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ASSESSMENT OF ANTIOXIDANT PROPERTIES OF GRAIN CONCENTRATE AND OXIDANT-ANTIOXIDANT STATUS PIGS AFTER ITS INCLUSION IN RATION FEEDING

Elena Kuznetsova, Elena Klimova, Dmitry Uchasov, Natalia Jarovan, Svetlana Motyleva, Jan Brindza, Natalia Berezina, Tatyana Bychkova, Vera Gavrilina, Gennadii Piyavchenko

ABSTRACT

A grain concentrate was developed for use in bread baking based on whole-ground fermented wheat grain, to enhance that the beneficial properties have fermented wholegrain buckwheat grains in an amount of 20% by weight of the fermented wheat. For the fermentation of grain used dry complex enzyme preparation comprising cellulose, β-glucanase and xylanase (producing Penicillin canescens), dissolved in a buffer based on succinic acid. Under the action of the drug, the micro structure surface of grain was changed. It is established that the character of the change in surface micro structure of wheat and buckwheat grain is the same. The results of the study of the content of vitamin E, flavonoids and antioxidant activity in wheat grains, buckwheat and grain concentrate are obtained by different technologies. The results show that grain concentrates from wheat grain with the addition of 20% buckwheat grains prepared using a solution of enzyme preparation of cellulolytic action in a buffer, based on succinic acid has a high antioxidant activity. As a biological model for studying changes oxidant-antioxidant status of the organism under stress when included in a diet designed grain concentrate, used pigs, that are under stress, caused by weaning them from sows and transportation. Investigated the following parameters oxidant-antioxidant status of the organism pigs: the level of malondialdehyde, ceruloplasmin, vitamins A, E and C in the blood of animals. It is concluded that, to improve the oxidative status of the piglets after weaning period recommended addition of concentrate fodder ration of grain wheat and buckwheat prepared using a solution of an enzyme preparation buffered cellulolytic action on the basis of succinic acid. The developed grain concentrate can be used for making the manufacture of cereal products, including grain bread included in the diet of people who live in conditions of oxidative stress.

Keywords: fermented grain; wheat; buckwheat; cereal concentrate; antioxidant activity; piglets, stress; oxidant-antioxidant status

INTRODUCTION

Studies show that whole grains of cereals can protect from obesity, diabetes, cardiovascular diseases and cancer. Nutritionists recommend cereal products to provide a diet, with food fibers, proteins, vitamins and minerals, located mainly in the shells of grain **(Buddrick et al., 2014; Vitaglione et al., 2008)**. Phenolic acids are widely distributed in grains and are present in high concentrations in whole grains. Ferulic acid is the main, and the most abundant phenolic acid is in wheat grains. Lesser concentrations of caffeine, p-coumaric, synapic acid, and other phenolic acids are also observed in wheat **(Verma et al., 2009)**. They are considered one of the important compound groups that are responsible for health **(Slavin et al., 2000; Truswell, 2002)**.

Buckwheat has a high level of antioxidant activity due to the content of flavonoid compounds in it **(Holasova et al., 2002)**. Over the past of few decades, the following flavonoid compounds have been identified in the buckwheat grains: rutin, quercetin and flavone C-glycosides (which include orientin, vitexin and isovitinexin) **(Zielińska et al., 2012)**.

It was found that in the wheat bread with buckwheat flour the total antioxidant activity increased with the increase in the percentage of buckwheat flour, and the level of routine in such bread ranged from 7.76 to 26.90 $mg.kg^{-1}$ **(Lin et al., 2009; Bojňanská et al., 2009; Brindzová et al., 2009)**.

Succinic acid is used as a growth stimulator of organisms and an antimicrobial agent for the prevention of bacterial pathogens, **(Ng et al., 2015; Kumar et al., 2015)**. It can

inhibit necrosis and apoptosis **(Tang et al., 2013)**, has anticonvulsant and antiepileptic action **(Cong et al., 2009)**, inhibits the skin allergic reaction and reduces the formation of serum antibodies IgE **(Ke et al., 1983)**. Oral administration of succinic acid to experimental animals after resuscitation helped normalize the formation of free radicals in the brain and serum **(Gurvitch et al., 1997)**. The introduction of succinic acid into the diet of mice exposed to hyperbaric oxygen, led to an increase in the level of γ-aminobutyric acid in the brain and the activity of the enzyme catalyzing his synthesis **(Schatz and Lal, 1980)**. Treatment with a complex preparation containing pantogs, succinic acid and chitosan normalizes the concentration of reduced glutathione and the activity of glutathione peroxidase, glutathione reductase in animals with experimental hypoxia/reperfusion of the brain. These results are explained by the suppression of free radical oxidation and the normalization of the antioxidant system associated with the neuroprotective, antihypoxic and antioxidant properties of these substances, their involvement in the regulation of cellular metabolism in pathological conditions accompanied by oxidative stress **(Safonova et al., 2015)**. Derivatives of succinic acid showed promising antifungal and antibacterial activity against various test microorganisms and possess antioxidant activity **(Raghavendra et al., 2017)**. The introduction of succinic acid derivatives in combination with plant polyphenols showed cytoprotective properties in rats exposed to histotoxic hypoxia, compared with the use of only a group of polyphenols plant **(Zadnipryany et al., 2016)**.

Thus, it is known that grains of buckwheat and wheat contain a complex of biologically active compounds, and succinic acid has an antioxidant effect. But in the literature, there is no information on how these components in combination, affect on the antioxidant activity of the grain product and the antioxidant status of the experimental animals.

Scientific hypothesis

The use of the wheat grain and buckwheat fermentation process in the presence of succinic acid for the production of grain concentrate has a significant effect on the modification of the antioxidant activity of the concentrate and on the oxidant-antioxidant status of the organism of experimental animals (pigs) under stress.

MATERIAL AND METHODOLOGY

The concentrate cereal was developed for use in bakery on the basis of whole grains fermented variety of winter wheat Moscow139. In the concentrate, to increase useful properties, fermented buckwheat grains in the open ground of the Bashkir variety of red wines were added at a rate of 20% of the weight of the fermented wheat grain. For the study was taking grain of wheat and buckwheat harvest in 2017 grown in the Orel region of the Russian Federation. A dry complex enzymatic preparation was used to ferment the grain, including cellulase, β-glucanase and xylanase (producer of *Penicillium canescens*). The enzymes have the following activities: cellulase-58 711 nkat.g^{-1}, xylanase-12 135 nkat.g^{-1}, β-glucanase-51 317 nkat.g^{-1}, provided by the Physico-Chemical Polymer Transformation Laboratory of the Faculty of Chemistry in Moscow university M.V. Lomonosov **(Sinitsyna et al., 2003)**. Fermentation of grain of wheat and buckwheat was carried out separately. Succinic acid was added as part of the buffer solution. The enzymatic preparation in powder form is mixed with a magnetic stirrer with a succinic acid buffer (pH 4.6) for 0.5 hours at a concentration of 0.6 g.L^{-1} for wheat grains and 0.4 g.L^{-1} for buckwheat kernels, then the grain was placed in the solution. As a reference sample, a solution of the enzymatic preparation in water was used. Whole grains of wheat and buckwheat were stored in a solution of the enzyme preparation in a grain ratio of 1:1.5 for 8 hours at 50° C in a thermostat. The hydrolysis regimes (t = 50° C, pH 4.6) are optimal for the action of their enzymes. After incubation, enzymatic inactivation was not performed. After the enzymatic hydrolysis time, the grain was washed with running water at t = 18 – 20 °C for 5 – 10 minutes. The wheat and buckwheat grain thus fermented were subjected to drying at a temperature not exceeding 50 – 60° C to a moisture content of at most 11 – 14% and then grinding to a size of particles not exceeding 0.08 mm. The vitamin content was determined by HPLC on a Milichrome-5 instrument (ZAO Nauchpribor, Russia). Analytical chromatographic column separon-SGX-C18 with the internal diameter of 2 mm, length of 70 mm for reversed-phase HPLC and software UniChrom (ZAO Nauchpribor, Russia). An aqueous extract of buckwheat grain (pH 3) was used: the eluent of the composition - acetonitrile: aqueous solution of sodium heptanesulfonate and monosubstituted potassium phosphate (pH 3.0, ratio 20/80), flow rate mobile phase 1 cm^3.min^{-1}; the elution mode is isocratic, the detection was carried out in the 200 - 400 nm wavelength range, the analysis time 12 – 25 min, the sample volume 2 – 6 μL. Microstructural studies were performed using a ZEISS EVO LS scanning electron microscope (Carl Zeiss Industrial Messerechnik GmbH, Germany). The investigation was conducted at an accelerated voltage of 15 kV. The complex of phenolic compounds was determined by HPLC on a Milichrome-5 instrument (ZAO Nauchpribor, Russia). An alcoholic extract of buckwheat grains was used, the eluent of the composition was acetonitrile: an aqueous solution of trifluoroacetic acid (pH 2.5, in the ratio 15/85); the mode of elution is isocratic, the analysis time is 12 to 25 minutes, the volume of the sample is 2 to 6 μL. Antioxidant activity was determined by the spectrophotometric method in an alcohol extract described by **Silva et al. 2005** based on percent inhibition of the DPPH (2,2-diphenyl-1-picrylhydrazyl) radical. We have been determined by the optical density of the solutions in the interaction, Specord M40 (Carl Zeiss Industriel Messtechnik GmbH, Germany) at a wavelength of 515 nm. All chemical reagents were used by Merk (Germany).

To study the effect of grain concentrates on the oxidant-antioxidant status of the animal body, an experiment was conducted on piglets under stress due to weaning of sows and transport. Pigs immediately after weaning 28-day-old sows were transported by motorized transport from the breeding farm to the cropping site (a distance of approximately 220 km). The loading time of the animals in the car before placement was 6 hours. On the day of arrival, four groups of 25 piglets each were formed from newly arrived pigs on the basis of analogues. Piglets in the control group received a ration in the form of mixed feed,

of which the evening portion for 14 days after weaning and transport was partially replaced (by 20% by weight) with native wheat flour. In the ration of the animals in the first test group, during the 14 days after weaning and transport, the evening portion of the compound feed was replaced by 20% by weight of a grain concentrate containing only wheat grain. wheat fermented with a succinic acid buffer. Piglets 2nd experimental group received a ration within 14 days of weaning and transport, the evening portion of mixed feed being replaced by 20% fermented wheat grain, the transformed enzyme preparation being dissolved in water. Succinic acid was not administered to the piglets of the 2nd test group. Animals third test group within 14 days after weaning and transport regime established in which the portion of a load portion at 20% by weight was replaced by concentrate of cereals prepared according to the developed wheat technology fermented and buckwheat using a succinic acid buffer to dissolve the enzyme preparation. Grain concentrate test samples were mixed with the mixed feed just before feeding the animals. The dose of succinic acid introduced with the feed corresponded to the recommended daily standard for piglets and was 30 $mg.kg^{-1}$ body weight.

Blood samples for laboratory tests were taken from five animals in each group prior to the experimental feed grain concentrate samples (weaning and transport days), and on day 3 and day 15 of the experiment. As indicators of the antioxidant status of pigs in the blood serum of their blood, the secondary product content of lipid peroxidation - malonic dialdehyde - was determined by reaction with thiobarbituric acid **(Korobeynikova, 1989)**, the level of antioxidant ceruloplasmin - express method according to E.V. Tan **(Ravin, 1961)**.

To evaluate the reliability of the test differences, t-statistics (a two-sample t-test for independent samples) were used. The tests were conducted at a level of significance p <0.05 using the Statistica 7.0 software (StatSoft Inc., USA). To confirm the linear relationship between the quantitative indicators, the Pearson correlation criterion (coefficient) was used, the paired linear regression method.

Statisic analysis

The results were evaluated statistically using the Analysis of Variance. Procedure compares the data in six varieties. The results assays were expressed as mean ±SD of eight repeated samples. To evaluate the reliability of the test differences, t-statistics (a two-sample t-test for independent samples) were used. The p -value used to test the null hypothesis in order to quantify the idea of statistical significance have to be provided. The tests were conducted at a level of significance p <0.05 using the Statistica 7.0 software (StatSoft Inc., USA). To confirm the linear relationship between the quantitative indicators, the Pearson correlation criterion (coefficient) was used, the paired linear regression method.

RESULTS AND DISCUSSION

Bioactive compounds in grain of wheat and buckwheat are mainly found in shells and bran. The peripheral parts of the grain have higher antioxidant activity, polyphenols, phytic acid, vitamins and minerals are concentrated here **(Vitaglione et al., 2008; Li et al., 2013; Higuchi, 2014)**. The largest proportion (80%) of thiamine is found in the outer layers of wheat **(Batifoulier et al., 2006)**. To modify the shell structure of wheat and buckwheat fruits and seeds in order to increase the yield of biologically active substances and to facilitate grain milling, a complex cellulase-based enzymatic preparation was used. Figure 1 shows microphotographs of the surface of the peripheral parts of the wheat grain in a cross-section. The photos were taken with a scanning electron microscope with an increase of 4000x. Figure 2 – microphotographs of the surface of the peripheral parts of the buckwheat kernels (increase of 800x). Under the action of cellulase - based biocatalysts in the fruit shells of the grain, longitudinal breaks are formed, bare strands of polysaccharides are found at the ends of the fibers – fibrillation. The fibers are folded, the outer layers of the adjacent microfibrils fibers are destroyed. The nature of the modification of the microstructure of the surface of fruit shells in wheat and buckwheat is identical.

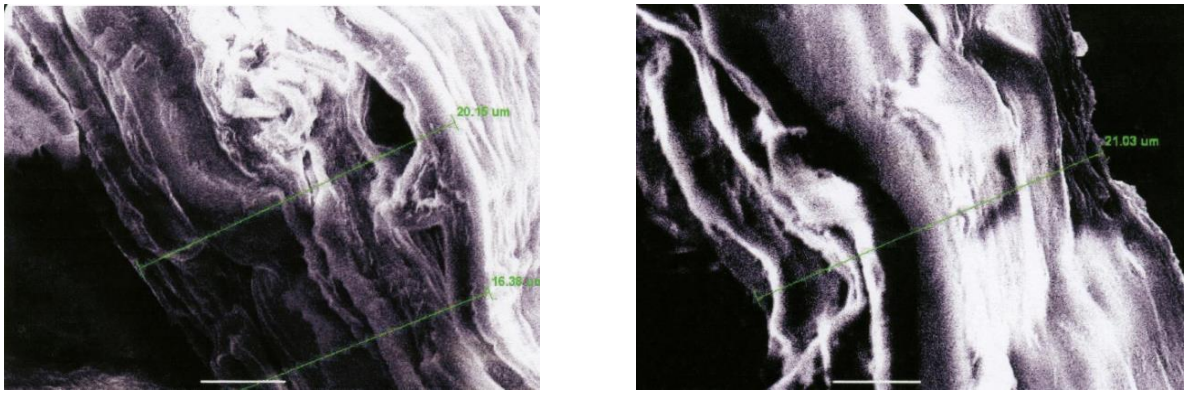

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Figure 1 Microphotographs of the superficial structure of the peripheral parts of buckwheat grains on a cross – section. Note: 1 - control without enzymes; 2 - complex enzyme preparation. Microscope: ZEISS EVO LS, Software: SmartSEM 5.06, magnification 4000x (Photo: S. Motyleva, 2017).

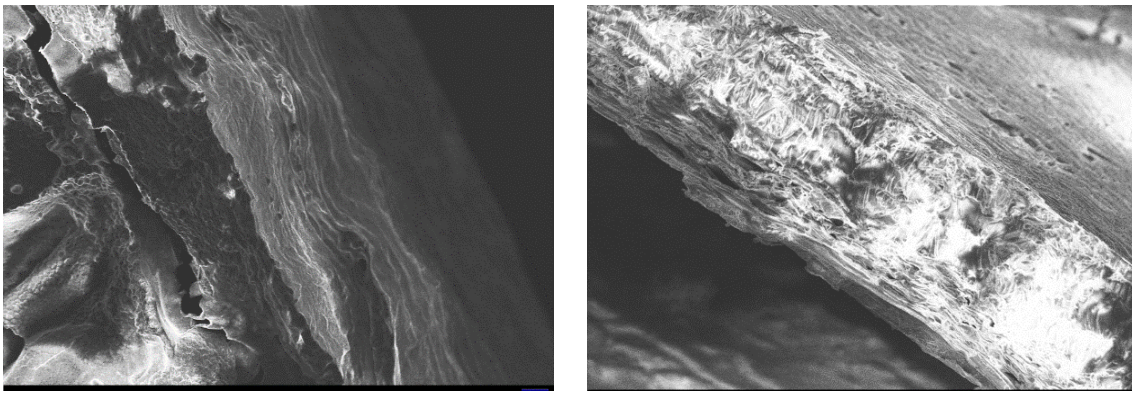

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Figure 2 Microphotographs of the structure of the surface of peripheral parts of buckwheat grains on a transverse section. Note: 1 - control without enzymes, 2 - complex enzyme preparation, magnification). Microscope: ZEISS EVO LS, Software: SmartSEM 5.06, magnification 800x (Photo: S. Motyleva, 2017).

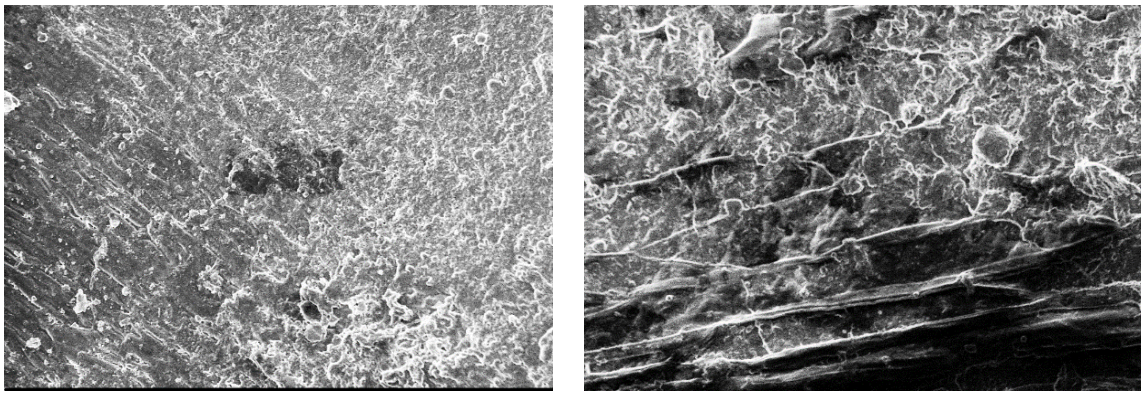

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Figure 3 Microphotographs of the surface structure of buckwheat grains. Note: 1 - control without enzymes, 2 - complex enzyme preparation. Microscope: ZEISS EVO LS, Software: SmartSEM 5.06, magnification 800x (Photo: S. Motyleva, 2017).

Table 1 - The content of vitamins, flavonoids in wheat grains, buckwheat and grain concentrate and their antioxidant activity (AOA).

Option of experience	**The content of biologically active substances (t/P) ***		**AOA, % inhibition of DPPH**
	Vitamin E, mg.100g^{-1}	**Mass fraction of flavonoids, %**	
Wheat grain	3.62 ±0.12	0.16 ±0.01	16.2 ±0.5
Wheat grain fermented	4.23 ±0.14 (3.31/0.05)	0.20 ±0.01 (2.83/0.05)	28.4 ±1.1 (10.01/0.001)
Buckwheat Grain	0.82 ±0.02	0.33 ±0.02	25.5 ±1.0
Buckwheat grains are fermented	0.91 ±0.01 (4.02/0.02)	0.45 ±0.01 (3.81/0.05)	40.8 ±1.3 (9.33/0.001)
Grain concentrate without succinic acid (the enzyme preparation was dissolved in water)	3.78 ±0.14	0.21 ±0.02	30.5 ±0.9
Grain concentrate with succinic acid (the enzyme preparation was dissolved in buffer based on succinic acid)	4.35 ±0.11 (3.20/0.05)	0.28 ±0.02 (3.13/0.05)	38.1 ±1.6 (4.14/0.02)

Note: * (t - Student's test, P - significance level).

In the works **(Kuznetsova et al., 2016)**, a change in the surface microstructure of cereal grains of wheat, rye and triticale under the action of complex enzymatic preparations based on cellulases is presented. The native grain surface has a characteristic first-order relief, showing parallel strands of cellulose fibrils of various thicknesses and tortuosities, coated with epidermal derivatives of polysaccharide matrix components.

Under the influence of a solution of cellulase-based biocatalysts, the surface relief of the grain has been modified, expressed in the form of bundles of long and virtually intact fibers, and interfibrillary cross-links constructed from hemicellulose molecules disintegrated. A similar picture can be seen on the micrographs of the surface of buckwheat grains (Figure 3).

The microphotographs show that the non-starch polymers of the grain blankets are destructuring, which can lead to the release of bound forms of biologically active compounds, for example flavonoids, and increase the antioxidant activity of the cereal product.

There was a statistically significant a relation between total flavonoid content, vitamin E, and antioxidant activity in the plant material studied. These data are consistent with the data **(Jiang et al., 2007)**. **Holasova et al. (2002)** found no correlation between tocopherol content and antioxidant activity. Differences in the results of different authors' experiments may be due to the difference between the objects used and the methods of analysis.

The results obtained show that the grain concentrate prepared using a solution of the cellulolytic enzymatic preparation in succinic acid buffer has a high antioxidant activity. This is due to the presence of succinic acid in the grain concentrate. In addition, it is known that flavonoids are located in associated forms in the cell walls of the seed, and their extraction requires alkaline, acidic or enzymatic treatment **(Hung and Morita, 2008; Ragaee et al., 2011)**. Most of the grain's antioxidants is linked by ester bonds to cell wall components by arabinoxylans **(Liyana-Pathirana and Shadidi, 2006)**. The increase in flavonoid and vitamin E content in wheat and buckwheat grains after fermentation was due to the decomposition of the complexes of these compounds with the cell wall polysaccharides after their modification, and also to the awakening of the embryo. The germination process is accelerated in the presence of succinic acid and cellulase biocatalysts. Under the conditions of germination in the grain, enzymatic systems are activated, the biologically active compounds are synthesized, including vitamin E, responsible for the antioxidant properties of biological systems. The combined use of grain in cellulolytic enzyme preparation stage preparation technology and succinic acid leads to an intensification of enzymatic hydrolysis of non-starch polysaccharides of the cell wall, and increased pore sizes in the cells. membranes mezhfibrillyarnyh intervals, the intensive penetration of the solvent in the caryopsis and acceleration of the synthesis of substances with antioxidant properties. The use of enzyme preparations in a succinic acid buffer solution increased the vitamin E content from 10.9 to 16.9%, 25.0 – 36.3% of the flavonoids, and AOA of 24.91 – 75.3% in the wheat concentrate. Differences in values of reliability values $p \leq 0.05$ in all investigated indicators. The value of the Pearson correlation coefficient was 0.8871 for antioxidant activity, 0.9992 for vitamin E content and 0.9996 for flavonoid content in grain raw material before and after enzymatic treatment. Using the Cheddock table, it can be concluded that it is advisable to use the cellulase enzyme preparation in a succinic acid buffer solution to pretreat the wheat and buckwheat kernels in order to increase their antioxidant activity.

Bojňanská et al. (2009) conducted clinical studies on a group of volunteers who consumed wheat bread enriched with 30% buckwheat for 4 weeks. The total antioxidant status of the participants in the experiment was found to increase significantly from 1.135 to 1.46 $mmol.dm^{-3}$. The porcine organism is similar to the human organism in many morphophysiological indices and these animals are therefore often used as a biological model to study the physiology of stress, obesity, cardiovascular disease and others **(Gorelov et al., 2002; Kapanadze, 2006)**. The elimination of piglets from sows and transporters is an important stressor that causes stress in young pigs. The development of a state of stress in animals is accompanied by an activation of lipid peroxidation processes, which is manifested by an increase in the content of these biochemical reactions, including malonic dialdehyde, in their blood **(Zhu et al., 2012)**. The imbalance between oxidative and antioxidant systems in pigs is also a concentrate of vitamins A, E, C in the blood **(Buchet et al., 2017**). Indicators of the antioxidant-oxidant status of the piglet organism, which received grain concentrate from fermented wheat and buckwheat as part of the diet, are presented in Table 2.

The results showed that the level of malonic dialdehyde increases on the third day after weaning and piglet transport, while the number of chemical compounds responsible for maintaining the antioxidant state - ceruloplasmin, vitamins A, E and C – is significantly reduced in the blood of animals. These data indicate a reduced ability of the body to generate reactive oxygen species. Similar results were obtained by **Yin et al. (2014); Buchet et al. (2017)**, who note that imbalance can be restored when the antioxidant system develops. The diet of the developed grain concentrates had a positive effect on the oxidant-antioxidant state of the body stressed animals manifest a decrease in the serum of the oxidative stress index in the blood – malondialdehyde levels and the increase antioxidants – ceruloplasmin, vitamins A, E and C, compared to the control. The best results were obtained with the use of the grain concentrate, the technology of which used an enzymatic preparation of the cellulolytic action, dissolved in a succinic acid buffer. Thus, on the fifteenth day from the beginning of the experiment, the level of malonic dialdehyde in piglets 1, 2 and PEP was lower than that of the control at 22.4; 7.1 and 27.7%. Depending on the blood serum content of ceruloplasmin, the animals of the 1^{st}, 2^{nd} and 3^{rd} more detailed studies on analogues of the control group were evaluated at 11.7; 7.6 and 15.2%, in vitamin A content - 23.5; 11.8 and 33.3%, vitamin E - 5.5; 4.8 and 7.6%, vitamin C - 10.8; 4.3 and 12.9% of the total body weight. The differences in oxidant-antioxidant status values of the piglets obtained are significant, $p \leq 0.05$ in all the indicators studied. These results coincide with the findings that to improve the oxidative status of pigs after weaning, it is recommended that vitamin E be added to the diet **(Rey et al., 2017)**.

Table 2 - Indicators of Oxidative-Antioxidant Status of Piglets Included in their Diet of Fermented Wheat Bean Concentrate and Buckwheat Grain

Indicators	Groups piglets	Indicators of oxidant-antioxidant status (t/P) *		
		research dates		
		on the day of weaning and transport	after weaning and transportation	
			on the 3rd day	on the 15th day
Malondialdehyde μmoL.L^{-1}	control	0.52 ±0.002	0.98 ±0.007	0.60 ±0.003
	1st experience	0.54 ±0.003 (5.54/0.01)	0.95 ±0.005 (3.49/0.05)	0.49 ±0.029 (3.77/0.05)
	2nd experience	0.53 ±0.001 (4.4/0.02)	0.96 ±0.001 (2.83/0.05)	0.56 ±0.009 (4.21/0.02)
	3rd experience	0.53 ±0.002 (3.54/0,05)	0.94 ±0,005 (4.65/0.02)	0.47 ±0.022 (5.85/0.01)
Ceruloplasmin, μmoL.L^{-1}	control	2.27 ±0.005	1.56 ±0.006	1.71 ±0.023
	1st experience	2.25 ±0.004 (3.12/0.05)	1.58 ±0.002 (3.16/0.05)	1.91 ±0.045 (3.96/0.02)
	2nd experience	2.26 ±0.001 (3.2/0.05)	1.58 ±0.001 (3.29/0.05)	1.84 ±0.017 (4.55/0.02)
	3rd experience	2.25 ±0.002 (3.71/0.05)	1.59 ±0.004 (4.16/0.02)	1.97 ±0.051 (4.65/0.02)
Vitamin A, μmoL.L^{-1}	control	0,67 ±0,007	0.42 ±0.004	0.51 ±0.02
	1st experience	0.65 ±0.005 (3.25/0.005)	0.44 ±0.004 (3.54/0.005)	0.63 ±0.03 (3.32/0.05)
	2nd experience	0.64 ±0.006 (3.32/0.05)	0.44 ±0.005 (3.12/0.05)	0.59 ±0.01 (3.58/0.05)
	3rd experience	0.65 ±0.001 (2.82/0.05)	0.45 ±0.006 (4.16/0.02)	0.68 ±0.03 (4.71/0.02)
Vitamin E, μmoL.L^{-1}	control	8.14 ±0.009	6.32 ± 0.005	6.93 ±0.10
	1st experience	8.09 ±0.003 (5.27/0.01)	6.37 ±0.002 (9.28/0.001)	7.31 ±0.06 (3.26/0.05)
	2nd experience	8.06 ±0.007 (7.01/0.01)	6.35 ±0.013 (5.14/0.01)	7.26 ±0.02 (3.24/0.05)
	3rd experience	8.11 ±0.002 (3.25/0.05)	6.40 ±0.016 (4.77/0.02)	7.46 ±0.09 (3.99/0.02)
Vitamin C, μmoL.L^{-1}	control	19.53 ±0.026	14.65 ±0.04	16.48 ±0.15
	1st experience	19.38 ±0.012 (5.24/0.01)	14.81 ±0.03 (3.2/0.05)	18.26 ±0.48 (3.54/0.05)
	2nd experience	19.34 ±0.019 (5.9/0.01)	14.78 ±0.01 (3.15/0.05)	17.19 ±0.13 (3.58/0.05)
	3rd experience	19.40 ±0.017 (4.18/0.02)	14.87 ±0.05 (3.44/0.05)	18.61 ±0.27 (6.9/0.01)

It has also been established that the addition of a mixture of plant polyphenols improves the antioxidant status of piglets after weaning and helps counteract some negative effects **(Jiang et al., 2014)**. Thus, experimental data show that the antioxidant activity of the grain concentrate increases after grain fermentation and that the feeding of the grain concentrates to piglets after weaning and transport results in an improvement of their oxidant-antioxidant status.

CONCLUSION

Thus, it was experimentally established, that the use of the process of fermentation of grain of wheat and buckwheat under the action of a complex enzyme preparation of celluloses ,dissolved in a buffer based on succinic acid, leads to a change in the microstructure of the grain surface.

Microphotographs show that the destructuring of non-starch polymers of grain covers is observed, which can lead to the release of bound forms of biologically active compounds, for example, flavonoids, and to increase the antioxidant activity of the grain product. It is established that the nature of the change in the microstructure of the surface of wheat and buckwheat grains is identical. There was a statistically significant relationship between the total content of flavonoids, vitamin E, and antioxidant activity in the plant material under study. The use of enzyme preparations in a solution of the buffer based on succinic acid allowed to increase the content of vitamin E by 10.9 – 16.9%, flavonoids by 25.0 – 36.3%, and AOA by 24.91 – 75.3% in processed wheat, buckwheat and grain concentrate. The statistical treatment of the results shows the expediency of using an enzyme preparation of cellulases in a buffer solution based on succinic acid for pretreating wheat and buckwheat grains to increase their antioxidant activity. To study the change in the oxidant-antioxidant status of an organism in a stressful state, when pigs were developed in the developed grain concentrate,

they were used in conditions of stress caused by their weaning from sows and transportation. The parameters of the oxidant-antioxidant status of the body of piglets were studied: the level of malonic dialdehyde, ceruloplasmin, vitamins A, E and C in the blood of animals. The results show that on the third day after weaning and transporting the pigs, the level of malonic dialdehyde is multiplied by 1.8, while the number of chemical compounds responsible for maintaining the antioxidant state – ceruloplasmin, vitamins A, E and C - is greatly reduced. (68 to 76%) in the blood of animals. These data indicate a reduced ability of piglets to bind to active forms of oxygen. On the 15th day after the start of the experiment, the level of malonic dialdehyde in the piglets was lower than that of the control. Depending on the blood content of ceruloplasmin blood and the animal vitamins studied, the experimental groups were higher than those in the control group. Thus, the addition of wheat grain concentrates, and buckwheat concentrates in the diet, prepared with a cellulase enzyme preparation solution in a succinic acid-based buffer, significantly influences the oxidative-antioxidant status of the diet. The organism of experimental animals (piglets) was subjected to stress.

The developed grain concentrate can be used to make grain products, including cereal bread, included in the diets of people living in oxidative stress.

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Contact address:

prof. Elena A. Kuznetsova, DrSc., Orel State University named ufter I.S. Turgenev, Institute of Natural Sciences and Biotechnology, Department of Industrial Chemistry and Biotechnology, 302026, Orel, Komsomolskaya street, 95, Russian Federation, E-mail: elkuznetcova@yandex.ru

doc. Ing. Elena V. Klimova, PhD, Orel State University named ufter I.S. Turgenev, Institute of Natural Sciences and Biotechnology, Department of Industrial Chemistry and Biotechnology, 302026, Orel, Komsomolskaya street, 95, Russian Federation, E-mail: kl.e.v@yandex.ru

prof. Dmitry S. Uchasov, DrSc., Orel State University named after I.S. Turgenev, Department of Theory and Methodology of the Chosen Sport 302026, Orel, Komsomolskaya street, 95, Russian Federation, E-mail: oks-frolova610@yandex.ru

prof. Natalia I. Yarovan, DrSc., Orel State Agricultural University named after N. In. Parakhin, Department of Natural Sciences and Humanities 302019, Orel, General Rodina str., 69, Russian Federation, E-mail: chemistry1@orelsau.ru

doc. Ing. Svetlana Motyleva, Laboratory of Physiology and Biochemistry and Biotechnology of Functional Products of Federal center of vegetable production, 115598, Moskow, Zagorievskay street, 4, Russian Federation, E-mail: motyleva_svetlana@mail.ru

Assoc. Prof. Ján Brindza PhD. Slovak University of Agriculture in Nitra, Faculty of agrobiology and food resources, Institute of biological conservation and biosafety. Trieda Andreja Hlinku 2, 949 76 Nitra, Slovakia, E-mail: Jan.Brindza@uniag.sk

doc. Ing. Natalia A. Berezina, PhD, Orel State University named ufter I.S. Turgenev, Department of Food Technology and Organization of Restaurant Business, 302026, Orel, Komsomolskaya street, 95, Russian Federation, E-mail: jrdan@yandex.ru

doc. Ing. Tatyana S. Bychkova, PhD, Orel State University named I.S. Turgeneva, Institute of Natural Sciences and Biotechnology, Department of Food Technology and Organization of Restaurant Business, 302026, Orel, Komsomolskaya street, 95, Russian Federation, E-mail: ya2810@mail.ru

prof. Vera A. Gavrilina, DrSc, Orel State University named after I.S. Turgenev, Institute of Natural Sciences and Biotechnology, Department of Industrial Chemistry and Biotechnology, 302026, Orel, Komsomolskaya street, 95, Russian Federation, E-mail: vega180267@mail.ru

Assistant Gennadii A. Piyavchenko, Orel State University named after I.S. Turgenev, Medical Institute, Department of Histology, Cytology and Embryology, 302026, Orel, Komsomolskaya street, 95, Russian Federation, E-mail: gennadii.piavchenko@yandex.ru