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Influence of zeolite honguruu on growth and development, digestibility and metabolism of geese

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Abstract. **The purpose** of the study is to determine the effect of zeolite honguruu on the growth and development, digestibility and metabolism of geese in the conditions of Yakutia. During the experiment, research **methods** generally accepted in poultry farming were used. Live weight – by weighing birds, digestibility and metabolism according to the method of VIZH, VNITIP. **The scientific novelty** of the research was to find the possibility of involving natural zeolite in the feed ration of young goose young in the conditions of Yakutia. For carrying out the experiments, we formed 3 groups of geese of 20 animals in each analogue method. Therefore, we determined the effect of zeolite on growth, development, physiological state, and digestibility of nutrients. The purpose of the research is to identify the degree of safety when using zeolite in poultry farming and to obtain an environmentally friendly product for human nutrition. The use of zeolite contributed to an increase in gross increase in live weight by 14.13 % and 19.22 %. So, the supplement contributed to an increase in average daily growth during all periods of cultivation: in 60–70 days – 7.85 % and 15.24 %; in 70–80 days – by 21.73 % and 28.30 %, in 80–90 days – by 13.61 % and 15.76 %. During the experiment, the control group of geese accounted less than the experimental groups of birds – 14.14 % and 19.22 %. A physiological experiment was conducted to determine the effect of zeolite honurin on metabolism. It was found that the additive contributes to better digestion of nutrients in terms of dry matter by 0.9 % and 1.58 %, organic matter by 0.83 % and 1.38 %, protein by 0.64 % and 0.92 %, fat by 0.84 % and 1.58 %, fiber by 0.33 % and 2.21 %, and nitrogen-free extractives by 0.96 % and 1.42 %. During the experiment, it was found that the nitrogen balance in all geese was positive but had differences in the degree of deposition in the body. So the experimental geese of the experimental groups exceeded their peers from the control group by 3.47 % and 5.56 %, respectively. Thus, the use of zeolite zeolite is positive for the growth and development, digestibility and metabolism of geese.
Keywords: geese, feeding, feed additives, metabolism.

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Introduction

Zeolites are of particular importance in the feeding of farm animals and birds. Their inclusion in the diet contributes to the enrichment of the mineral composition, and also to more active assimilation of nutrient and mineral elements. Zeolites have ion-exchange, sorbing and bactericidal properties [1, p. 433], [4, p. 2], [7, p. 1130], [8, p. 3488], [11, p. 2092], [20, p. 160].

Zeolites are used in feeding poultry not only as the mechanically acting factor, but also as an effective source of macro- and microelements. Their use in feeding birds helps to mitigate the regime of limited feeding, as well as it improves the degree of the safety of birds [6, p. 102], [17, p. 2], [18, p. 1633], [19, p. 77], [22, p. 422].

The first tests of zeolite as feed additives were carried out in Japan in 1965. Zeolite was included in the composition of feed for birds. Studies have shown that the inclusion of 3.5–10 % of zeolites in animal feed contributed to a decrease in feed intake, as well as an increase in growth intensity and an increase in the safety of birds. In the USA, Cuba, Bulgaria, Hungary and Japan, zeolites have been widely used in various industries [14, p. 54].

Conducted comprehensive research Yu. V. Pavlenko (2018) on the use of zeolite shivyrtuin as a feed additive in the sectors of livestock and poultry, specialized dairy and beef cattle breeding, sheep breeding, fish farming, as well as in the production of premixes, various veterinary preparations, animal feed, etc. showed the economic and practical effectiveness of their use in agriculture. It allowed determining the norms for their inclusion in the diets ensuring environmental safety of the resulting food product [16, p. 35].

Stationary studies of the effect of various dozolite of the Khotynetsk field of the Oryol region in the feeding of farm animals and birds. The authors found out that the optimal dose for cattle is their inclusion in the amount of 5 % of the dry weight of the feed, this proportion was most conducive to increasing the immunity and productivity of cattle: increase

in large-fruited by 11.8 %, increase in the content of immunoglobulins by 13.1 % , milk productivity by 7.8 %, young growth in live weight by 7–16 % with a decrease in feed consumption for growth by 0.4–0.5 feed units, improved blood picture (increase in the number of red blood cells by 9.2 %, content total protein by 6.2 % and albumin 5.4 %, improved phosphorus-calcium metabolism in the organism of experimental animals. In feeding sows and piglets, the optimal dose of zeolite incorporation was found to be 3 % of the dry weight of the feed. The use of zeolite in pig diets made it possible to: increase immunity, improve the morphological composition and biochemical parameters of blood, increase the average daily increase by 7.2–13.5 %, save by 11.1 %, reduce the incidence of the gastrointestinal tract. Tests of zeolite in the feeding of hen eggs revealed that the additive is the optimal norm which amounted to 4–5 % of the dry weight of the feed. The use of zeolite 4 % of dry food in the diet of Super nick cross chickens allowed to achieve: improved morphological and biochemical parameters of blood (red blood cells by 1.8–4.2 %, hemoglobin by 3.3–4.6 %, total protein by 9, 7–12.1 %, albumin by 1.6–7.6 %, calcium by 7.0–13.1 %), while the qualitative indicators changed (egg weight increased by 3.3–5.3 %, thickness shells by 13.2–14.6 %, strength by 5.4–16.1 %, egg production by 10.7 %). The use of zeolite 5 % of dry food in the diet of hens cross-country Lohmann Brown, allowed to improve indicators: blood (red blood cells by 6.5–7.4 %, hemoglobin by 2.8–4.2 %, total protein by 4.9–11,0 %, albumin by 8.9–38.0%, calcium by 13.7–14.6 %), a decrease in feed costs for growth by 5.1–13.0 % and egg production by 10.5 % , preservation by 3.1–9.5 %, egg production by 11.7 %, egg weight by 1.4 %. When using the Khotynets zeolite, the performance indicators were in feeding cattle 1.8 rubles, pigs 3.41–4.76 rubles, chickens – 4.4 rubles for 1 ruble of expenses [5, p. 37].

In Yakutia, there is a large deposit of zeolite – honguruu in the Suntarsky district [9, p. 32065], [10, p. 20010], [15, p. 1652].

The aim of the research is to study the effect of zeolite honguruu on the growth and development, digestibility and metabolism of geese.

Research objectives:

– to study the growth and development of geese when feeding them zeolite honguruu;

– to indentify digestibility of nutrients and nitrogen metabolism of geese when honguruu zeolite is included in the diet.

Methods

The studies were carried out in the subsidiary farm of the Yakut State Agricultural Academy. Scientific and economic experiments were conducted on geese at the age of 8 weeks with the use of zeolite honguruu as part of their diet according to the following scheme (table 1).

Zeolite honguruu was mixed with a daily portion of the diet of birds. The geese were fed 4 times a day, the content is outdoor. The main diet was calculated on the basis of feeding rates, taking into account the availability of feed. The quality of feeding was controlled by live weight, age and the amount of feed consumed. At the end of the experiment, a pathological dissection of three geese from each group was performed, followed by a histological examination of the internal organs. The living conditions of all experimental birds were the same and corresponded to the technology adopted in the Yakut State Agricultural Academy farm.

Results

The organization of feeding geese has its own peculiarities of their growing technology [2, p. 526], [3, p. 536], [13, p. 888]. Therefore, the feeding of geese is taken into account with the calculation of the breeding season of birds, where they must have good nutrition. For a day, geese in a good pasture can consume up to 2 kg of green food.

It is known that geese are distinguished by an intensive metabolism [21, p. 288], [23, p. 2], therefore, their diets should contain all normalized organic, mineral substances and vitamins.

Under the conditions of industrial poultry farming, geese are fed with full-feed feed families in loose and granular form (pellet size does not exceed 6 mm), on average, geese can consume up to 330–350 g of feed per head per day.

There is a message that when energy is reduced to less than 1.01 MJ in compound feeds, a decrease in live weight is observed, and while ensuring high caloric content of compound feed (above 1.17 MJ), obesity and termination of egg laying are observed.

Therefore, the diets of geese should be optimal in accordance with modern detailed feeding standards. Feeding of adult geese should be carried out taking into account their biological cycle and level of productivity. Therefore, the quality control of feeding geese should be carried out systematically taking into account the live weight and quality of the eggs. When feeding goslings take into account the breed, age and direction of productivity. In the first eight weeks, goslings are characterized by very intensive growth, therefore, for sufficient supply, highly nutritious diets are required.

Table 1

Scheme of experience in testing honguruu in the diet of young geese

Group of birds	*Experimental groups*	*Number of animals*	*Feeding conditions*
Fattening young geese	*Control*	*20*	*BD*
	I experimental group	*20*	*BD + X 3 % of the dry matter of the diet*
	II experimental group	*20*	*BD + X 5 % of the dry matter of the diet*

Note: BD – basic diet, X – zeolite.

When growing geese, they can use the dry type of feeding, namely the use of full-feed compound feeds in accordance with modern classifiers (brands PK-31, PK-32, PK-33).

Peculiarities of feeding geese from other types of farm birds lies in the possibility of eating feed at night. Therefore, in the evening, the feeders are filled with feed and drinking water. With poor plumage, goslings need to include methionine or feather flour in the diet, and instead of water, drink a weak solution of sodium chloride (0.2–0.3 %) for 2–3 days to better cleanse the beak.

This must be done to preserve the number of birds.

During the day, geese can consume up to 2 kg of green food. Geese perfectly eat the green mass of legumes and cereal grasses.

Experimental geese on walking grounds from special feeders received up to 15 % of fresh herbs and mixed fodder, chalk, vitamin and amino acid supplements (lysine, methionine and cystine), to improve digestibility, along with gravel, they gave honguruu.

An active exercise was organized daily for experimental geese, feeding of experimental geese was organized 5–6 times a day until reaching 30 days of age, 4 times until reaching 60 days, 3 times – over 2 months of age. During the experiment, geese were provided with clean, warm drinking water, in order to improve the vitamin-amino acid nutrition of birds, trivit and methionine were additionally included in the diet (table 2).

Feeding analysis of geese meets the required feeding standards. Energy supply is 101.2 %; the ratio of calcium and phosphorus is 1.73:1, according to the composition of the essential amino acids, there are some differences in the lysine content of 85.4 %, methionine + cystine, respectively, 86.2 %; there is a lack of sodium of only 30 %.

The quality control of the feeding of experimental geese was evaluated by live weight and the amount of feed consumed.

At the age of 9 weeks, experimental birds consumed cereal grasses, complete feed from 30 to 90 g or more (per head per day), as well as 150 g of cabbage leaf (table 3).

At the end of the scientific and economic experiment, experimental geese consumed 270 g of mixed feed and 150 g of cabbage leaf or 3.040 MJ of exchange energy, which corresponded to the required feed for bird feeding in terms of energy content.

Thus, the analysis of the actual feeding of the experimental geese corresponded to the norms of feeding poultry.

According to [12, p. 11], the quality control of feeding young geese should be carried out according to live weight and average daily feed intake (table 4).

The live weight of the experimental geese was recorded at the beginning of the experiment – 3248–3254 g, at the end of the experiment it was 5180.06 g in the control, 5450.41 g in the experimental I and 5554.59 g in the experimental II (fig. 1).

The addition of 3 % honguruu to the main diet, or 8.6 g/day per head in the experimental group I increases the gross increase in live weight by 14.13 % ($P > 0.999$), in the experimental group II, where the supply of zeolite was 5 % (14,4 g/day) – by 19.22 %, compared with the control ($P > 0.999$).

Table 2

The ration of geese during the experiment (age 8 weeks, live weight 3250 g), per one head per day

Index	Norm	Geese group		
		Control	I experimental group	II experimental group
Compound feed, g		328	328	328
Cabbage leaf, g		100	100	100
Zeolite,% of the dry matter of the diet or g per day per 1 head		–	8.6 g	14.4 g
The ration contains, g:				
Metabolic energy, MJ	3.961	4.009	4.009	4.009
Dry matter	280.0	293.0	293.0	293.0
Crude protein	75.0	64.7	64.7	64.7
Crude fiber	15.0	18.0	18.0	18.0
Fat	8.0	7.8	7.8	7.8
Calcium	4.1	4.5	4.5	4.5
Phosphorus	2.7	2.4	2.4	2.4
Lizin	1.7	1.4	1.4	1.4
Methionine + cystine	1.5	1.3	1.3	1.3
Sodium	1.0	0.3	0.3	0.3

Table 3

Ration geese at the end of scientific experience, age 9 weeks

Index	The amount of feed, g	Metabolic energy, MJ	Dry matter, g	Crude protein, g	Crude fiber, g	Ca, g	P, g	Na, g
Compound feed	270	2.835	229.5	42.12	13.23	3.24	1.67	0.74
Cabbage leaf	150	0.209	21.3	3.6	2.85	0.24	0.06	0.07
Total	–	3.044	250.8	45.72	16.08	3.48	1.73	0.81
Normally required	–	3.040	243	44.2	17.35	3.98	1.83	0.84
Difference	–	+0.004	+7.8	+1.52	–1.27	–0.5	–0.1	-0.03
Enough feed, %	–	100.1	103.2	103.4	92.7	87.4	94.3	96.4

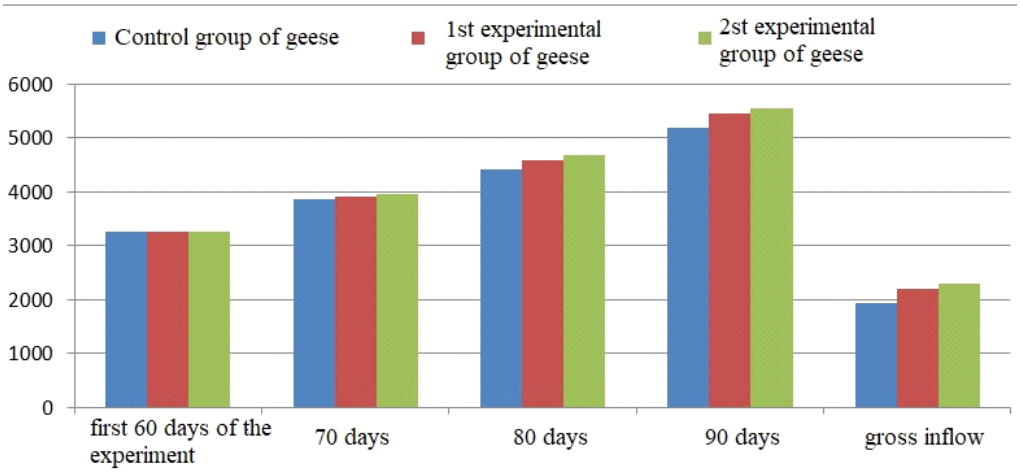

Fig. 1. Dynamics of live weight of experimental geese, g

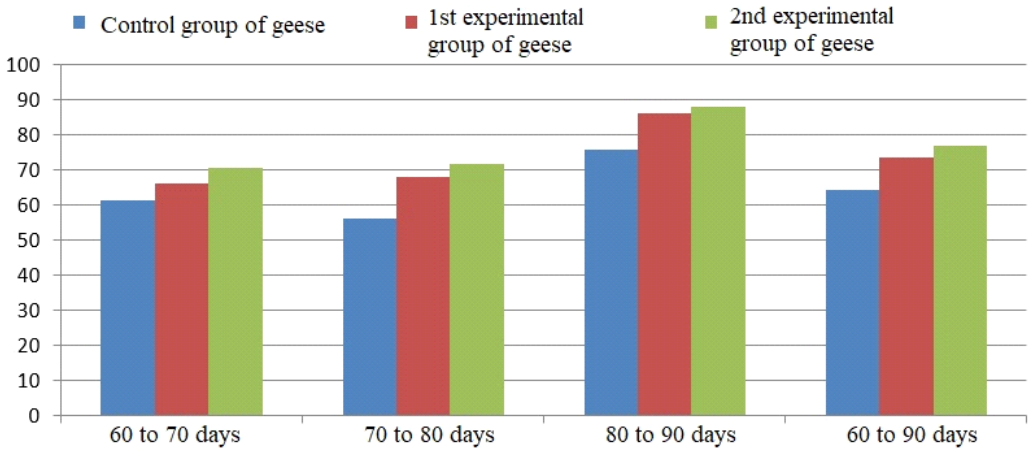

Fig. 2. The average daily gain in live weight of experimental geese, g

Table 4

Consumption of feed and nutrients of geese during the experiment (30 days), kg

Indicator	*During the experiment, one head per experience (all feed)*	*During the experiment, one head per experience (feed)*	*During the experiment for 20 animals per experiment (all feed)*	*During the experiment, 20 animals per experience (feed)*
Compound feed PK-32	*8.97*	*10.05*	*179.4*	*201.0*
Cabbage leaf	*3.75*		*75.0*	
Meadow grass, g	*5.10*		*153.0*	
Contained in the diet				
ME, MJ	*117.6*	*117.6*	*2 352.0*	*2 352.0*
ME, kcal	*28 350.0*	*28 350.0*	*567 000.0*	*567 000.0*
Crude protein, g	*1 769.1*	*1 809.0*	*35 382.0*	*36 180.0*
Calcium, g	*160.5*	*160.8*	*3 210.0*	*3 216.0*
Phosphorus, g	*74.7*	*80.4*	*1 494.0*	*1 608.0*
Sodium, g	*43.8*	*40.2*	*876.0*	*804.0*
Zeolite Honguruu (I experimental group), g	*300*	*300*	*6 000*	*6 000*
Zeolite Honguruu (II experimental group), g	*510*	*510*	*10 200*	*10 200*

The dynamics of average daily gains in live weight of geese with the inclusion of 3 % and 5 % honguruu is presented in the diagram (fig. 2).

The addition of honguruu to the daily diet of geese contributed to an increase in the average daily growth of young animals of the experimental groups of birds in comparison with the control group of geese by growing periods: in 60–70 days – 7.85 % and 15.24 %; in 70–80 days – by 21.73 % and 28.30 %, in 80–90 days – by 13.61 % and 15.76 %, respectively. On average, the control group lost 14.14 % and 19.22 % to the experimental groups of birds during the experiment. For all growing periods, the difference is significant $P > 0.999$. This proves that honguruu has a positive effect on the growth and development of experimental geese.

Table 5

The digestibility coefficient of nutrients of geese, % (M ± m, n = 3)

Geese group	Dry matter	Organic matter	Protein	Fat	Cellulose	nitrogen-freeextractive substances
Received with feed, g						
Control	269.82	248.21	56.95	13.73	19.76	157.76
I experimental group	269.82	248.21	56.95	13.73	19.76	157.76
II experimental group	269.82	248.21	56.95	13.73	19.76	157.76
Excreted in feces, g						
Control	94.93 ± 13.33	77.57 ± 10.50	10.44 ± 1.80	5.05 ± 0.88	9.42 ± 1.09	52.65 ± 6.85
I experimental group	92.51 ± 4.85	75.51 ± 3.87	10.07 ± 0.76	4.93 ± 0.48	9.35 ± 1.10	51.14 ± 2.75
II experimental group	90.67 ± 4.81	74.15 ± 3.81	9.91 ± 0.72	4.83 ± 0.54	8.98 ± 0.53	50.41 ± 2.95
Digested, g						
Control	174.88 ± 13.33	170.63 ± 10.50	46.50 ± 1.80	8.68 ± 0.88	10.34 ± 1.09	105.10 ± 6.85
I experimental group	177.30 ± 4.85	172.69 ± 3.87	46.87 ± 0.76	8.79 ± 0.48	10.41 ± 1.10	106.62 ± 2.75
II experimental group	179.14 ± 4.81	174.05 ± 3.81	47.03 ± 0.72	8.89 ± 0.54	10.78 ± 0.53	107.34 ± 2.95
Digestibility coefficient, %						
Control	64.81 ± 4.94	68.74 ± 4.23	81.66 ± 3.17	63.20 ± 6.44	52.33 ± 5.56	66.62 ± 4.34
I experimental group	65.71 ± 1.79	69.57 ± 1.56	82.30 ± 1.34	64.04 ± 3.52	52.66 ± 5.59	67.58 ± 1.74
II experimental group	66.39 ± 1.78	70.12 ± 1.53	82.58 ± 1.26	64.78 ± 3.99	54.54 ± 2.71	68.04 ± 1.87

Table 6

Nitrogen balance of experimental geese, (M ± m, n = 3)

Indicator	Geese groups		
	Control	I experimental group	II experimental group
Taken with food, g	3.17 ± 0.00	3.17 ± 0.00	3.17 ± 0.00
Allocated, g	1.74 ± 0.30	1.68 ± 0.13	1.52 ± 0.06
Digested, g	1.44 ± 0.30	1.49 ± 0.13	1.52 ± 0.06
Balance, (+, -)	+1.44 ± 0.30	+1.49 ± 0.13	+1.52 ± 0.06
Used from accepted,%	45.26 ± 9.47	47.12 ± 4.01	47.85 ± 2.00

The digestibility and nutritional balance of the diet in experimental geese was carried out in the middle of a scientific and economic experiment by putting 3 heads from each study group according to the generally accepted zootechnical method. The digestibility ratios of nutrients of birds are presented in table 5.

In the course of studies it was found that honguruu influenced the digestibility of nutrients, so the control group of geese lost to the experimental groups I and II of the birds in terms of indicators: dry matter by 0.9 % and 1.58 %, organic matter by 0.83 % and 1.38 %, protein 0.64 % and 0.92 %, fat 0.84 % and 1.58 %, fiber 0.33 % and 2.21 % and nitrogen-free extractive substances 0.96 % and 1.42 %, respectively.

An increase in the digestibility of nutrients in diet components in experimental groups of young geese is explained by the action of honguruu on the rate of digestion of feed.

The data of the balance sheet data are presented in table 6.

Studies have shown that the nitrogen balance in all groups of experimental geese was positive but had differences in the degree of deposition in the body. So geese of I and II of the experimental groups exceeded their counterparts from the control group in terms of nitrogen digestibility by 3.47 % and 5.56 %, respectively.

Discussion and Conclusion

Thus, the experimental data showed that the inclusion of honguruu in the diet of experimental geese contributed to a better assimilation of nitrogen by the body. At the same time, the best dose that showed the highest result was honurin at a dose of 5 % of the dry matter of the diet.

References

1. Alekseev V. A., Nemtseva E. Yu., Evdokimov N. V., Lavrentiev A. Y., Sherne V. S., Petrov N. S., Danilova N. V. The effect of the mineral supplement “Permait” and vitamin B13 on the productivity of broiler chickens // IOP Conference Series: Earth and Environmental Science. 2020. Vol. 433. No. 1. P. 012020.

2. Arroyo J., Fortun-Lamothe L., Lavigne F. Influence of choice feeding and cereal types (maize or triticale), during the growing-finishing period on performance of geese used for foie gras production [Conference poster] // 12e Journées de la Recherche Avicole et Palmipèdes à Foie Gras. 2017. 5 & 6 Avril. Tours, France. Pp. 526–530.

3. Arroyo J., Lavigne F., Bannelier C., Fortun-Lamothe L. Influence of the incorporation of the sugar beet pulp in the diet in farm geese for the foie gras production [Conference poster] // 12e Journées de la Recherche Avicole et Palmipèdes à Foie Gras. 2017. 5 & 6 Avril. Tours, France. Pp. 536–540.

4. Basha H. A., Goma A.A., Taha A. E., Abou Elkhair R. Effect of different forms of natural zeolite (clinoptilolite) on productive performance and behavioral patterns of broiler chickens. International Journal of Agriculture Science and Veterinary Medicine. 2016. No. 4(4). Pp. 1–11.
5. Belkin B. L., Kubasov V. A. Ispol'zovaniye Khotynetskikh prirodnykh tseolitov v veterinarii i ptitsevodstve [The use of Khotynetsk natural zeolites in veterinary medicine and poultry farming] // Vestnik OrelGAU. 2011. No. 6 (33). Pp. 35–38. (In Russian.)
6. Bİntaş E., Özdoğan M. Effects of feeds containing boron and zeolite on aged laying hens // Journal of Tekirdag Agricultural Faculty. 2017. No. 14 (2). Pp. 101–109.
7. Dragotoiu D., Marin M., Pogurschi E., Dragotoiu T. The efficiency of using zeolites in dairy farms // International Multidisciplinary Scientific GeoConference: SGEM: Surveying Geology & mining Ecology Management. 2017. No. 17. Pp. 1129–1136.
8. Eroglu N., Emekci M., Athanassiou C. G. Applications of natural zeolites on agriculture and food production // Journal of the Science of Food and Agriculture. 2017. No. 97 (11). Pp. 3487–3499.
9. Egorova A., Zhirkova L., Emelianova Z. Honguruu as hydraulic additive to magnesian-binding substance // IOP Conference Series: Materials Science and Engineering. 2018. Vol. 365. No. 3. P. 032065.
10. Innokentieva L. S., Egorova A. D., Emelianova Z. V. Peculiarities of the processes of hydration of binding substances in the arbolite mixture // AIP Conference Proceedings. 2017. Vol. 1886. No. 01. P. 020010.
11. Jarosz Ł., Stępień-Pyśniak D., Grądzki Z., Kapica M., Gacek A. The effect of feed supplementation with Zakarpacki zeolite (clinoptilolite) on percentages of T and B lymphocytes and cytokine concentrations in poultry // Poultry science. 2017. No. 96 (7). Pp. 2091–2097.
12. Kalashnikov A. P. Normy i ratsiony kormleniya sel'skokhozyaystvennykh zhivotnykh [Norms and diet for feeding of agricultural animals]. Moscow, 2003. 450 p. (In Russian.)
13. Karwowska M., Grabowicz M., Stadnik J., Szterk P., Bernacki Z., Dolatowski Z. J. The effect of corn or beet pulp silage supplemented diet on production parameters, oxidative stability of muscles and fatty acid composition of abdominal fat in geese // Annals of Animal Science. 2017. No. 17 (3). Pp. 887–902.
14. Makarenko L. Yu. Effektivnost' ispol'zovaniya tseolita pegasskogo mestorozhdeniya v kormlenii krupnogo rogatogo skota: dissertatsiya na soiskanie uchenoi stepeni doktora sel'skokhozyaistvennykh nauk [Efficiency of using the zeolite of the Pegasus field in cattle feeding: dissertation for the degree of doctor of agricultural sciences]. Kemerovo, 2003. 289 p. (In Russian.)
15. Nikolaeva N. A., Pankratov V. V., Chernogradskaya N. M.б Grigoriev M. F. The use of feed additives in the diet of cows and young cattle in Yakutia // Biosciences Biotechnology Research Asia. 2015. No. 12 (2). Pp. 1651–1657. DOI: http://dx.doi.org/10.13005/bbra/1827.
16. Pavlenko Yu. V. Agropromyshlennaya geologiya: shivyrtuin [Agro-industrial geology shivyrtuin] // Transbaikal State University Journal. 2018. No. 24 (4). Pp. 33–42. (In Russian.)
17. Prasai T. P., Walsh K. B., Bhattarai S. P., Midmore D. J., Van T. T., Moore R. J., Stanley D. Biochar, bentonite and zeolite supplemented feeding of layer chickens alters intestinal microbiota and reduces campylobacter load // PLoS One. 2016. No. 11 (4). Pp. 1-6.
18. Prasai T. P., Walsh K. B., Midmore D. J., Bhattarai S. P. Effect of biochar, zeolite and bentonite feed supplements on egg yield and excreta attributes // Animal Production Science. 2018. No. 58 (9). Pp. 1632–1641.
19. Rajendran R. M., Umesh B., Chirakkal H. Assessment of H-β zeolite as an ochratoxin binder for poultry // Poultry science. 2020. No. 99 (1). Pp. 76–88.
20. Valpotić H., Gračner D., Turk R., Đuričić D., Vince S., Folnožić I., Getz I. Zeolite clinoptilolite nanoporous feed additive for animals of veterinary importance: potentials and limitations // Periodicum biologorum. 2017. No. 119 (3). Pp. 159–172.
21. Wang W., Cao J., Yang F., Wang X., Zheng S., Sharshov K., Li L. High-throughput sequencing reveals the core gut microbiome of Bar-headed goose (Anser indicus) in different wintering areas in Tibet // Microbiology Open. 2016. No. 5 (2). Pp. 287–295.
22. Wawrzyniak A., Kapica M., Stępień-Pyśniak D., Łuszczewska-Sierakowska I., Szewerniak R., Jarosz Ł. The effect of dietary supplementation of transcarpathian zeolite on intestinal morphology in female broiler chickens // Journal of Applied Poultry Research. 2017. No. 26 (3). Pp. 421–430.
23. Xu Q., Yuan X., Gu T., Li Yu., Dai W., Shen X. Chen G. Comparative characterization of bacterial communities in geese fed all-grass or high-grain diets // PloS one. 2017. No. 12 (10). Pp. 1–7.

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