https://doi.org/10.26898/0370-8799-2021-2-8
УДК: 636.52/58.087.7
Тип статьи: оригинальная
Type of article: original

ИСПОЛЬЗОВАНИЕ ФРАКЦИОНИРОВАННОЙ БЕЛКОВО-ВИТАМИННОЙ МУКИ ИЗ ПШЕНИЧНЫХ ОТРУБЕЙ В РАЦИОНАХ ПЕРЕПЕЛОВ

Мерзлякова О.Г., (✉) **Рогачёв В.А.**
Сибирский федеральный научный центр агробиотехнологий Российской академии наук
Новосибирская область, р.п. Краснообск, Россия
(✉) e-mail: helmmet@mail.ru

Представлены результаты эксперимента по использованию в рационе выращиваемых перепелов белково-витаминной муки из пшеничных отрубей, разделенной на фракции с размером частиц 140, 400 и 800 мкм. Опыт продолжительностью 60 дней проведен по общепринятой методике на перепелах японской породы, сформированных в суточном возрасте в четыре аналогичные группы (одна контрольная и три опытные) по 80 гол. в каждой. Все группы получали комбикорм (основной рацион), приготовленный с учетом возраста и физиологических особенностей перепелов, но в рационе молодняка 1, 2 и 3-й опытных групп часть пшеницы (7%) заменили пшеничной белково-витаминной мукой трех фракций с размером частиц 140, 400 и 800 мкм соответственно. Птицу содержали в клеточной батарее при соблюдении требуемых условий микроклимата. Изучено влияние скармливания фракционированной белково-витаминной муки из пшеничных отрубей на сохранность поголовья, интенсивность роста цыплят, показатели мясной продуктивности и гематологические показатели, изменение видового состава микроорганизмов желудочно-кишечного тракта. Определены оптимальные по эффективности продуктивного и физиологического действия фракции муки из пшеничных отрубей при использовании их в качестве нового кормового средства в рационах перепелов. При введении в комбикорм перепелов белково-витаминной муки из пшеничных отрубей с размером частиц 140 и 400 мкм в количестве 7% от зерновой части рациона повысились сохранность птицы на 3,0%, среднесуточный прирост живой массы на 2,30 и 5,59%, масса потрошеной тушки на 4,5 и 6,16%, содержание белка в мясе на 0,84 и 0,57%. Скармливание перепелам муки различных фракций не оказало положительного влияния на конверсию корма в продукцию. Биохимические показатели крови цыплят оставались в пределах физиологической нормы. Фракционированная белково-витаминная мука с размером частиц 400 и 800 мкм стимулировала рост бифидобактерий, с размером частиц 140 и 800 мкм сдерживала развитие кишечной палочки.

Ключевые слова: перепела, комбикорм, белково-витаминная мука, фракции, сохранность, живая масса, микрофлора

THE USE OF FRACTIONATED PROTEIN-VITAMIN FLOUR FROM WHEAT BRAN IN THE DIETS OF QUAILS

Merzlyakova O.G., (✉) **Rogachev V.A.**
Siberian Federal Research Centre for AgroBiotechnologies of the Russian Academy of Sciences
Krasnoobsk, Novosibirsk region, Russia
(✉) e-mail: helmmet@mail.ru

The results of the experiment on the use of protein-vitamin flour from wheat bran, divided into fractions with particle size of 140, 400 and 800 μm in the diet of domesticated quails are presented. The experiment lasted for 60 days and was carried out according to the generally accepted methods on quails of the Japanese breed, formed in four similar groups (one control and three experimental), 80 heads each, at the age of one-day old. All groups received compound feed (the main diet), prepared taking into account the age and physiological characteristics of quails, but in the bird diet of the 1st, 2nd and 3rd experimental groups, part of the wheat (7%) was replaced with wheat protein-vitamin flour of three fractions with a particle size of 140, 400 and 800 μm, respectively. The poultry was kept in a battery cage under required microclimate conditions. The effect of feeding fractionated protein-vitamin flour from wheat bran was studied on the survival rate of quail chicks,

their growth rate, indicators of meat productivity and hematological parameters, changes in the species composition of microorganisms of the gastrointestinal tract. The optimal fractions of wheat bran flour as the new feed in the diets of quails were determined in terms of efficiency of their productive and physiological action. The introduction of protein-vitamin flour from wheat bran into the compound feed of quails with a particle size of 140 and 400 μm in the amount of 7% of the grain part of the diet increased the survival rate of quail chicks by 3.0%, the average daily gain in live weight by 2.30 and 5.59%, the weight of eviscerated bird carcass by 4.5 and 6.16%, protein content in meat by 0.84 and 0.57%. Feeding the quails with flour of various fractions did not have a positive effect on the conversion of feed into produce. The biochemical parameters of the quail chicks' blood remained within the physiological norm. Fractionated protein-vitamin flour with a particle size of 400 and 800 μm stimulated the growth of bifidobacteria, and with a particle size of 140 and 800 μm inhibited the development of Escherichia coli.

Keywords: quail, compound feed, protein-vitamin flour, fractions, survival rate, live weight, microflora

Для цитирования: *Мерзлякова О.Г., Рогачёв В.А.* Использование фракционированной белково-витаминной муки из пшеничных отрубей в рационах перепелов // Сибирский вестник сельскохозяйственной науки. 2021. Т. 51. № 2. С. 65–72. https://doi.org/10.26898/0370-8799-2021-2-8

For citation: Merzlyakova O.G., Rogachev V.A. The use of fractionated protein-vitamin flour from wheat bran in the diets of quails. *Sibirskii vestnik sel'skokhozyaistvennoi nauki = Siberian Herald of Agricultural Science,* 2021, vol. 51, no. 2. pp. 65–72. https://doi.org/10.26898/0370-8799-2021-2-8

Конфликт интересов
Авторы заявляют об отсутствии конфликта интересов.
Conflict of interest
The authors declare no conflict of interest.

INTRODUCTION

One of the most widespread innovations in animal husbandry is the use of feed additives to balance rations in terms of standardized nutrients and make them more complete. A feeding system based on the use of various feed additives is the best way to increase animal productivity, reduce feed consumption per unit of production and improve its quality.

A promising feed additive for poultry should be considered protein-vitamin flour, obtained by grinding wheat or rye bran in a finger-type mill with further fractionation and screen sizing. The resulting flour fractions (140, 400, 800 μm) are characterized by a different granulometric composition. During varietal milling of wheat and rye, biologically valuable morphological parts, such as shells, aleurone layer and germ, are separated from the grain. Cellulose and lignin are practically absent in the aleurone layer, which makes up from 6 to 9% of the mass of wheat kernels, but a higher content of soluble dietary fiber, ferulic acid, and lignans, which have significant antioxidant activity [1–8]. Small fractions of flour are enriched to a greater extent with elements of the aleurone layer and germ, the protein content of which reaches 35%. The protein of the obtained fractions significantly differs in amino acid composition from endosperm proteins and is characterized by better balance in amino acids [9, 10].

To assess the productive and physiological effect of fractionated wheat bran flour, it is advisable to use a model species of poultry - Japanese quails, which are phylogenetically closely related to broiler chickens (they also belong to the order of chickens of the Phasianidae family). The conclusions drawn from the results of experiments carried out on quails can be transferred to other bird species [11, 12].

The purpose of the research is to experimentally substantiate the effectiveness of using a new feed additive in feeding quails grown up to 60 days of age - fractionated protein-vitamin flour from wheat bran. The objectives of the study are to determine the effect of the feed additive on the safety and growth rate, indicators of meat productivity and biochemical parameters of blood, the species composition of the intestinal microflora of quails.

MATERIALS AND METHODS

An experiment lasting 60 days was carried out according to the generally accepted method on the quail farm of the physiological yard of the Siberian Scientific Research and Design Technological Institute of Animal Husbandry (SibNIPTIZh SFSCA RAS) on Japanese quails formed at one day old into four similar groups (one control and three experimental) 80 heads each[1].

The conditions of keeping the birds and the microclimate in the cage battery corresponded to the zootechnical requirements. All experimental quails were fed the same compound feed (main diet), prepared taking into account the age and physiological characteristics of the given bird species.

The intergroup differences were as follows: young animals of the control group consumed only compound feed, for poultry of the 1st, 2nd and 3rd experimental groups, part of the wheat (7%) of the main diet was replaced with protein-vitamin flour from wheat bran, divided into fractions with a particle size of 140, 400 and 800 μm, respectively. Fractionated flour from wheat bran (feed additive) used in the experiment was developed at the experimental stand of Siberian Branch of the Federal Scientific Center for Food Systems named after V.M. Gorbatov RAS (see Table 1).

Fractionated protein-vitamin flour from wheat bran can have various action models: increasing the efficiency of nutrient use in diets, activating animal immunity, stimulating the growth and development of young animals, egg production and reproductive function of poultry, improving and stabilizing the intestinal microflora.

The rations were made in accordance with the standards of the All-Russian Scientific Research Technological Institute of Poultry, Russian Academy of Sciences[2,3]. The compound feed contained a sufficient amount of metabolizable energy and essential nutrients. For the first 5 days, the chickens were fed boiled quail eggs in addition to the compound feed in order

Табл. 1. Характеристика опытных образцов белково-витаминной муки из пшеничных отрубей, разделенной на различные фракции, %

Table 1. Characteristics of control samples of protein-vitamin flour from wheat bran, divided into various fractions, %

Indicator	Fractions of protein-vitamin flour from wheat bran, microns		
	140	400	800
Exchange energy, MJ	13,76	12,98	13,06
Crude fat	2,28	3,52	3,05
Crude protein	17,52	12,36	13,43
Crude ash	3,93	4,43	5,53
Crude fiber	4,91	9,87	8,02
Nitrogen-free extractive substances	58,44	56,83	55,65
Calcium	0,625	0,550	0,649
Phosphorus	0,763	0,887	1,084
The amount of essential amino acids	10,493	8,340	9,786
The amount of nonessential amino acids	10,736	7,402	9,000
Amino acid index	0,977	1,127	1,087

[1]Methodology for conducting scientific and industrial research on feeding poultry / ed. by Fisinin V.I. and Imangulov Sh.A.. Sergiev Posad, 2000. 33 p.

to improve the adaptation of the quail to the external environment. The feed intake was taken into account daily by weighing the given feeds and their residues. Quail behavior and health were monitored daily.

Control weighing of poultry was carried out when setting up for experiment, at the age of 30 days and at 2 months after the end of the growing period. At the age of 60 days, quails were slaughtered (3 heads from each group).

The chemical composition of feed, flour from wheat bran and quail meat was investigated in the biochemical laboratory of SibNIPTIZh SFSCA RAS according to generally accepted methods of zootechnical analysis.

The biochemical composition of the poultry blood was determined in the biotechnology laboratory of the Institute of Experimental Veterinary Medicine of Siberia and the Far East of the Siberian Federal Scientific Center of the Russian Academy of Sciences.

The composition of the microflora isolated from the gastrointestinal tract of quails was determined in the laboratory for the regulation of microbiocinosis of farm animals and plants of SibNIPTIZh SFSCA RAS. When studying the microflora of the digestive tract of birds, we used the Hangate anaerobic technique and nutrient media (we used an extract from quail feces).

The digital material obtained in the experiment was processed by the method of variation statistics on a personal computer using the Microsoft Excel software.

RESULTS AND DISCUSSION

Compound feed for quails was prepared in accordance with the basic requirements for this type of poultry in terms of balance, high calorie content and the required degree of grinding. The composition of the feed consisted of the following components: feed wheat, full-fat soy beans, sunflower meal, fish meal, meat and bone meal, feeding yeast, vegetable fats, Ca / P mineral, feed chalk, premix. The percentage of compound feed ingredients and its nutritional value were different depending on the age of the bird (1–30 and 31–60 days). On average, 100 g of compound feed contained 1.26 MJ of metabolic energy, 26.4 MJ of crude protein, 3.7% crude fiber.

The introduction of fractionated flour from wheat bran into the quail compound feed had a noticeable effect on its palatability. During the growing period (60 days), the poultry of the experimental groups consumed compound feed by 14.55–25.02% more in comparison with the control analogues.

The safety of the livestock of chickens in the experimental groups turned out to be higher compared to the control by 2–3% (see Table 2).

Quails of the 1st and 2nd experimental groups had higher growth vigor and better conversion of feed into meat products. They exceeded the control counterparts in absolute gain in live weight by 2.31 and 5.68%, in average daily gain by 2.30 and 5.59% ($p > 0.05$).

The results of the control slaughter of poultry showed that the weight of the gutted carcass of quails of the 1st and 2nd experimental groups was more than in the control group by 4.50 and 6.16%, the slaughter yield was higher by 1.73 and 3.25% ($p > 0.05$) (see Table 3). The bird of the 3rd experimental group was 3.09% inferior to the control analogues in terms of gutted carcass weight.

The poultry meat of the 1st-3rd experimental groups, in comparison with the control analogues, contained less dry matter (by 2.94, 3.35 and 4.31%), as well as fat (by 1.96; 2.02 and 3, 37 times), but there was more protein (by 0.84, 0.57 and 0.83%) (see Table 4). The poultry meat of the experimental groups had a better balance in amino acids, as evidenced by a higher (1.17–1.50 times) amino acid index.

Biochemical blood parameters reflect the state of the bird's body and are closely related to its productivity. There was an increase in the total protein in the blood serum of quail chick-

[2]Recommendations for feeding poultry / ed. by Fisinin V. I., Imangulov Sh.A., Egorov I.A., Okolelov T.M., Sergiev Posad, 2003.142 p.

[3]Fisinin V.I., Egorov I.A., Okolelova T.M., Imangulov Sh.A. Feeding poultry: a textbook. Sergiev Posad, 2003.375 p.

Табл. 2. Сохранность, прирост живой массы и затраты корма на единицу прироста у цыплят-перепелов за период выращивания

Table 2. Survival rate, live weight gain and feed use per unit of weight gain of quail chicks during the growing period

Indicator	Group			
	control	experimental		
		1-st	2-nd	3-rd
Wheat bran flour fraction, microns	–	140	400	800
Survival rate, %	94	97	97	96
Live weight, g:				
at the beginning of the experiment	8,53 ± 0,08	8,57 ± 0,08	8,61 ± 0,08	8,50 ± 0,07
in 30 days	112,12 ± 2,23	110,74 ± 2,41	114,46 ± 2,10	106,96 ± 2,26
in 60 days	190,71 ± 2,61	194,96 ± 2,45	201,14 ± 2,43	189,47 ± 2,69
Absolute live weight gain, g:				
in 30 days	103,59 ± 2,06	102,17 ± 2,22	105,85 ± 1,94	98,46 ± 3,08
in 60 days	182,18 ± 2,49	186,39 ± 2,34	192,53 ± 2,33	180,97 ± 2,57
Average daily gain in live weight, g:				
in 30 days	3,45 ± 0,07	3,41 ± 0,07	3,53 ± 0,06	3,28 ± 0,07
in 60 days	3,04 ± 0,04	3,11 ± 0,04	3,21 ± 0,04	3,02 ± 0,04
Feed consumed, kg	1,251	1,433	1,564	1,433
Feed costs per 1 g of growth, g	6,87	7,74	8,12	7,97

ens of the 3rd experimental group by 8.71 g / l (21.69%) compared with the control and by 9.36-10.36 g / l (24.87-26, 91%) compared with the 1st and 2nd experimental groups. This trend also applies to the content of globulin, creatinine, AST and phosphorus in the blood. In general, the studied biochemical parameters of the entire experimental bird varied within the physiological norm.

As you know, the main representatives of the normal microflora of the intestines of poultry, including quail, are bifidobacteria and lactobacilli. Their conglomerates are localized on the intestinal mucosa, adjacent to the membranes of enterocytes, and can also be located in the immediate vicinity of the surface of the epithelium in the mucin layer covering the membranes of epithelial cells. Conditionally pathogenic microflora is constantly present in the intestine, the activity of which is restrained by the general resistance of the organism. The prominent representatives of this microflora in the intestines of birds are enterococci, streptococci and Escherichia coli.

Табл. 3. Результаты убоя подопытной птицы

Table 3. Results of slaughter of experimental poultry

Indicator	Group			
	control	experimental		
		1-st	2-nd	3-rd
Wheat bran flour fraction, microns	–	140	400	800
Pre-slaughter live weight, g	185,67 ± 0,67	189,67 ± 0,67	189,00 ± 0,58	177,67 ± 0,67
Gutted carcass weight, g	140,67 ± 0,88	147,00 ± 4,16	149,33 ± 0,88	136,33 ± 1,76
Slaughter yield, %	75,76 ± 0,33	77,49 ± 1,93	79,01 ± 0,23	76,73 ± 0,80

Табл. 4. Химический состав мяса цыплят перепелов, %
Table 4. Chemical composition of quail chick meat, %

Indicator	Group			
	control	control		
		1-st	2-nd	3-rd
Wheat bran flour fraction, microns	–	140	400	800
Dry matter	28,92 ± 0,19	25,98 ± 0,08	25,57 ± 0,30	24,61 ± 0,64
Fat	7,22 ± 0,20	3,69 ± 0,07*	3,57 ± 0,11*	2,14 ± 0,19*
Protein	20,66 ± 0,30	21,50 ± 0,09	21,23 ± 0,25	21,49 ± 0,48
Ash	1,02 ± 0,06	0,93 ± 0,04	0,89 ± 0,03	0,98 ± 0,05
Calcium	0,115 ± 0,003	0,156 ± 0,004	0,155 ± 0,004	0,204 ± 0,006
Phosphorus	0,234 ± 0,006	0,229 ± 0,006	0,209 ± 0,003*	0,199 ± 0,005*
The amount of essential amino acids	8,03	8,36	7,76	7,86
The amount of nonessential amino acids	10,50	9,38	6,99	6,87
Amino acid index	0,76	0,89	1,11	1,14

During the study of quail intestinal microbiosis, material was selected for sowing on special nutrient media in order to determine the main symbionts and pathogenic microorganisms. Obligate intestinal microflora of young monogastric animals and poultry is represented mainly by strict and facultative anaerobes.

Feed additives from fractionated flour, used in the diet of quails of the 2nd and 3rd experimental groups, stimulated the growth of bifidobacteria (increase in lg CFU/ g by 1.68 and 1.63 times). Fractionated flour fed to poultry of the 1st and 3rd experimental groups inhibited the development of E. coli (decrease in lg CFU/ g by 1.6 and 1.88 times) (see Table 5).

CONCLUSIONS

1. The optimum particle size of fractionated protein-vitamin flour from wheat bran, introduced into the diet of quail in the amount of 7% of its grain part, is 140 and 400 μm for chickens raised for 60 days. Feeding poultry with compound feed, consisting of flour with a particle size of 140 and 400 microns, increases the safety of young animals by 3.0%, the average daily gain in live weight by 2.30 and 5.59%, improves the meat productivity of quails (an increase in the weight of gutted chicken carcasses by 4.50 and 6.16%, protein content in meat by 0.84 and 0.57%).

2. The use of fractionated flour from wheat bran in the amount of 7% of the grain portion of the diet does not have a positive effect on the conversion of feed into products.

3. Fractionated bran flour with a particle size of 400 and 800 microns stimulates the growth of bifidobacteria (an increase in lg CFU/ g by 1.68 and 1.63 times), with a particle size of 140

Табл. 5. Видовой состав микрофлоры кишечник перепелов, lg КОЕ/г
Table 5. Species composition of microflora intestines of quails, lg CFU/g

Indicator	Group			
	Control	experimental		
		1-st	2-nd	3-rd
Wheat bran flour fraction, microns	–	140	400	800
Type of microorganism:				
Lactobacillus	9,0	10,1	9,4	10,7
Bifidobacterium	7,3	7,1	12,3	11,9
Enterococcus	6,0	7,3	5,1	7,0
Escherichia coli	3,2	2,0	3,4	1,7

and 800 microns inhibits the development of E. coli (a decrease in lg CFU/ g in 1, 6 and 1.88 times).

СПИСОК ЛИТЕРАТУРЫ

1. *Вишняков А., Власов В., Тоньшина Т., Новицкий О., Панин И.* Мука зародышей пшеницы в комбикормах // Комбикорма, 2003. № 4. С. 41–42.
2. *Казаков Е.Д., Кретович В.Л.* Биохимия зерна и продуктов его переработки: монография. М.: Агропромиздат, 1989. 368 с.
3. *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.
4. *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.
5. *Якунина Н., Мальцева Н., Ядришенская О., Невинный В.* Кормовая добавка из зародышей пшеницы // Комбикорма. 2004. № 4. С. 37–38.
6. *Колпакова В.В., Крикунова Л.Н., Кононенко Н.Н.* Исследование возможности получения белковых препаратов из дифференцированных фракций зерна ржи и ячменя // Известия вузов. Пищевая технология. 2001. № 5-6. С. 35–37.
7. *Courtine C.M., Broekaert W.F., Swennen K., Lescroart O., Onagbesan O., Buyse J., Decuypere E., Van de Wiele T., Marzorati M., Verstraete W., Huyghebaert G., Delcour J.A.* Dietary inclusion of wheat bran arabinoxylo-oligosaccarides induce beneficial nutritional effects in chickens // Cereal Chemistry. 2008. Vol. 85. N 5. P. 607–613.
8. *Szwajgier D., Jakubczyk A.* Biotransformation of ferulic acid by Lactobacillus acidophilus KIand selected Bifidobacterium strains // Acta Scientiarum Polonorum Technologia Alimentaria. 2010. Vol. 9 (1). P. 45–59.
9. *Журлова Е.Д., Карпельянц Л.В.* Исследование пребиотической активности ксилоолигосахаридов из ржаных и пшеничных отрубей *in vitro* // Scientific Journal «Science Rise». 2015. Vol. 4/1. N 9. P. 79–84.
10. *Яшин А., Яшин Я., Федина П., Черноусова Н.* Определение природных антиоксидантов в пищевых злаках и бобовых культурах // Аналитика. 2012. № 1. С. 32–36.
11. *Rezaeia M., Karimi Torshizib M., Walla H., Ivarssona E.* Body growth, intestinal morphology and microflora of quail on diets supplemented with micronised wheat fibre // Poultry Science. 2018. Vol. 59. P. 422–429. DOI:10.1080/00071668.2018.1460461.
12. *Mills A., Crawford L., Domjan M., Faure J.* The behavior of the Japanese or Domestic Quail Coturnix Japonica // Neuroscience and Biobehavioral Reviews. 1997. Vol. 21. P. 261–281. DOI: 10.1016/S0149-7634(96)00028-0.

REFERENCES

1. Vishnyakov A., Vlasov V., Tonshina T., Novitsky O., Panin I. Wheat germ flour in compound feed. *Kombikorma = Compound Feeds Magazine*, 2003, no. 4, pp. 41–42. (In Russian).
2. Kazakov E.D., Kretovich V.L. *Biochemistry of grain and products of its processing*. Moscow, Agropromizdat Publ., 1989, 368 p. (In Russian).
3. Lukyanchikova N.L., Scriabin V.A., Tabanyukhov K.A. Peculiarities of the composition of wheat and rye bran and their role in the prevention of chronic diseases of human. *Innovatsii i prodovol'stvennaya bezopasnost' = Innovations and Food Safety*, 2020, no. 4 (30), pp. 41–58. (In Russian).
4. 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, no. 46, pp. 327–347.
5. Yakunina N., Maltseva N., Yadrishenskaya O., Nevinniy V. Feed additive from wheat germ. *Kombikorma = Compound Feeds Magazine*, 2004, no. 4. pp. 37–38. (In Russian).
6. Kolpakova V.V., Krikunova L.N., Kononenko N.N. Study of the possibility of obtaining protein preparations from differentiated fractions of rye and barley grain. *Izvestiya vuzov = Food Technology*, 2001, no. 5-6, pp. 35–37. (In Russian).
7. Courtine C.M., Broekaert W.F., Swennen K., Lescroart O., Onagbesan O., Buyse J., Decuypere E., Van de Wiele T., Marzorati M., Verstraete W., Huyghebaert G., Delcour J.A. Dietary inclusion of wheat bran arabinoxylo-oligosaccarides induce beneficial nutritional effects in chickens. *Cereal Chemistry*, 2008,

vol. 85, no. 5, pp. 607–613.
8. Szwajgier D., Jakubczyk A. Biotransformation of ferulic acid by Lactobacillus acidophilus KI- and selected Bifidobacterium strains. *Acta Scientiarum Polonorum Technologia Alimentaria*, 2010, vol. 9 (1), pp. 45–59.
9. Zhurlova E.D., Karpeliants L.V. Study of the prebiotic activity of xylooligosaccharides from rye and wheat bran in vitro. *Scientific Journal «Science Rise»*, 2015, vol. 4/1, no. 9, pp. 79–84. (In Russian).
10. Yashin A., Yashin Ya., Fedina P., Chernousova N. Determination of natural antioxidants in cereal grains and legumes. *Analitika = Analytics*, 2012, no. 1, pp. 32–36. (In Russian).
11. Rezaeia M., Karimi Torshizib M., Walla H., Ivarssona E. Body growth, intestinal morphology and microflora of quail on diets supplemented with micronised wheat fibre. *Poultry Science*, 2018, vol. 59, pp. 422–429. DOI: 10.1080/00071668.2018.1460461.
12. Mills A., Crawford L., Domjan M., Faure J. The behavior of the Japanese or Domestic Quail Coturnix Japonica. *Neuroscience and Biobehavioral Reviews*, 1997, vol. 21, pp.261–281. DOI: 10.1016/S0149-7634(96)00028-0.

Информация об авторах

Мерзлякова О.Г., старший научный сотрудник

(✉) **Рогачев В.А.,** доктор сельскохозяйственных наук, заведующий лабораторией; **адрес для переписки:** Россия, 630501, Новосибирская область, р.п. Краснообск, СФНЦА РАН, а/я 463; e-mail: helmmet@mail.ru

Author information

Olga G. Merzlyakova, Senior Researcher

(✉) **Viktor A. Rogachev,** Doctor of Science in Agriculture, Laboratory Head; **address:** PO Box 463, SFSCA RAS, Krasnoobsk, Novosibirsk Region, 630501, Russia; e-mail: helmmet@mail.ru

Дата поступления статьи / Received by the editors 19.01.2021
Дата принятия к публикации / Accepted for publication 06.04.2021
Дата публикации / Published 25.05.2021