International Transaction Journal of Engineering, Management, & Applied Sciences & Technologies

http://TuEngr.com

TuEngr Group

PAPER ID: 10A19N

CORRECTION OF OXIDATIVE METABOLISM OF ANIMALS BY MEANS OF BIOLOGICALLY ACTIVE COMPLEX OF ANTIOXIDANT DEFENCE

A.P. Poryvaeva [a], I.M. Donnik [b*], A.G. Isaeva [a,b], A.S. Krivonogova [a,b], I.A. Shkuratova [a,b], N.B. Musikhina [b], A.A. Baranova [b], O.G. Loretts [b], M.V. Petropavlovskiy [a]

[a] *Federal State Budgetary Scientific Institution "Ural Federal Agrarian Scientific Research Centre, Ural Branch of the Russian Academy of Sciences" (FSBSI UrFASRC, UrB of RAS), 112 A, Belinskogo St., Ekaterinburg, RUSSIA.*

[b] *Federal State Budgetary Educational Institution of Higher Education "Ural State Agrarian University" (FSBEI HE Ural SAU), 42, K. Liebknechta St., Ekaterinburg, RUSSIA.*

ARTICLEINFO

Article history:
Received 31 May 2019
Received in revised form 24 September 2019
Accepted 14 October 2019
Available online 30 October 2019

Keywords:
Pigs; Oxidative stress; Vitamin-mineral; Blood serum; Longissimus; Amino acid composition; Biologically active complex of antioxidant defense; Oily and plant components.

ABSTRACT

Nowadays one of the most burning issues in manufacturing of high-quality hog products is reduction of biological value of meat. The reasons for that are low quality of feed stuff, huddling, limited activity of animals, and contamination of the feed stuff with xenobiotics of technogenic nature. All the factors result in development of animals' stress that firstly triggers activation of free-radical process. Thus, the research on correction of oxidative stress of animals is considered to be essential. To eliminate negative effect of lipid peroxidation among fattening pigs, biologically active complex of antioxidant defence, including vitamin-mineral, oily and plant components, was used. Content of malondialdehyde in blood serum and content of amino acids in longissimus was determined.

The use of biologically active complex of antioxidant defence in diet of the experimental pigs made it possible to reduce negative influence of LP metabolites on organism. Besides, in the experimental group the number of animals with the meat parameters of biological value close to the expected level according to genetic potential, increased.

Disciplinary: Animal Sciences, Biosciences/Biotechnology.

1. INTRODUCTION

Under the conditions of large industrial livestock breeding complexes, the influence of various stress factors on the organism of agricultural animals has a synergetic effect. According to a number of authors, low quality of hog products, as well as veterinary problems in agricultural enterprises in this sphere of livestock breeding, are mostly caused by stress factors [3, 7].

One of the basic components of organism adaptation to living conditions is oxidative metabolism and its supporting homeostatic mechanisms. The improper physiological balance between intensity and speed of free-radical reactions on one side and activity of antioxidant systems on the other side leads to metabolic changes in the organism, i.e. to “oxidative stress” [5]. Hypersynthesis of various bioradicals, such as reactive oxygen species (ROS) and reactive nitrogen species (RNS) is accompanied by quick depletion of reserves of the antioxidant system [6]. On the molecular-cellular level, it is characterized by activation and intensity of the LP process that results in both changes in properties of biomembranes and in the complete cellular dysfunction [4]. Transition LP products are able to induce oxidative transformation of nucleic acids, and protein and lipidic macromolecules. Under the conditions of oxidative stress, the speed of reparation of those macromolecules is much less than the speed of the formation of bioradicals [4, 5]. Oxidative modifications mostly affect amino acids included in the composition of proteins, such as cysteine, methionine, histidine, arginine, tryptophan, tyrosine, and phenylalanine [3, 6].

According to both Russian and foreign authors, the influence of stress factors on porcine organisms firstly results in a reduction of the expected genetic level of production [1, 2]. Issues of correction and regulation of processes of oxidative metabolism in porcine organisms are still considered to be essential in veterinary theory and practice.

This research concentrated on the influence of alimentary biologically active complex of antioxidant defense on the amino acid composition of porcine muscles under the conditions of oxidative stress.

2. MATERIALS AND METHODS

Dynamics of the MDA level in blood serum of fattening pigs was studied under the conditions of research and production experiment. Blood of animals was taken from ear’s marginal vein on the 1^{st}, 30^{th} and 60 days of research. Quantification of MDA in biological material, such as blood serum, and samples of muscles, heart, liver, kidneys, and lungs was done according to standard methods. Amino acid profile was identified in homogenate consisting of equal weights of longissimus, and shoulder, round and iliac muscles, according to 17 parameters. Analysis of amino acid composition was done on a liquid chromatograph LC-20 Prominence (Shimadzu production) with spectrophotometric detector (254 nm); reverse stationary phase column C18 (Analysentechnik 250 x 4.6 mm, 5 mcIU, Germany) and proper precolumn; mobile phase – mixture of sodium acetate liquor (0.06 mmol/dm3. pH≤5.5 and 4.05.and 1% liquor 2-propanol in acetonitrile.

Possibility of correction of oxidative stress was evaluated by means of implementation of a biologically active complex of antioxidant defense (BACAD), consisting of vitamin-mineral, oily and plant components, into the porcine organism. The complex included soy isolate, pyridoxine, niacin, vitamin C, magnesium citrate, a complex of calcium with methionine hydroxy analog (MHA), lysine, threonine, valine, tryptophan, flaxseed, olive and jinjili oils (gingili/gingelly oils), and leaves of Urtica dioica.

Two groups of landrace breed of pigs were formed on the principle of analogs (n=40). The animals from the control (C) and experimental (E) groups were kept under the usual conditions of the pig-breeding farms. The pigs from the experimental group were given BACAD for 14 days.

The authenticity of the results was proved using statistic techniques with averaging and standard deviation calculation using Student's t-test. The results were considered to be verified by $p<0.05$.

Processing of the obtained data was done using Microsoft Excel®.

The research on the dynamics of the MDA level in blood serum of pigs has shown that only 8.75% of animals had background concentration within physiological standards that was 0.853±0.015 mcIU/l. In 15% of cases MDA content increased by 59.5% (1.276±0.023 mcIU/l). Most of the pigs under research (76.25%) had MDA content on the level of 1.045±0.019 mcIU/l that on average was higher than physiological standards by 30.6% ($p \leq 0.05$). For the whole period of research and production experiment in the Control group of pigs MDA level increased by 7.2-8.5% as compared with background parameters. The obtained data proved that the pigs under the conditions of industrial breeding technologies suffer from depression of system of antioxidant defence. Organisms of animals are subjected to constant intensive influence of toxic products of lipid peroxidation. In the Experimental group of pigs having the diet with added BACAD, there was positive dynamics in reduction of MDA level ($p \leq 0.05$). By the 30th day of research, MDA content in blood serum was 0.967±0.020 mcIU/l. by the 60th day of research 0.834±0.022 mcIU/l. that was not different from physiological standards of that kind of animals.

Table 1: MDA concentration in samples of tissue and organs of the experimental pigs, mcIU/l.

№	Sample of the researched biomaterial	MDA concentration. mcIU/l	
		The Control group	The Experimental group
1.	Blood serum	1.386±0.036	0.834±0.022
2.	Muscle tissue	1.296±0.027	1.195±0.031
3.	Heart	1.432±0.024	1.367±0.026
4.	Liver	2.180±0.032	2.053±0.035
5.	Kidney	1.955±0.026	1.986±0.028
6.	Lung	1.733±0.022	1.420±0.032

Table 2: Amino acid composition of porcine muscle tissue under the conditions of oxidative stress, (mg/100g).

№	Parameters	Performance standard [2]	Parameter among the pigs from Control group (n=20)	Parameter among the pigs from Experimental group (n=20)
Irreplaceable amino acids		**7801**	**5840.2±51.7**	**7736.5±35.4**
Including:				
1	Valine	1135	668.2±22.3	917.7±14.5
2	Isoleucine	970	763.3±12.9	1226.5±17.3
3	Leucine	1538	845.3±18.4	1194.8±20.4
4	Lysine	1631	1526.4±92.9	1857.2±25.1
5	Methionine	478	515.5±15.4	402.8±11.7
6	Threonine	961	818.2±20.3	1251.5±19.9
7	Tryptophan	274	138.6±16.9	156.8±13.8
8	Phenylalanine	814	565.1±15.2	728.7±14.4
Non-essential amino acids		**10832**	**9569.6±94.8**	**10954.2±69.4**
Including:				
9	Alanine	1213	1219.3±62.4	1194.3±57.8
10	Arginine	1223	1020.1±63.7	1372.5±35.3
11	Asparagine acid	1895	1801.8±70.5	2197.5±52.8
12	Histidine	773	705.6±19.4	764.7±14.1
13	Glycine	864	698.0±14.7	792.6±18.3
14	Glutamine acid	3385	2899.7±113.5	3136.8±103.7
15	Oxyproline	50	48.6±5.4	38.4±4.8
16	Serine	743	641.5±17.6	822.5±10.6
17	Tyrosine	695	535.0±14.8	710.3±11.2
Total number of amino acids		**18633**	**15409.8±101.6**	**18690.2±62.2**

The research on MDA level in samples of porcine tissue and organs have shown that in homogenate of liver of animals from both the Control and Experimental group, MDA concentration was the highest - 2.180±0.032 mcIU/l and 2.053±0.035 mcIU/l, respectively (Table 1).

According to the results shown in Table 1, distribution of toxic LP products in other tissues under research is equal enough. Difference in MDA concentration in homogenate of muscle tissue between the Control group and Experimental group was 7.8%.

The results of defining amino acid composition of muscle tissue of the experimental animals are shown in Table 2.

Comparative analysis of the obtained data has stated that total number of amino acids in samples of muscle tissue of the pigs from the Control group was 17.3% lower than the performance standards for muscle tissue of this kind of animals [2]. Total number of amino acids in samples of muscle tissue of the pigs from the Experimental group was within performance standards.

In the amino acid composition in samples of muscle tissue of the pigs from the Control group the content of tryptophan was 49.4% lower; the content of leucine - 45% lower; the content of valine - 41.1% lower; the content of phenylalanine - 30.6% lower ($p<0.05$). In muscle tissue from the Experimental group shortage of tryptophan stayed stable (42.8%). However. it was not so prominent (22.4%). the content of valine was 19.2%. and the content of phenylalanine was 10.5% ($p\leq0.05$). It is worth to note that content of isoleucine, lysine and threonine in samples from the Experimental group was generally 24-25% higher than in the samples from the Control group (Figure 1).

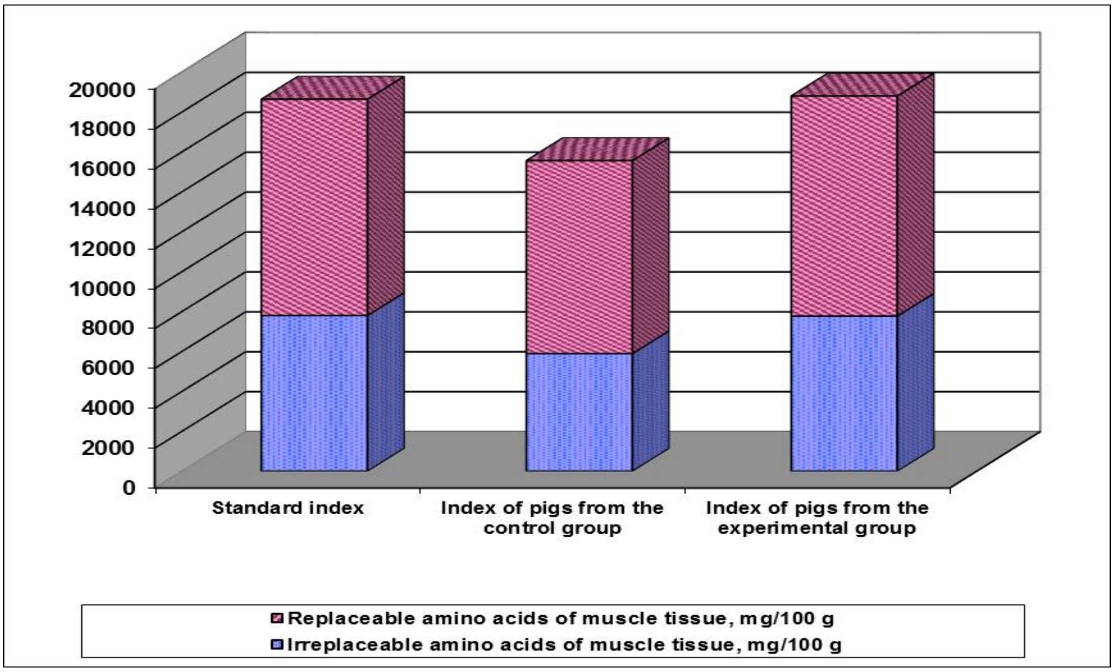

Figure 1: Indexes of amino acid composition of muscle tissue of Landrace breed of pigs.

Shortage of non-essential amino acids – arginine, glycine, glutamine acid, serine and tyrosine – in the samples from the Control group was from 12.6 to 23%, as compared to both performance standards and data obtained in the Experimental group. No prominent differences between the data obtained from the Experimental group and performance standards regarding content of non-essential amino acids in porcine muscle tissue have not been found ($p\geq0.05$). In all the samples of porcine muscle tissue under research disbalance in proportion tryptophan/ oxyproline (index of protein value) was identified. It was most prominent in the Control group 2.85±0.16, performance standard 5.2-5.8 [2]. In the Experimental group index of protein value was 4.13±0.09.

In samples of muscle tissue of the pigs from the Control group changes in amino acid composition were identified in 82.5% of cases. and in 17.5% of cases the data were within low limit of performance standards. Shortage of amino acids in muscle tissue of the pigs from the Experimental group was identified in 27.5% of cases. and in 72.5% cases the data met performance standards.

Thus, the research done have shown that under the conditions of industrial breeding technologies in 85-90 % of cases pigs suffer from oxidative stress. Local signs of oxidative stress in porcine organism were identified by increased MDA content in tissues of liver, kidneys and lungs. Concentration of that LP metabolite in organs were 1.5-2 times higher than its concentration in blood serum that may be indirect implication of oxidative damage of cell structure and disorder in process of reparation of protein macromolecules [9], as well as of trigger action of oxidative stress on whole organisms of animals (Figure 2).

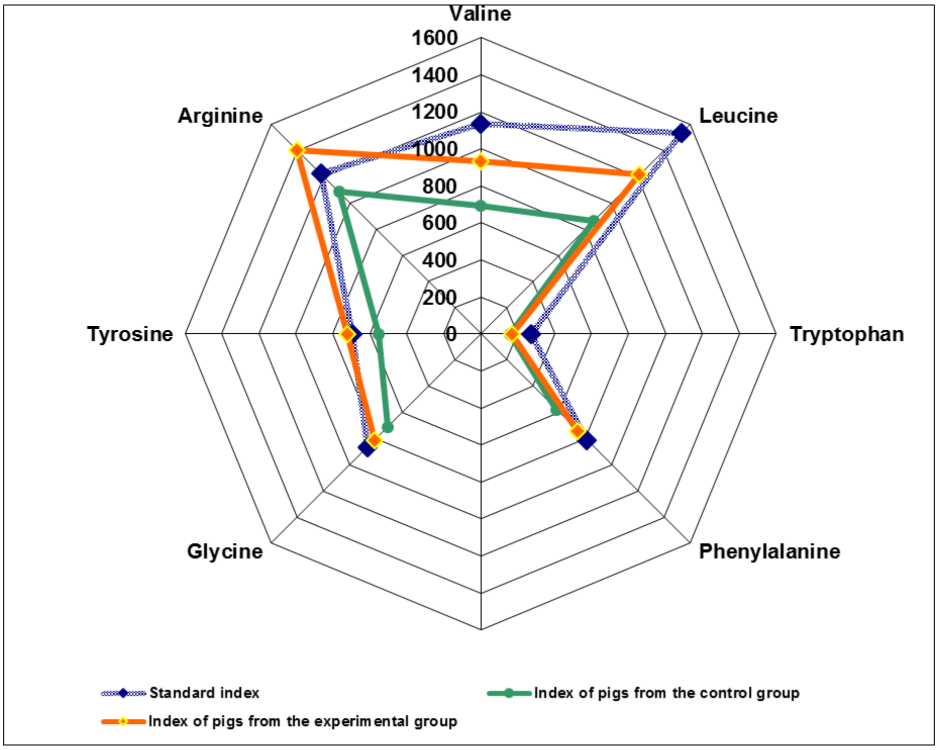

Figure 2: Quantative content of amino acids: targets of oxidative modifications in muscle issue of pigs.

Under the conditions of research and production experiment it was shown that the targets of oxidative modifications in porcine organism were mostly irreplaceable amino acids, such as valine, leucine, tryptophan and phenylalanine. Content of those amino acids in samples of muscle tissue was 30.6–49.4% lower. AS is commonly known, oxidative modification of irreplaceable amino acids results in changes in not only primary, but also both secondary and tertiary structure of protein. Changes in protein structure create conditions for their agglomeration that in a number of cases causes autostimulation of free-radical processes in organism [4, 5]. In the range of non-essential amino acids the most prominent quantity changes were identified regarding arginine, glycine and tyrosine. In samples of porcine muscle tissue their content was 17-23% lower. Like irreplaceable amino acids, during oxidative modification arginine and glycine cause transformation of protein macromolecules [4, 5, 6]. Modification of tyrosine leads to inhibition and blocking cell signals [5, 7]. Identified changes show that there are high chances of that under the conditions of industrial breeding technologies pigs suffer from depression of antioxidant defence of organism.

3. CONCLUSION

The use of BACAD in feeding diets of experimental pigs allowed to reduce the negative effect of metabolites on the organism of experimental pigs [8, 10, 11]. MDA content in the blood serum of animals reduced up to the level of physiological standard. In the tissue of the liver, kidneys, and lungs' positive dynamics were less prominent, and the MDA level was 6-8% lower than in samples of tissue of the animals from the Control group. The other result of equal importance is the standardization of most quantity indexes of the amino acid composition of muscle tissue. Content of irreplaceable amino acids – valine, leucine, and phenylalanine – was 10-20% lower than the reference value. However, as compared with the data obtained from the animals from the Control group, obtained results can be considered to tend to normalization of protein synthesis in organisms and reduction of the intensity of oxidative modification of amino acids. The positive effect of the use of BACAD was also proved by that the number of animals with the meat having a biological value close to the expected level according to genetic potential, increased by 3.2 times.

4. DATA AND MATERIALS AVAILABILITY

Relevant information is available by contacting the corresponding author.

5. CONFLICT OF INTEREST

The authors confirm that the given data do not have any conflict of interest.

6. ACKNOWLEDGEMENT

The research was supported by a grant from the Russian Science Foundation (Project No. 16-16-00071). The paper preparation was backed by Ural State Agrarian University (FSBEI HE Ural SAU) and Federal state budgetary scientific institution «Ural Federal Agrarian Scientific Centre, Ural Branch of the Russian Academy of Science” (FSBSI UrFASC, UrB RAS).

7. REFERENCES

[1] Belik S.N., Belik V.V., Kolmakova T.S. Lipid peroxidation and antioxidant activity among breeding boars with various genotypes. Health and Education in 21st century. 2015. 17(2), 1-4.

[2] Lisitsyn A.B., Chernukha I.M., Kuznetsova T.G., Orlova O.N., Mkrtchian V.S. Chemical composition of meat: Reference tables of overall chemical, amino acid, fatty acid, vitamin, macro- and microelement compositions and nutrition (energy and biological) value of meat. M.: VNIIMP. 2011. 104 pages.

[3] Liubin N.A.,Stetsenko I.I., Liubina E.N. Functional status of system of antioxidant defence and free-radical oxidation of pigs according to the use of various forms of vitamin A and B-Carotene. Herald of Ulianovsk State Agricultural Academy. 2013: 54-59.

[4] Makeev A.A., Sakharov A.V., Prosenko A.E., Zhutchaev K.V., Riabtchikova E.I. Influence of oxidative stress on structural-functional organization of porcine runner // Herald of Krasnodar State Agrarian University. 2009. 7: 120-123.

[5] Martusevitch A.K., Karuzin K.A. Oxidative stress and its role in formation of misadaptation and pathology. Bioradicals and Antioxidants. 2015. 2(2): 5-18.

[6] Mentschikova E.B., Lankin V.Z., Zenkov N.K., Bondar I.A., and coauthors. Oxidative stress. Prooxidants and antioxidants. 2006, 556.

[7] Titov V.Yu., Dolgorukova A.M., Osipov A.N. Suggested mechanism of specificity of interaction between nitrogen oxide and physiological targets. Bioradicals and antioxidants. 2017. 4(2): 36-40.

[8] Einafshar S., Poorazrang H., Farhoosh R., Seiedi S.M. Antioxidant activity of the essential oil and methanolic extract of cumin seed (Cuminumcyminum)// European Journal of Lipid Science and Technology. 2012. 114: 168-174.

[9] Niki E, Yoshida Y, Saito Y, Noguchi N. Lipid peroxidation: mechanisms, inhibition, and biological effects. BiochemBiophys Res Commun. 2005. 338: 668–676.

[10] Young A.J., Lowe G.M. Antioxidant and prooxidant properties of carotenoids. // Arch. Biochem. and Biophys. 2001. 385(1): 20-27.

[11] Zhang P., Omate S. β-carotene oxidation: effect of ascorbic acid and α-tocopherol. J.Toxicology. 2000. 146(1): 37-47.

[12] Poryvaeva, A.P., Donnik, I.M., Isaeva, A.G., Krivonogova, A.S., et al. Oxidative Stress Of Pigs Under The Conditions of Industrial Production. International Transaction Journal of Engineering, Management, & Applied Sciences & Technologies. 2019. 10(19), 10A19L: 1-7.

Dr.Poryvaeva Antonina Pavlovna holds a D.Sc. in Biological Sciences. She is interested in Virology, Immunology, Microbiology, Epidemiology, Epizootiology.

Dr.Donnik Irina Mikhailovna is an Academician of Russian Academy of Sciences. She holds a D.Sc. in Biological Sciences, professor. She is interested in Antibiotic resistance of Microorganisms, Infectious Diseases of Animals, Immunodeficiency State, Ecological and Biological Monitoring, Bovine Leukemia, Molecular Genetic Studies.

Dr.Isaeva Albina Gennadievna holds a D.Sc. in Biological Sciences, docent. She is interested in Immune Status, Biologically Active Additives, Productive, Ecology, Productive Animals.

Dr.Krivonogova Anna Sergeevna holds a D.Sc. in Biological Sciences, docent. She is interested in Molecular-Genetic Technologies, Agricultural Animals, Microbiology, Radiation Biology, Radiation Technologies, Biotechnologies, Foods, Food Safety, Animals And Human Health.

Professor Dr.Shkuratova Irina Alekseevna is a corresponding member of Russian Academy of Sciences. She holds a D.Sc. in Veterinary Sciences, Professor. She is interested in Ecology, Immunology, Productive Animals, Animals Health, Metabolic Process, Milk Yield And Milk Quality, Industrial Pollution, Quality Of Primary Products Of Animal Origin.

Musikhina Nina Borisovna is an Assistant of Department of Infectious and Non-communicable Diseases. Molecular-Genetic Technologies, Agricultural Animals, Microbiology, Radiation Biology, Radiation Technologies, Biotechnologies, Foods, Food Safety, Animals And Human Health.

Baranova Anna Aleksandrovna is a Candidate of Biological Sciences. She is interested in Biotechnologies, Genetic Variation, Food Safety, Agricultural Animals.

Professor Dr.Loretts Olga Gennadievna holds a D.Sc. in Biological Sciences. She is interested in Selection, Genotype, Milk Composition, Processing.

Dr.Petropavlovskiy Maxim Valerievich holds a Ph.D. in Veterinary. His research interests are Virology, Immunology, Microbiology, Molecular Biology, Virology, Epidemiology, Epizootiology, Bovine Leukaemia Virus, Syncytium Test, Polymerase Chain Reaction, Phylogenetic Analysis, DNA Sequencing.