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БЕЛКОВО-ВИТАМИННАЯ МУКА ИЗ ПШЕНИЧНЫХ ОТРУБЕЙ, ОБОГАЩЕННАЯ ФИТАЗОЙ В РАЦИОНЕ ПЕРЕПЕЛОВ

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Представлены результаты эксперимента по использованию в рационе выращиваемых перепелов фракционированной белково-витаминной муки из пшеничных отрубей (в чистом виде и в смеси с ферментным препаратом, выпускаемым под торговой маркой Фитбест) с размером частиц 140 мкм. Опыт продолжительностью 60 дней проведен по общепринятой методике на перепелах японской породы. Для эксперимента три аналогичные группы по 80 гол. (одна контрольная и две опытные) сформированы в суточном возрасте птиц. Все группы получали основной рацион, приготовленный с учетом возраста и физиологических особенностей перепелов. В рационе молодняка 1-й и 2-й опытных групп часть пшеницы (7%) комбикорма заменили пшеничной белково-витаминной мукой (размер частиц 140 мкм). При этом перепелам 2-й опытной группы скармливали белково-витаминную муку с ферментным препаратом Фитбест Р5000 GT, предназначенным для повышения биодоступности фосфора, минеральных элементов и аминокислот из компонентов кормов для сельскохозяйственной птицы и свиней. Птицу содержали в клеточной батарее при соблюдении требуемых условий микроклимата. Изучено влияние скармливания экспериментальных добавок на сохранность поголовья цыплят, интенсивность их роста, мясную продуктивность, химический и аминокислотный состав мяса (фарша), гематологические показатели. Введение в комбикорм перепелов белково-витаминной муки из пшеничных отрубей в чистом виде и с ферментным препаратом Фидбест Р5000 GT повысило сохранность птицы на 3,01%, среднесуточный прирост живой массы на 3,09 и 3,44% при практически равных затратах кормов на единицу продукции. В мясе птицы, потреблявшей в составе комбикорма муку из пшеничных отрубей с препаратом, содержащим фитазу, содержание жира, кальция и фосфора увеличилось соответственно в 1,17; 1,13 и 1,17 раза. Концентрация кальция и фосфора в мясе перепелов, получавших муку без ферментного препарата, была ниже, чем у аналогов, потреблявших муку с фитазой в 1,2 и 1,1 раза. Биохимические показатели крови всех подопытных цыплят оставались в пределах физиологической нормы.

Ключевые слова: перепела, комбикорм, белково-витаминная мука, ферментный препарат, сохранность, живая масса

PROTEIN-VITAMIN FLOUR FROM WHEAT BRAN ENRICHED WITH PHYTASE IN THE DIET OF QUAILS

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The results of the experiment on the use of fractionated protein-vitamin wheat bran flour (pure and mixed with enzyme preparation produced under Feedbest® trade mark) with particle size 140 microns in the ration of growing quails are presented. The experiment lasting 60 days was conducted according to the generally accepted methodology on quails of the Japanese breed. For the experiment, three similar groups of 80 birds each (one control and two experimental) were formed at one day of age. All groups received a basic diet prepared taking into account the age and physiological characteristics of quails. In the diet of young animals of the 1st and 2nd experimental groups a part of wheat (7%) mixed fodder was replaced by wheat protein-vitamin flour (particle size 140 microns). The quails of the 2nd experimental group were fed protein-vitamin meal with the enzyme preparation Feedbest® P5000 GT designed to increase the bioavailability of phosphorus, mineral elements and amino acids from components of feed for poultry and pigs. The birds were kept in a cage battery under the required microclimate conditions. The effect of feeding experimental additives on the safety of chickens, the intensity of their growth, meat productivity, chemical and amino acid composition of meat (minced meat), hematological parameters was studied. Introduction of protein-vitamin wheat bran meal pure and enzyme preparation Feedbest® P5000 GT into quail mixed fodder increased bird survival by 3.01%, average daily gain of live weight by 3.09 and 3.44% with almost equal feed expenses per unit production. The fat, calcium and phosphorus content in the meat of poultry fed with wheat bran flour containing phytase increased by 1.17, 1.13 and 1.17 times, respectively. The concentration of calcium and phosphorus in the meat of quail that received flour without enzyme preparation was 1.2 and 1.1 times lower than that of their counterparts that consumed flour with phytase. Biochemical blood parameters of all the experimental chickens remained within the physiological norm.

Keywords: quail, compound feed, protein-vitamin flour, enzyme preparation, livability, live weight

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Conflict of interest
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INTRODUCTION

Optimization of poultry feeding presupposes a balance of diets in terms of essential nutrients [1]. Consequently, developments aimed at improving the efficiency of grain raw materials in mixed fodders are of particular importance. During variety milling of wheat and rye grains the shells, aleurone layer and germ, morphological parts containing biologically valuable components are separated from the kernel [1,2] [2-4]. In the Siberian branch of the Federal Scientific Center of Food Systems named after M.M. Gorbatov of the Russian Academy of Sciences works are carried out to substantiate the possibility of producing biologically active forage high-protein and protein-vitamin additives from the products of flour-milling production (bran). The fractions obtained by milling bran and separating them on sieves differ in their biochemical composition. High-protein flour is a very fine fraction (50-60 microns) of milling. The fine fraction (140 μm) contains more protein and vitamins, but less crude fiber compared to the coarse fraction (400-800 μm). The amino acid composition of the protein of the obtained fractions significantly differs from the composition of wheat endosperm proteins and is characterized by a more balanced amino acid composition [5]. The content of dietary fiber in wheat bran can reach more than 50%. They are represented mainly by non-starch polysaccharides: arabinoxylans, β-glucans, fructans, cellulose [6]. In our previous studies, it was found that the use in the diet of laying quail of fractionated wheat bran flour with a particle size of 140 microns instead of 7% wheat feed is the most effective [7]. This fine fraction of flour contains more protein and almost 2 times less crude fiber than the large fractions (400-800 microns), because it is enriched with elements of the aleurone layer and germ, the concentration of protein in which reaches 35%, and cellulose and lignin are practically absent. The aleurone layer is also characterized by a higher content of soluble fibers compared to the outer shells of the grain [8]. The predominance of elements of the aleurone layer and germ in the fine fraction of the flour is explained by their more fragile structure compared to the outer shells of the grain; they are easier to dry grind and form a fine powder. The main form of phosphate storage in grains, legumes and nuts is phytic acid. Up to 80% of all phosphorus in seeds can be complexed with this natural compound. Almost 90% of phytic acid in cereals is localized in the aleurone layer, some amount (10%) is in the seed bud [9]. Phytic acid is considered an antialimentary factor because of its ability to firmly bind iron, calcium, zinc and magnesium ions to form phytate-mineral complexes whose solubility and digestibility are reduced. In wheat bran, the concentration of phytic acid is 3116-5839 mg/100 g [10]. During grain germination, phytic acid is decomposed by endogenous phytases, resulting in increased bioavailability of phosphorus and 2-valent ions. The addition of preparations containing phytase to bran should contribute to the enzymatic degradation of phytate and, as a consequence, increase the bioavailability of minerals. Therefore, studies on the effect of phytase introduced into the feed additive of fractionated protein-vitamin flour of wheat bran on the productivity and physiological condition of poultry are relevant.

The aim of the research was to evaluate the efficiency of using the protein-vitamin fraction of wheat bran (grinding degree 140 microns) enriched with a new generation enzyme preparation Fitbest® P5000 GT in diets of quails grown up to 60 days of age.

The research objectives are to determine the effect of the studied feed additive on the safety and growth rate of quail chickens, their meat productivity, chemical and amino acid composition of meat, and biochemical blood parameters.

[1]Sivilgaev A.V., Skryabin V.A., Reimer V.A. Production and application of activated high-protein additives from grain raw materials. Proceedings of the II International Conference "Food, Ecology, Quality". Krasnoobsk, 2002. P. 216.

[2]Machikhin L.I., Skryabin V.A. Production of protein-vitamin products from secondary grain raw materials. Food. Ecology. Quality. Proceedings of the V International Scientific and Practical Conference / RASKhN. Siberian Branch. SSI SibNIPTIP. Novosibirsk. 2008. Pp. 144-146.

MATERIAL AND METHODS

The experiment with duration of 60 days was carried out according to the standard methodology in 2021 on the quail farm of the physiological cage of the Siberian Research and Technological Design Institute of Animal Husbandry of the Siberian Federal Scientific Centre of Agro-BioTechnologies of the Russian Academy of Sciences (SRTDIAH SFSCA RAS) on Japanese quails formed at the age of one day into three similar groups (one control and two experimental) with 80 birds in each[3] (see Table 1).

Poultry housing conditions and microclimate in the cage battery complied with zootechnical requirements. All experimental birds were fed the same basic diet (mixed fodder), prepared taking into account the age and physiological characteristics of the quails. Intergroup differences were as follows: the birds of the control group received only the basic diet (BD), the quails of the 1st and 2nd experimental groups consumed BD, in which part of the wheat (7%) was replaced by a protein-vitamin fraction of wheat bran with a grinding degree of 140 microns. Quails of the 2nd experimental group received the protein-vitamin fraction of wheat bran to which the enzyme preparation Fitbest® P5000 GT, designed to increase the bioavailability of phosphorus, mineral elements and amino acids from components of feed for poultry and pigs, was introduced. Heat stable preparation of new generation Fitbest® P5000 GT ensures release of more than a half of P and amino nitrogen bound in protein matrix with phytin, chelated minerals (Ca, Mg, Zn, Cu, Fe, etc), eliminates anti malnutrition factors, increases availability of nutrients and energy in feed. Dosage of enzyme preparation (300 g/t feed) corresponds to the norm for broiler chickens, recommended in the instructions for its use. Protein-vitamin flour with particle size of 140 microns used in the experiment was produced at the experimental bench of the Siberian branch of the Federal Research Center of Food Systems named after M. Gorbatov RAS by grinding wheat bran on a finger-type mill and further fractionation on sieves. The output of the required fraction is 50% of the initial mass of wheat bran.

Табл. 1. Схема опыта
Table 1. Experiment scheme

Group	Number, heads	Feeding conditions
Control	80	BD (basic diet – mixed fodder)
Experimental:		
1st	80	BD, containing 7% of the protein-vitamin fraction of wheat bran (140 microns grinding)
2nd	80	BD, containing 7% of protein-vitamin fraction of wheat bran (140 microns grinding) with enzyme preparation Fidbest® P5000 GT (dosage 300 g/t)

The diets were prepared in accordance with the norms of the All-Russian Research Technological Institute of Poultry Breeding of the Russian Academy of Sciences[4] [1]. The mixed fodder fed according to the eating capacity contained the recommended amount of metabolizable energy and basic nutrients. For the first 5 days, the chicks were fed boiled quail eggs in addition to the mixed fodder in order to improve their adaptation to the external environment. Feed intake was monitored daily by weighing the given feed and its residues. The behavior and health status of the quails was monitored daily. Control weighings of the birds were performed at starter, at 30 days of age, and at 2 months of age at the end of the rearing period. At 60 days of age, quail cockerels were slaughtered, selected according to the average live weight of the group (three heads from each group) (see footnote 3). The chemical composition of mixed fodder, wheat bran meal, and quail meat was studied in the biochemical labo-

[3]Methodology of scientific and industrial research on the feeding of poultry. Edited by V.I. Fisinin and Sh.A. Imangulov. Sergiev Posad, 2000. 33 p.

[4]Recommendations on feeding of farm poultry. Edited by V.I. Fisinin and Sh.A. Imangulov, I.A. Egorov, T.M. Okolelova. Sergiev Posad, 2003. 142 p.

ratory of the SRTDIAH SFSCA RAS according to generally accepted methods of zootechnical analysis. Biochemical composition of poultry blood was determined in the biotechnology laboratory of the Institute of Experimental Veterinary Science of Siberia and the Far East SFSCA RAS. The digital material obtained in the experiment was processed by the method of variation statistics on a personal computer using Microsoft Office Excel software.

Табл. 2. Структура и питательность комбикормов для перепелов

Table 2. Structure and nutritional value of mixed fodder for quails

Component	Age, days	
	0–30	31–60 and older
Structure, %		
Feed wheat	60,0	57,0
Full fat soybeans	10,0	10,0
Sunflower seed cake	10,0	10,0
Fish meal	5,0	–
Meat and bone meal	5,0	10,0
Fodder yeast	5,0	5,0
Premix	1,0	1,0
Tricalcium phosphate	2,0	2,0
Fodder chalk	2,0	2,0
Shell	–	3,0
100 g of mixed fodder contains		
Exchange energy, MJ		
crude nutrients	1,28	1,32
digestible nutrients	1,10	1,11
Crude protein, %	26,40	20,88
Digestible protein, %	15,45	14,60
Crude fat, %	3,71	3,83
Crude fiber, %	7,29	3,97
Nitrogen-free extractive substance, %	41,28	45,49
Crude ash, %	1,31	1,21
Calcium, %	1,46	1,84
Phosphorus, %	0,86	1,01

RESULTS AND DISCUSSION

Quail fodder was prepared taking into account their age and in accordance with the basic requirements for this type of birds: balance, high caloric value, and the required degree of milling (see Table 2). The mixed fodder was fed according to the eatability.

In terms of energy nutrition, pure and enriched with enzyme preparation Fitbest® P5000 GT fractionated protein-vitamin wheat bran flour were practically equal (difference in ME concentration of 0.78%). No significant differences between them in crude protein content (0.35% difference) and amino acid index (amino acid balance) (2.06% difference) were also noted (see Table 3).

In 1 kg of fractionated protein-vitamin wheat bran flour with a grinding degree of 140

Табл. 3. Питательность и химический состав фракционированной белково-витаминной муки пшеничных отрубей (степень помола 140 мкм)

Table 3. Nutritional value and chemical composition of fractionated protein-vitamin wheat bran flour (degree of grinding 140 microns)

Indicator	Fractionated protein-vitamin wheat bran flour	
	pure	with enzyme preparation Feedbest® P5000 GT
Exchange energy, MJ/kg	14,17	14,06
Chemical composition, %		
Crude protein	14,68	15,03
Crude fat	3,86	3,97
Crude fiber	3,80	3,09
Nitrogen-free extractive substance	60,7	57,51
Crude ash	2,86	2,98
Calcium	0,500	0,546
Phosphorus	0,252	0,246
Essential amino acids sum	4,297	3,686
Dispensable amino acids sum	8,035	7,038
Amino acids total	12,332	10,724
Amino acid index	0,535	0,524

microns the content of vitamin B1 was 7.6 mg, vitamin B3 - 3.8 mg vitamin B5 - 72.3 mg, vitamin E - 31.0 mg, which is more than in the original wheat bran by 2.17; 1.52; 1.64 and 1.24 times respectively.

The use of protein-vitamin wheat bran flour of 140 microns grinding degree in pure form and enriched with enzyme preparation Fidbest® P5000 GT in quail diets was found to have a positive effect on the safety and growth rate of birds (see Table 4).

The survival of chickens in the 1st and 2nd experimental groups increased by 3,01% relative to the control, the average daily gain of live weight (for 60 days of experience) by 3,09 and 3,44% (p>0,05) with almost equal feed consumption per unit (the maximum intergroup difference between the control and the 2nd experimental group was 1,75%). Feed consumption by poultry of the 1st and 2nd experimental groups increased insignificantly by 3.55 and 5.0% in comparison with the control counterparts.

The results of the control slaughter of quail chickens showed that the weight of the pan-ready carcass in the 1st and 2nd experimental groups was 1.44 and 3.36% higher than in the control (p> 0.05) (see Table 5). Intergroup differences in slaughter yield were insignificant (maximum 1.92%).

Inclusion of wheat bran protein-vitamin flour in the diet affected the chemical composition of meat (minced meat) of quail chickens (see Table 6). The first experimental group exceeded the control group in meat dry matter content by 1.75% (p> 0.05), fat by 1.18 times, but was inferior to it in calcium concentration by 1.06 times (p> 0.05). The meat of poultry of the 2nd ex-

Табл. 4. Сохранность, прирост живой массы цыплят-перепелов и расход корма на 1 кг прироста
Table 4. Safety, live weight gain of quail chickens and feed consumption per 1 kg of gain

Indicator	Group		
	control	experimental	
		1st	2nd
Safety, %	94,00	97,01	97,01
Live weight, g:			
in the beginning of the experiment	8,50 ± 0,07	8,50 ± 0,09	8,73 ± 0,07
at the age of 30 days	79,81 ± 2,42	90,32 ± 2,42	85,31 ± 2,08
at the age of 60 days	183,37 ± 2,53	188,73 ± 2,55	189,26 ± 2,04
Live weight gain in 60 days, g:			
absolute	174,87 ± 2,39	180,23 ± 2,44	180,53 ± 2,38
daily average	2,91 ± 0,03	3,0 ± 0,04	3,01 ± 0,03
Feed consumption in 60 days, kg	1,100	1,139	1,155
Feed expenses per 1 kg of growth, kg	6,29	6,32	6,40

Табл. 5. Результаты контрольного убоя подопытной птицы
Table 5. Results of control slaughter of experimental poultry

Indicator	Group		
	control	experimental	
		1st	2nd
Pre-slaughter live weight, g	180,12 ± 0,77	185,43 ± 0,68	184,29 ± 0,59
Gutted carcass weight, g	139,0 ± 0,84	141,00 ± 0,63	143,67 ± 0,99
Slaughter yield, %	77,17 ± 0,43	76,04 ± 0,95	77,96 ± 0,53

perimental group fed wheat bran with enzyme preparation contained 0,87% more dry matter, 1,17 times more fat ($p < 0,01$), 1,13 times more calcium and 1,17 times more phosphorus ($p < 0,05$) than the control. The concentration of calcium and phosphorus in the meat of quails fed with flour without enzyme preparation was 1.2 and 1.1 times lower than that of counterparts consuming flour with phytase.

No significant intergroup differences in the balance of meat amino acids were observed. The amino acid index of meat of quail of control counterparts, the 1st and 2nd experimental groups was almost the same (within 0.92-0.97).

Hematological studies indicate that all experimental quails were clinically healthy (see Table 7). No significant intergroup differences in biochemical blood parameters of the birds were observed.

Табл. 6. Химический и аминокислотный состав мяса (фарша) цыплят перепелов, %
Table 6. Chemical and amino acid composition of meat (minced meat) of quail chickens, %

Indicator	Group		
	control	experimental	
		1st	2nd
Dry matter	29,27 ± 0,17	31,02 ± 0,09	30,14 ± 0,20
Proteic substance	19,67 ± 0,27	20,32 ± 0,11	19,58 ± 0,22
Fat	6,00 ± 0,19	7,07 ± 0,10	7,00 ± 0,10
Ash	3,60 ± 0,08	3,63 ± 0,05	3,56 ± 0,04
Calcium	1,329 ± 0,004	1,250 ± 0,005	1,504 ± 0,004
Phosphorus	0,800 ± 0,005	0,846 ± 0,006	0,933 ± 0,005
Amino acids:			
Essential amino acids sum (arginine, valine, histidine, lysine, leucine, isoleucine, tryptophan, threonine, tyrosine, phenylalanine)	7,81	7,76	7,72
Dispensable amino acids sum (proline, serine, alanine, glycine, glutamine, asparagine, cystine)	8,46	7,99	7,92
Amino acid index	0,92	0,97	0,97

Табл. 7. Биохимические показатели крови цыплят перепелов
Table 7. Biochemical blood parameters of quail chickens

Indicator	Group		
	control	experimental	
		1st	2nd
Total protein, g/l	38,15 ± 1,54	38,50 ± 0,75	39,12 ± 1,60
Albumin, g/l	21,08 ± 1,22	20,81 ± 0,74	21,69 ± 0,83
Globulin, g/l	17,07 ± 0,43	17,69 ± 0,35	17,43 ± 0,76
SGOT, units/l	280,77 ± 27,18	278,32 ± 19,18	293,03 ± 35,10
SGPT, units/l	15,67 ± 3,16	14,73 ± 1,58	14,73 ± 3,68
Calcium, mmol/l	2,41 ± 0,07	2,47 ± 0,09	2,57 ± 0,07
Phosphorus, mmol/l	2,32 ± 0,13	3,15 ± 0,51	3,19 ± 0,47
Glucose, mmol/l	4,54 ± 0,27	5,02 ± 0,31	4,70 ± 0,21

CONCLUSIONS

1. The use of protein-vitamin wheat bran flour of 140 μm grinding degree in pure form and with enzyme preparation Fitbest® P5000 GT (instead of 7% wheat mixed feed) in quail diets had a positive effect on the livestock breeding indicators. The survival rate of chickens in the experimental groups increased by 3.01% relative to the control; average daily gain of live weight increased by 3.09 and 3.44% ($p < 0,05$) with practically the same amount of feed per unit. Intergroup differences in slaughter yield are insignificant (maximum 1.92%).

2. The meat of quails fed with protein-vitamin wheat bran meal containing Fitbest® P5000 GT containing phytase had 1.17; 1.13 and 1.17 times more fat, calcium and phosphorus, respectively, in comparison with the control ($p < 0.05$). The concentration of calcium and phosphorus in the meat of quails fed with flour without enzyme preparation was 1.2 and 1.1 times lower than that of counterparts consuming flour with phytase. Biochemical blood parameters of all experimental chickens remained within the physiological norm.

СПИСОК ЛИТЕРАТУРЫ

1. *Фисинин В.И., Егоров И.А., Околелова Т.М., Имангулов Ш.А.* Кормление сельскохозяйственной птицы: монография. Сергиев Посад, 2003. 375 с.
2. *Вишняков А., Власов В., Тоньшина Т., Новицкий О., Панин И.* Мука зародышей пшеницы в комбикормах // Комбикорма. 2003. № 4. С. 41–42.
3. *Казаков Е.Д., Кретович В.Л.* Биохимия зерна и продуктов его переработки: монография. М.: Агропромиздат, 1989. 368 с.
4. *Якунина Н., Мальцева Н., Ядришенская О., Невинный В.* Кормовая добавка из зародышей пшеницы // Комбикорма. 2004. № 4. С. 37–38.
5. *Скрябин В.А., Сабоиев И.А., Табанюхов К.А.* Побочные продукты мукомольно-крупяного производства как источник белка повышенной биологической ценности // Инновации и продовольственная безопасность, 2019. № 3 (25). С. 105–111.
6. *Лукьянчикова Н.Л., Скрябин В.А., Табанюхов К.А.* Особенности состава отрубей пшеницы и ржи и их роль в профилактике хронических заболеваний человека. Обзор // Инновации и продовольственная безопасность. 2020. № 4 (30). С. 41–58.
7. *Рогачёв В.А., Мерзлякова О.Г., Чегодаев В.Г., Лукьянчикова Н.Л.* Фракционированная белково-витаминная мука из пшеничных отрубей в рационах несушек перепелов // Кормление сельскохозяйственных животных и кормопроизводство. 2021. № 11 (196). С. 40–48.
8. *Hemery Y., Rouau X., Lullien-Pellerin V., Barron C., Abecossis J.* Dry processes to develop wheat fractions and products with enhanced nutritional quality // Journal of Cereal Science. 2007. N 46. P. 327–347.
9. *Dost K., Tokul O.* Determination of phytic acid in wheat and wheat products by reverse phase high performance liquid chromatography // Analytica Chimica Acta. 2006. N 558. P. 22–27.
10. *Bilgicli N., Ibanoglu. S.* Effect of wheat germ and wheat bran on the fermentation activity, phytic acid content and colour of tarhana // Journal of Food Engineering. 2007. N 78. P. 681–686.

REFERENCES

1. Fisinin V.I., Egorov I.A., Okolelova T.M., Imangulov S.A. *Feeding of poultry*. Sergiev Posad, 2003, 375 p. (In Russian).
2. Vishnyakov A., Vlasov V., Tonshina T., Novitsky O., Panin I. Flour of wheat germ in compound feeds. *Kombikorma = Compound feeds*, 2003, no. 4., pp. 41–42. (In Russian).
3. Kazakov E.D., Kretovich V.L. *Biochemistry of grain and products of its processing.* Moscow, Agropromizdat Publ., 1989, 368 p. (In Russian).
4. Yakunin, N., Maltsev N., Adriansky O., Nevinny V. Feed additive of wheat germ. *Kombikorma = Compound feeds*, 2004, no. 4, pp. 37–38. (In Russian).
5. Skryabin V.A., Sabayev I.A., Tabanyukhov K.A. By-products of milling and corn production as a source of protein of increased biological value. *Innovatsii i prodovol'stvennaya bezopasnost' = Innovation and food safety,* 2019, no. 3 (25), pp. 105–111. (In Russian).
6. Lukyanchikova N.L., Skryabin V.A., Tabanyukhov K.A. Peculiarities of the composition of wheat and rye bran and their role in the prevention of chronic diseases. Review. *Innovatsii i prodovol'stvennaya bezopasnost' = Innovations and food safety,* 2020, no. 4 (30), pp. 41–58. (In Russian).

7. Rogachev V.A., Merzlyakova O.G., Chegodaev V.G., Lukyanchikova N.L. Fractionated protein and vitamin flour from wheat bran in the diets of laying quails. *Kormlenie sel'skokhozyaistvennykh zhivotnykh i kormoproizvodstvo = Feeding of farm animals and feed production,* 2021, no.11 (196), pp. 40–48. (In Russian).
8. Hemeri Yu., Ruau H., Lullien-Pellerin V., Barron S., Abekossis J. Dry processes for obtaining wheat fractions and products with increased nutritional quality. *Journal of Grain Sciences,* 2007, no. 46, pp. 327–347.
9. Dost K., Tokul O. Determination of phytic acid in wheat and wheat products by high-performance liquid chromatography with a reverse phase. *Analytica Chimica Acta,* 2006, no. 558, pp. 22–27.
10. Have Bilgili N., Ibanoglu. S. Effect of wheat germ and wheat bran on the activity of fermentation, the contents of phytic acid and color Tarkhany. *Journal of food engineering,* 2007, no. 78, pp. 681–686.

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