans. Indicators of blood cholesterol and beta-lipoprotein also have much in common with those in humans. Pigs, like humans, are omnivorous, so they have cholesterol in a certain amount entering the body with food and, apparently, this exogenous cholesterol is important in the development of atherosclerosis. These data were the subject of selection of pigs as a model of experimental atherosclerosis. For animal science interest is the extent to which diets are able to prevent or to provoke disturbances in the animal organism lipid-cholesterol metabolism, related to the activation of lipid peroxidation and its consequences in the form of the high content of components of lipid peroxidation in foods of animal origin.

CONCLUSION

As a result of the impact of technological stressors on the standard production cycle of growing and fattening pigs, the level of overall reactivity has been increased. Based on the data obtained, it can be concluded that lithium ascorbate activates the processes associated with the participation of α -, β - globulins in the transport of lipids, as well as in the performance of γ-globulins protective functions in the system of nonspecific immunity.

Analysis of lipid metabolism in the blood of pigs under study characterizes the use of lithium ascorbate as normalizing and stimulating lipogenesis, i.e. synthesis of energy-plastic substances of the body. It is important in early weaning, because the accumulation of lipid in the body increases energy resources for adaptation to environmental conditions, thereby contributing to stress resistance, safety and productivity.

The revealed effects of lithium ascorbate indicate the prospects of development of new effective ways to increase stress resistance, nonspecific resistance and productivity of animals with the help of drugs based on organic lithium salts.

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