

AGRONOMY AND AGROECOLOGY АГРОНОМИЯ И АГРОЭКОЛОГИЯ

NATURAL ZEOLITES IN POULTRY FARMING

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The review paper is devoted to the analysis of work performed in the republics of the former Soviet Union, to identify the use of such mineral additives to animal feed, as natural zeolites. Despite the mixed results of several studies, as a whole, this supplement has a positive effect on the development and growth of poultry, in particular, on the increase in body weight of chicks and their livestock as well as egg production and quality hatching eggs of laying hens.

Poultry farming is one of the most important sectors of agriculture, providing population with full food (meat, eggs). Main poultry products are egg and meat, by-products fluff and feather. Development of poultry farming is linked to the strengthening of forage base: grain, animal feed and feed dry yeast, grass flour, vitamin preparations, biologically active substances, as well as mineral supplements. It is very important to thoroughly examine the country's mineral resources, establish standards and methods of their use in the poultry industry. One of the sources of such minerals is natural zeolites of sedimentary origin. This is a very cheap and affordable mineral raw material, which by the end of the last century began to be used in the poultry industry. Natural zeolites are used in two directions.

The first area is feeding of poultry with the feed containing a certain amount of zeolite tuffs, that in the case of chickens-broilers provides the increase in their weight and keeping of livestock, in the case of laying hens it fosters their egg production. In both cases, the costs of fodder decrease in comparison with standard feeds, without zeolite additives.

The second area is the use of natural zeolites to provide normal sanitary conditions on poultry farms. Japan was the first to consider the usefulness of the zeolite-containing tuffs as additives to animal feed intended for feeding poultry [1]. In Japan there are more than ten deposits of zeolite-containing rocks with a high content of clinoptilolite and mordenite [2].

The efficacy of the two types of natural zeolites as feed additives in feeding poultry were studied [3-5].

Chickens were divided into seven groups (Table 1). Chickens in the first three groups (I, II, III) were fed with compound feed containing clinoptilolite –containing tuff in quantities of 10, 5 and 3 %. In the fourth, fifth and sixth (IV, V, VI) groups chickens were fed with the feed containing mordenite tuff in the same quantities of 10, 5 and 3 %. The seventh Group (VII) chicks (control) received feed without zeolite additives. The experiment duration was 14 days. Using zeolite additives contributed to increased live weight gains of chicks at the end of the experiment compared with controls. Maximum gain of BW (47.7%) was observed in chickens fed with 10% supplement of clinoptilolite tuff as well as chicks (48%) who received 3% additive of mordenite tuff (41.2% in the control). preservation of the chicks in all groups during the experiment was 100%. All in all, feed consumption and drinking water in all experimental groups were significantly lower than the control.

Approximately ten years later, similar experiments were initiated in a number of other countries: the United States, the former Soviet Union, Bulgaria, Hungary, Romania, Cuba, etc., i.e. in the countries where zeolite-containing tuffs were found and exploited. In Georgia, clinoptilolite-heilandite; phillipsite-; analcime-; lomontite-and partly mordenite containing rocks represent the industrial significance [6]. Currently, Georgia has identified six zeolite districts [6.7]. For the first time in Georgia studies to determine the feasibility of utilization of natural zeolites as mineral additives to animal feed intended for feeding poultry, were started in 1974-1975. These studies were developed in two directions: feeding laying hens and broiler chickens. Only clinoptilolite-heilanditetuffs of Dzegvi-Tedzami deposit were used as additives.

First in small quantities were selected laying hens 150 days of age, who were divided into three groups, in equal quantities [8]. In the first group (control) chickens were fed with standard mixed feed without zeolitic additives. In the second and third groups (experimental) in the feed were added respectively 1 and 3% of zeolite. Experiment duration was 52 days. The best results of a living mass of chickens, egg production and average egg weight were obtained in the second group. The experiment was continued in an expanded version, with a lot of experimental chickens. The first group was control, and the second was experimental. In the mixed fodder of the second group was added zeolite in the amount of 1.3% instead of 1.2% corn and 0.3% shells. The experiment lasted 153 days, at the end of the experiment the following indicators were identified: safety of livestock, changes in body weight, consumption of poultry feed, egg laying, hatching egg quality and digestibility of nutrients.

For all these indicators the best results were obtained in chickens of experimental group compared to the control group. Egg laying increased by 4.42%; hatchability-7.54%; rate of digestibility of crude protein and phosphorus by 5.1% and 12.7%. The second direction research objects served chicken broilers of a day old.

Chickens were divided into two groups: experimental and control. Chickens from the experimental group were fed with compound feed containing zeolitic tuff in the amount of 5%, granule size 1-2.5 mm. Experiment duration was 60 days [9]. In subsequent experiments [10.11] was investigated the effect of the size of tuff grinding on growth and development of the chicks of egg direction. To do this, the feed, at the expense of reducing its weight part,

was injected with 5% clinoptilolite-containing tuff, both in the form of crumbs (1-2.5 mm) and in the form of powder. On the 60<sup>th</sup> day of experiment, the live weight of chicks treated with zeolite as a crumb, was 8.7% higher, and feed consumption per unit of weight gain by 1% lower than in the broilers treated with powdered zeolite. Using zeolite as a crumb, promotes better digestion of nutrients than powder, use of 3% additive of zeolite in feed for growing chicks to a nine-week age improves a number of indicators (Table 2).

Experiments [12] on the effectiveness of the use of synthetic zeolites (CaA, NaA) and natural zeolite-clinoptilolite, has revealed the unsuitability of synthetic zeolites in feeding poultry because of low biological activity in comparison with natural zeolite. Zeolite NaA did even worse. The age of chicks was determined from which it is most effective to begin their feeding with zeolite compounds [13]. If you use 5% clinoptilolite tuff, it is most favourable to feed broilers from 24-hour age. The influence of both synthetic (CaA, NaA) and natural-clinoptilolite tuffs on the blood composition of the test chicks was studied [14]. Application of clinoptilolite in the feed of chickens as an ingredient contributes to the accumulation of glycogen in the hepatic cells, indicating the activation of the intracellular biosynthesis [15]. The work [16] shows the possibility of use of waste clinoptilolite in poultry farming. The possibility of feeding poultry with rocks with a relatively low content of zeolite has been identified [17]. The object of the study served zeolite-containing tuffs of Noemberyan deposit (Armenia) with different content of clinoptilolite and montmorillonite in horizontal layers of rock sediments. The investigation was conducted on the influence of zeolitic rocks selected from the various layers of the deposits, on meat productivity of broilers. Tuffs, with particle size of 1-2 mm were applied in full feed at the rate of 5% of their total mass. During 50 days of the experiment average daily gain of body weight of the chickens in the experimental groups increased from the first group by 2.0%; from the second-8.8 % and the third -10.2% compared with the control.

In Transcarpathia there are huge deposits of natural clinoptilolite and mordenite of sedimentary origin with high content of essential minerals [7.18]. The experiments were performed to identify the effect of zeolitic additives to animal feed on the growth and development of the broiler chicks [19].

In the first experiment, as zeolitic additives were used finely ground clinoptilolite tuffs up to 100 microns, grade b of Sokyrnitsky deposit. In the experimental groups, the cost of animal feed was 4.3-5.8% lower than in the control. Chemical composition of chicken meat was the same. In the second experiment as a mineral supplement was used tuff with a high content of clinoptilolite (75-80%), with a larger grinding 0.16-0.35 mm. Six groups were formed, one control, the other five experimental, in which compound feed contained tuff in the amount of 2-10%. Experiment with daily chickens lasted 56 days. It was found that the doses of the supplements do not affect negatively the safety of chickens, even in some cases this indicator increases by 2-3% as compared with the control. However, by the end of the experiment, there is a decrease in body weight, the chicks, in the experimental groups 98,7-82.5% (control 100%).

In order to identify the optimal dose of clinoptilolite supplements, optimum degree of grinding and the content of the main mineral in the rocks in poultry feed, a series of experiments were conducted in the Crimean 1974-1981 [20]. Test objects served clinoptilolite-containing tuffs of the Sokyrnitsky and Kraynikovsky deposits that differ in cationic composition of zeolite and zeolite content in the rock. Tuff from Sokyrnitsky deposit contains different number of main mineral depending on the grade of A and B : 76-

75,4% and 55-60%, respectively. Zeolitic rocks from the Kraynikovsky deposit correspond to class A regarding the content of clinoptilolite.

The impact of their effect is stronger in the case of variety A, that is probably due to the high content of clinoptilolite in the rock. In most of the test groups where hens were fed with combined feed containing 2, 4, 5, 6, 8 and 10% clinoptilolite, safety of chickens is higher than in the control by 0.5-2.0%. The most effective is the animal feed containing 6% clinoptilolite. In the first case, when feeding chickens with 6% additive of clinoptilolite, on the 56<sup>th</sup> and 63<sup>th</sup> days of the experiment, live weight of chicken increased by 37%, expenses decreased by 8.4% per 1 kg gain; output of the first category increased by 4.6% compared with controls. In the second case, the figures were respectively: 12.6; 3.10 and 28.5%. Safety of livestock in the first case, increased by 0.3 percent, in the second it dropped by 3.8% compared with the control. These experiments show that adding 6% clinoptilolite in the feed increases the digestibility of nutrient and digestibility coefficient as well as the content of vitamin A and carotene in the liver of chickens compared with the control group [21].

The work deals with [22] the influence of two types of feed on the process of feeding chickens: when clinoptilolite additive was added to the main compound feed (1) and as a component of mixed feed (2). Percentage content of clinoptilolite 2, 4 and 6%, 1.2 and 3 mm grinding. The experiment was run with chickens daily in 10 variants using the above feed. The use of clinoptilolite additives influences the weight gain of chicks. The largest increase was observed in groups, where the first type of fodder was used, and in the third group (feed containing 2% clinoptilolite with 2 mm grinding), when feeding the chicks with feed of the second type – in the tenth group (when feeding with the feed containing 6% clinoptilolite, grinding 2 mm). In the experimental groups there was a reduction in the cost of feed per 1 kg gain compared with controls.

In order to make animal feed, a research on the possibility of relatively high doses of zeolite additives was done [23]. Zeolite-containing tuff of grade "b" from Sokirnitisky was used. In the first experiment with chickens from 5 to 90 days of age chickens were fed with compound feed plus zeolite addition of 2.4 and 5.0%, from 91 to 150 days to 4.8 and 7.5% of the dose. At the end of the experiment, there was a slight increase in body weight of chicks in the experimental groups, while retaining the control of livestock, feed costs decreased by 5.1% for 1 kg gain compared with controls. A similar experiment was carried out with the laying hens. For 270 days a productive period of chickens fed with zeolite additive in amount 4 and 8%, reduced egg production, however, with increasing to 12% additives, egg production increased compared with controls. There was also an increase in the mass of eggs, the strength of the shell. In the experimental groups increased fertility and hatchability of eggs. The use of additives containing 8-12% clinoptilolite supplements helps reduce the cost of feed per unit of output by 5-15%.

The paper deals with [24] the effectiveness of zeolite additives in feeding of chickens of different ages with compound feed different levels of crude protein. As a mineral supplement was used clinoptilolite-containing tuffs grade "A" of Sokirnitisky deposit. Application of natural zeolites in feeding broilers is acceptable when feeding chickens, feed contains 100 grams of 21 and 19 crude protein, depending on the growing period: 5-28 and 29-49 days.

The lower limit of protein in feeds with the zeolite must be at least 20 % in the first growing period and 16.5 % in the second growing period . 6% of natural zeolite in feed for broilers should be added for five- day old chicks until the end of growing. Based on the research [25] on the development of methods and efficient use of natural zeolites grade "A" , "B" and "B" of

Sokirnitsky deposits it was found that feeding poultry with the additive which includes clinoptilolite is profitable. In compound feed produced in the Transcarpathian region, there is a significant shortage of calcium, phosphorus, copper, cobalt, manganese, zinc, etc., which is the cause of the disease of chickens with microelementoses [26]. The use of natural zeolites of Sokirnitsky and Ganichsky deposits has been proposed, in which the content of manganese, copper, zinc and nickel ranges from 0.001-0.02%, calcium - 3.3%, potassium - 2.9%, iron - 2.5%. Adding to the feed of clinoptilolite of Sokirnitsky deposit, while feeding broilers caused a significant increase in the content of manganese and iron in the liver of chickens [27].

Using zeolite crumbs in combined feed is more efficient than traditionally used in poultry feeding supplements as physiological and mechanical factors of digestion [28]. This is confirmed by American and South African scientists [29]. In the work [30], performed in Ukraine, was proposed manufacturing feed additive based on zeolites and poultry industry waste. The technology of preparation of this feed additive was developed consisting of zeolite and bird blood, named by the author as "blood-zeolite flour". This supplement consists of (in %): moisture - 11.7, crude protein - 33.3, crude fat - 0.84, ash - 30.7, BEV - 23.46, calcium - 1.9, P - 0.3. These additives are very similar to those of powdered milk.

There were two trials with broilers and laying hens fed on feed enriched with clinoptilolite-containing tuff (Dzegvi deposit) [31]. The first experiment was conducted with chicken broilers of 8-weeks, placed in 4 groups. The first group (control) received only feed. The second, third and fourth (experimental) groups were fed on mixed feed with zeolite in an amount of forage 3.5 and 7.0%. Feeding was carried out up to 21 weeks of age of chickens. At the end of the experiment in all groups the safety of livestock was high - 98.8%. Live weight gain in the experimental groups compared with the control, was not observed, but there was a decrease of feed costs in the experimental groups: 2.5, 4.3 and 7.7%. In the experimental groups, chickens increased the digestibility of protein and nitrogen as compared with the control. In the second experiment, with the laying hens in the experimental groups treated with feed 3 and 5% of zeolite supplements, egg production increased compared with controls: 69.7 and 71.2% (66.8% in the control), and decreased feed consumption per 10 eggs (kg) 1.53, 1.46 (control 1.60). The quality of eggs slightly improved, levels of vitamin A, carotenoids, riboflavin in egg yolk increased.

The experiment showed the efficiency of using clinoptilolite-containing tuffs of Dzegvi deposit as a mineral additive to animal feed, when fed to chickens from a day to 56 days of age [32]. Chicks were placed in two groups. The first (control) received a full feed. The second (experimental) - 95% of the same feed with 5% additive of zeolite tuff gained 1.0-2.5 mm. At the end of the experiment the live weight of chickens in the experimental group was 3.4% higher and the yield of the carcasses of the first category is 6% more control.

Experiments on the use of zeolite supplement in the diet of poultry, showed their efficiency in relation to broiler chickens (live weight gain, safety stock, the use of feed nutrients, low cost of feed) [33]. Positive effect of zeolite additive in feeding was obtained for water flocks as well. Using mineral supplements (clinoptilolite-containing tuff) contributed to the increase in preservation of ducklings by 1.7-2.5%, live weight by 1.7 - 5.5%, decrease in feed consumption per unit of production by 2.0-5.3% [34]. Output of standard carcasses is 2.0-3.4% higher compared with the control.

The experiments on feeding ducklings and goslings with fodder enriched with zeolite tuff of Dzegvi deposit showed greater efficiency of feed mixtures [35].

In the first experiment ducklings of 2 weeks were divided into four groups. In the experimental groups (2,3,4) ducklings received diets containing 3.0, 5.0 and 7.0 % clinoptilolite. The first group (control) received only feed additives without zeolite. By the end of the experiment (on the 50th day) live weight of ducklings in the experimental groups increased by an average of 4%, the cost of feed per unit of gain decreased by 11-13% compared with control. Safety of livestock in all experimental groups was 97-99%.

In the second experiment geese (30 to 120 days old) were placed into two groups. In the first group (experimental) goslings received feed with 5% addition of clinoptilolite. The second (control) group received only feed. At the end of the experiment, average daily weight gain of goslings in the experimental group was higher than the control by 7.6%, reducing the cost of feed per unit of gain. Safety of livestock was 97-98%.

The paper gives [35] the results of feeding week-old birds with natural zeolites from Sibai and Baynak deposits. When using zeolite in the amount of 3% of the daily norm feed, egg fertilization on the 48th week was 96.67 and 97.5% (91.67% in the control), output of chickens - 95.83 and 96.67% (in the control group - 85.0%), incubation waste decreased in the experimental group compared to the control group. In the experimental group there was a slight increase in the content of carotene and vitamin A in the egg yolk and vitamin B2 protein.

The paper [36] presents the data on efficiency of glauconite (Karinsky deposit, Chelyabinsk region) and zeolite of deposits of Sibai as mineral supplements to mixed fodder. In the first (control) group feeding was carried out only with forage, in the second (experimental) group - with the addition of glauconite and in the third - forage supplemented with zeolite. Average daily gain in the experimental groups was superior to the control by 6.8 and 10.8%, respectively, preservation - 96.08 - 96.45% (92.33% in the control). Digestibility of forages in the experimental groups increased compared with the control. Thus, in the second group, crude protein by 2.0%, crude fat - 2.45% and BEV - by 5.05% in the third group - by 4.24, 2.44 and 5.66% respectively.

Slaughter yield of carcasses in the second group was superior to the yield of the control group by 1.55%, and the third - 2.08%. The consumption of feed per kg of absolute growth declined by 6.3 and 9.8%. Regarding the effectiveness of the positive effects of feeding chickens zeolite supplement exceeds glauconite.

In the period 2005-2007 [37] a series of works were carried out on the use of natural zeolites of Baynak deposits mineral feed additives. The experiment was conducted on a large population of ducks of both sexes of 180 days old. The poultry was distributed into five groups. The first group (control) received only full feed. Others (2,3,4,5) were experimental, which were fed with the feed mixed with 2.0, 3.0, 3.5 and 4.0% of zeolite rocks respectively. The duration of the experiment was 100 days. In general, it was found that the ducks and drakes treated with mineral additive in a dose of 3.5% from the weight of the feed, were characterized by high levels of safety, egg production, hatching egg quality, the reproduction compared with the 2.0, 3.0 and 4.0% - additives. The most optimal is the introduction of the zeolite into the feed at a dose of 3.5% by weight. In Siberia, more than 20 deposits of zeolite materials were discovered [38]: heulandite, clinoptilolites and partly mordenite. The content of these minerals in rocks is 15-90% [38].

In Siberia, two experiments were conducted on feeding with heulandite of Pegas deposit [39]. The first experiment was conducted with adult birds, 166 days old. Chickens were divided into three groups. The first (control) received only feed. The second (experimental)

received 10 % feed of zeolite-containing tuff. Third ( experimental) - feed + 5 % tuff. The duration of experiment was eight months (November to June). In the third group of chickens throughout the experiment was observed monthly increase in egg production by 1,9-9,1 % compared with the control. In chickens in the second group in the initial two months egg production decreased by 5.0 and 7.5 % compared to the control. In this regard, the dosage of zeolite was decreased to 3%, resulting in increased productivity of laying hens to the end of the experiment. In May, egg production increased by 13.4% compared with the control.

The second experiment was performed with 1- day old broilers, which were divided into six groups. In the first ( control) group feeding was carried out without zeolite forage additives . In the other five groups (experimental) broilers received feed supplement with zeolite in an amount of 2 , 3, 4, 5 and 6 %. Duration of experiment was 61 days. The maximum gain in body weight in the group receiving heilandite additive in an amount of 3%, was as follows: 10.58 % in males, females - 8.04 % compared to control. Increasing doses of zeolite in feed led to a decrease in live weight and reached a minimum in the group fed with 6 % zeolite addition. This result was similar to the results from the control group of hens. Safety of livestock during the experiment in the experimental groups was 88,33-95,0 % (in control - 93%).

In the experiment [40] conducted with day-old chicks, adding heilandite tuff to the mixed fodder in the amount of 2, 4, and 6% by the end of the 12th week results in increased live weight of chickens in all experimental groups. The greatest increase in live weight was observed in chickens fed with zeolite feed additive in an amount of 6%, 4.7% higher than the control group [39]. In this group, maximized safety livestock is 98.75% (93.75% in the control). Feed consumption per unit gain decreased for chickens from this group from 465 kg to 424 kg.

The work gives [41] the results of six studies on the effects of heilandite additives of Pegas deposits that were made in the animal feed in an amount of 2 , 4 and 6% , on the intensity of laying. In chickens fed with feed (94% of the basic diet + 6 % heulandite) egg production increased by 13.29 %, the safety of livestock - by 3.7%. Feed consumption per 1 kg gain decreased by 3.9%. In the experimental hens with increasing dosage of the zeolite increased the total protein, albumin, calcium and the alkali reserve in the blood serum. Analysis of experimental hens' eggs showed increase in carotene by 0,6-3,4 mg/kg, vitamin A by 0,63-3,36 mg/kg, vitamin B2 in 0,66-2,68 mg/kg compared with control. Studies were conducted to determine the optimal dose of zeolite additives (for example Pegasin) necessary for maximum egg production of laying hens and livestock preservation [42]. For this six groups of 150 -day laying hens were formed by analogy. The first group (control) received feed without Pegasin. The experimental group (2-6) chickens were fed with the additive Pegasin to the feed in an amount of 6,7,8,9 and 10 %, respectively. It was established that productivity of chickens in the second group is by 7.29 %, the third - by 3.83 %, the fourth - by 3.40 % higher than in the chickens of the control group (Table 4).

The efficiency of the fifth and sixth groups of hens decreased by 0.4 and 1.8 % compared to the control. Average weight of eggs from hens of the experimental groups were higher than the control, the cost of feed per 1000 pieces dropped. The best results were obtained for chickens in the diet containing 6 % Pegasin. Egg laying per hen increased by 7.29 %, the intensity of laying - by 4.7%, the safety of livestock - 3.7 %, reducing the consumption of feed per 1000 pieces by 14.55 %, compared with a control group of hens . Biochemical analysis of blood serum of chickens from experimental groups showed improvement in some

indicators: content of albumin 1,2-4,6 % , total protein 0,42-0,57 % higher than the control [43]. The experiment was conducted with chickens cross "Hisex white", selected on the basis of analogues and placed into two groups : control and experimental .

It was found that Pegasin also positively affect the use of energy and digestibility of nutrients[45]. Pegasin is considered as a means of preventing nutrition-related diseases of poultry. In the experimental groups , where chickens consume food enriched with Pegasin , broilers' deaths from metabolic disorders decreased by 1.4 %; coccidiosis - 3.3%; colibacilliosis - 0.7% compared with the control. Identification of possible use of rocks with a lower content of the zeolite in the feeding of birds is an issue of interest. To this end, the experiments were performed in broilers with Pegasin containing 40 and 68 % heulandite in the rock [46]. The average live weight gain of the experimental groups of chickens increased by 10.3 , 9.2 , 6.5 and 7.6 % compared with the control. Pegasin with 40 % content of zeolite in its effectiveness in feeding broilers is almost equal to Pegasin with 68 % content of the zeolite.

В другой работе [47] производственными опытами доказана целесообразность использования горных пород с низким содержанием цеолита в кормлении кур.

Другой опыт [48] (продолжительность 214 дней) показал, что включение в рацион кур-несушек сахаптина в дозе 4%, позволило повысить сохранность поголовья на 2,3%, яйценоскость на 7,5%, а затраты корма на 1000 штук яиц сократились на 10% по сравнению с показателями контрольной группы. Авторами [49] предложена новая кормовая добавка – цеогумитон, изготовленная путём смешения гумитона и сахаптина, в процессе которого сахаптин адсорбирует гумитон.

В одной из работ [50] пегасин рассматривается как источник микроэлементов, при внесении его в качестве добавки к комбикормам.

Подсчитано [51], что при производстве мяса птицы и яиц снижение затрат на единицу продукции только на 1%, позволило сэкономить в птицеводстве Кемеровской области до 2-х тысяч тонн корма в год. В практике птицеводства, оптимальной дозой внесения в комбикорма минеральных добавок, в частности природных цеолитов, считается 3-6% этого минерала.

In another study [47] production experiment proved the feasibility of using rocks with low zeolite content in feeding chickens. Another experiment [48] (duration 214 days ) showed that the inclusion of sahapitin in dose of 4 % in the diet of laying hens, allowed to increase the safety of livestock 2.3%, egg production by 7.5 % , while the consumption of feed per 1000 eggs decreased 10% compared with the control group. Authors [49] proposed a new

feed additive - zeohumiton made by mixing humiton and sahaptin, during which sahaptin adsorbs humiton. In one study [50] Pegasin is seen as a source of trace elements, inserting it as an additive to feed.

It is estimated [51] that the production of poultry meat and egg, reduction of production costs per by only 1% , resulted in savings in poultry of Kemerovo region up to 2 thous.tons of feed per year. In the practice of the poultry, the optimal dose of mineral feed additive, in particular natural zeolites is considered to be 6.3 % of the mineral.

The authors of the work [52] in order to limit the consumption of basic diet and nutrition , conducted an experiment to identify the possibility of using large doses of zeolite additives (for example, Pegasin) in feeding broiler chickens 41 days of age and laying hens. We investigated the possibility of using the following doses of zeolite as compound feed additives: 10,15,20,30, 40%. Average daily gain was greatest with the addition of 10% zeolite, with a 100% safety of livestock and decreased feed consumption by 15 -22 % compared with the control.

The foregoing zeolites have been used in the study [53] in order to identify the maximum tolerated dose of making a mineral feed additive in feeding chickens. It was found that egg-laying of experimental hens was by 20.8 % higher than the control, hatching egg properties were better in chickens fed with zeolites. Hatchability of eggs in experimental hens was 91%, in control - 75%.

In another similar experiment [54] the positive impact of fodder with high zeolite content (20%) is noted on egg laying hens. For the six-month reference period, it was higher than the control by an average of 27%. Hatching egg properties from the chickens of the experimental group were also better (Table 7). However , prolonged use of compound feed with a high content of zeolite ( 20%), when fed to chickens for 12 months, had a negative impact on the body of the experimental birds [55,56].

Experiments carried out [57,58] on 10- day-old broilers cross "Broiler" and "hybridization-6", shows the efficiency of the use of 55-60 % clinoptilolite-containing rocks of Holinsky deposit as a mineral supplement to mixed fodder when feeding chickens. Experiments conducted using zeolites of Pashensky deposit despite the low content of the main mineral heulandite -40% , when fed to chickens cross "hybridization-6" as a mineral additive, had a positive impact on such factors as an increase in live weight of broilers , the preservation of their livestock, feed consumption per 1 kg of growth [59,60]. Novosibirsk on farm experiment was carried out on the comparative evaluation of different deposits of zeolites used in the feeding of broilers as a mineral supplement[61]. In the experiment, feed was added 3 % zeolites of the following deposits :Dzegvi (Georgia), Pegassky and Pashensky (Siberia). Maximum live weight gain of chicks was obtained from a group where Georgian zeolites were used, among Siberian it wasPegasin. Inclusion of 3% zeolite-containing tuff of Dzegviand Pegassky deposits in feed mixtures increased live weight gain by7.6 and 5.0% , and the safety by 5.5 and 6.8% , reduced cost of feed per unit gain by7.1 and 8.8% compared to the control group. In another study [62] experiments were carried out feeding poultry with zeolites of different deposits: Tedzami (Georgia), Pegassky ( Kemerovo region, Siberia) and Hongurinsky (Yakutia). Feeding chickens on zeolite had a positive impact on the quality of hatching eggs. Thus, the percentage of hatchability of chickens in the experimental groups was 89-93 % ( 71.8% in the control). Scientists [63] conducted a study to identify possible use of other sources of raw materials in Siberia as a mineral supplement (limestone, granite, quartz sand) and to compare the effectiveness of their use in poultry with natural zeolite

(hongurinom ). The best results in terms of productivity of chickens (compared to controls) were obtained in experiments with hongurin and granite as mineral additives. In all experimental groups was observed saving food, increase in the number of laid eggs, their weight, a reduction in mortality of birds, eggs battlefield and notches. Economic effect only on the above data was about 20%.

Zeolite rocks of Western Yakutia are of particular interest [64,65]. The first experiments to identify the effectiveness of the use of zeolites of these deposits in feeding birds were conducted at the poultry farm in Yakutsk [66] with laying hens of 9-10 months old. By the end of the experiment the productivity of the test group hens, which used the feed from 2% zeolite additive increased slightly, only 0.7 % compared with the control. In other groups productivity decreased by 5,6-1,9 %. However, in all experimental groups safety of livestock increased to 97,5-98,1 % (82.2% in the control).

Further investigations [67] show slightly different results. The addition of 3-5% hongurin to feed increased egg production by 4,3-7,4 %, the absolute gain in live weight increased by 6 and 9 %, and ensured the normal physiological state of the bird.

The article [68] presents data on the comparative efficiency of hongurin and Pegasin as a feed additive. It was found that the most effective supplements rate is 6% hongurin to the weight of the feed.

In most studies on the efficiency of zeolite additives in mixed foddors for feeding birds, focuses on the improvement of indicators such as the increase in live weight of the bird, its preservation, saving feed [69].

The work [70] attempted to study the impact of zeolitic tuff of the deposits of Khongurouu on a number of indicators of metabolism in chickens. Feed with 2.0 % and 4.0 hongurin causes increase in blood of growth hormone having anabolic effect, increase in speed of glycolysis and glycogenolysis in the liver of experimental chickens, and also contributes to increased glycogen deposition and total lipids in the liver and muscle, which in their turn cause the activation of the exchange of tissues and organs. In another study, the authors [71] studied the effect of hongurin when used as a feed additive for meat quality. Using Yakut zeolite does not affect the amino acid and mineral composition of poultry meat, but promotes fat chicken, by increasing the relative content of the most valuable components of fat - unsaturated fatty acids.

The first information about the use of zeolites of this deposit as mineral additives to animal feed, while feeding their birds are given in the monograph [ 72]. Blood tests (hemoglobin, erythrocyte sedimentation rate, the time of coagulation, the amount of leukocytes, erythrocytes), showed that it was no different from the control group. Other experiments conducted with laying hens [73] also showed a positive effect of zeolite supplements of Lyutogsky deposit on their productivity and hatching eggs properties. In subsequent experiments [74 ] as mineral additives were used tuffs of Lyutogsky deposit. As it can be seen (Table 9) Na form of clinoptilolitehas a more beneficial effect on live weight gain of chickens.

Production experiments [75] found that by introducing into the feed 3% zeolitic tuff (graining 1-3 mm) of Lyutogsky deposit, increased live weight of chickens from 20 to 58 -day old by 14%, safety – by 3.0 %, feed consumption per 1 c growth decreased by 27 kg. The digestibility of protein and crude fat also improved( %): 80.28 and 52.25 (in the control 77.48 and 42.21 %). In the experimental group significantly improved the efficiency of use of nitrogen, phosphorus and calcium.

Production experiments, conducted on Sakhalin poultry [76] demonstrated the feasibility and efficiency of the use of zeolites of local deposits as mineral additives to mixed fodder for feeding them as broilers and laying hens.

Zeolites of other deposits from the Far East have been used successfully as a mineral feed additive. For example, the work [77] gives the results on the application of Yagodinsky zeolitic tuff (Kamchatka) with mordenite - clinoptilolite content of 40-75 % [38]. To determine the effectiveness of its action in the experiment as a reference (comparison) was used clinoptilolite–heilandite tuffs of deposits of Dzegvi (Georgia). Nitrogen assimilation in all experimental broilers increased compared with the control, especially in chickens fed on 4.5 % mineral feed additives of Georgian and Kamchatkan zeolites: 45.77 and 44.74 % (40.34 % in the control).

Another experiment with zeolitic tuff [78] of Chuguevsky deposit with content up to 60% clinoptilolite and mordenite to 29% in 1984-85 studied their effectiveness as feed additive in feeding broiler chickens and laying hens. Optimal rate of zeolite supplements for laying hens was set -6%. For 365 days chicken productivity increased by 10.5%, the consumption of feed for 10 eggs decreased by 8.4%. Slightly increased egg weight and the thickness of their shells as compared to control. Birds of experimental groups increased the level of digestibility of feed nutrients. A comparative evaluation was conducted on the use of feeding birds with zeolite tuffs from various deposits of the Far East, Seredochny and Ugolny manifestations (Khabarovsk district) and Chuguevsky (Primorsky district). The experiment was conducted with day-old chicks [79]. Zeolites of Ugolny manifestations were more effective than Seredochny. Under their influence the live weight of chickens increased by 9.5%.

In general, a positive effect of zeolite content in feeds on the growth and development of poultry is reflected on the following factors:

1. increase in live weight and safety of both chickens and hens;
2. increased egg production and quality of hatching eggs and laying hens;
3. reduced cost of feed per unit of live weight gain in poultry and feed savings for 1000 eggs;
4. increased time of passage of feed in the digestive tract, which improves digestion and digestibility of feed nutrients;
5. maintaining mineral balance, optimal acidity, positive impact on the symbiotic microbial activity in the digestive tract of poultry;
6. facilitating the excretion of metabolic products of poultry and poisonous substances introduced with food and harmful gaseous compounds (NH<sub>3</sub>, H<sub>2</sub>S, in the digestion process);
7. reducing the risk of disease with not contagious poultry disease that makes it possible to use them as a prophylactic and therapeutic agent in poultry;
8. accumulation in the internal organs of poultry (in the liver) of vitamins and some essential amino acids;
9. in hematological and biochemical parameters of birds, deviations from physiological norms in poultry are not observed.

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## ПРИРОДНЫЕ ЦЕОЛИТЫ В ПТИЦЕВОДСТВЕ

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Статья обзорного характера, посвящена анализу работ, выполненных в республиках бывшего Советского Союза, по выявлению целесообразности использования таких минеральных добавок к комбикормам, как природные цеолиты. Несмотря на неоднозначность результатов в ряде исследований, в целом, эти добавки положительно влияют на развитие и рост птицы, в частности, на увеличение живой массы цыплят и сохранности их поголовья, на повышение яйценоскости и на качество инкубационных яиц кур-несушек.