Silicon-based natural zeolites in feeding store pigs

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Abstract. To realize the genetic potential of pig productivity and balance diets, it is perhaps to use various additives, including silicon-containing zeolite trepel. The novelty of the work – the use of zeolite in feeding as a preventive and therapeutic additive allows you to increase productivity and reduce the cost of feed and feed costs compared to similar additives. For the experiment, 4 recipes of mixed feeds were developed: one without the content of zeolite trepel and 3 with 3, 4, 5% of this additive. It is proved that the best dose of this drug is 3% of the mass of feed. It was found that the body weight gain in II group increased by 13.5%, in III group by 7.2%, and in IV group decreased by 4.41% compared to the control group. The addition of silicon-containing zeolite in the II and III experimental groups did not affect the consumption of mixed feed, and in the IV experimental group, a decrease in the consumption of mixed feed was observed. Feed consumption in the I, III and IV experimental groups decreased by 12.1%, 6.7% and 0.3%.

1. Introduction
Today, the increase and maintenance of high animal productivity mainly associated with the state and prospects for the entire compound feed industry development in Russia. The inclusion of grain feeds in the composition of compound feeds for different types of animals in order of normalized and complete feeding today is one of the main opportunities for increasing their productive effect [1-3].

The targeted use of silicon-based zeolites in feeding animals and birds as a preventive and therapeutic additive allows increasing the productivity of animals and birds. As a biocatalyst, silicon-based zeolites is one of the essential products for the stomach microflora and the milieu interieur hygiene. It is a silicon-based zeolite, which can change and correct the pericellular space for the better, thereby performing the function of a catalyst for carrying out normal biochemical processes in the body of animals, supply a number of irreplaceable microadditives [4-6].

Major absorption and cation exchange properties of silicon-based zeolite contribute to elimination of ammonia, heavy metals, etc. from the body. Silicon-based zeolites attract excess water contained in the body, reduces the intestinal activity of an unhealthy animal, thereby reducing the rate of nutrients, minerals and biologically active substances movement through the gastrointestinal tract. This ensures their good digestibility and absorption [7-9]. At the same time, silicon-based zeolite contributes to the formation of denser fecal masses, reduces or completely eliminates the development of diarrhea [10-12]. All this contributes to the improvement of nutrients and biologically active
substances digestibility and absorption, increasing the productive action of compound feed, which contributes to an increase in productivity and a reduction in feed consumption [13-14].

When using silicon-based zeolite, the toxic substances contained in feed, while interacting with useful nutrients and biologically active substances contained in silicon-based zeolites, can replenish the body of animals with them. Silicon-based zeolite, entering the gastrointestinal tract of the animal, is digested and absorbed. Thus, they contribute to an increase in the digestibility and absorption coefficient of nutritious and biologically active substances in compound feed, an increase in live weight, etc. [15-16].

The research objective was to select the optimal dose of silicon-based zeolite in compound feed recipes for store pigs and to identify its effect on gain, feed consumption and economic indicators.

2. Materials and methods

Experimental research were carried out with the fattening livestock of large white store pigs at the age from 4 to 8 months based on the dynamics of their growth and development. In accordance with the scheme of scientific and economic experience, according to the method of A I Ovsyannikov [17], 4 groups were formed according to the principle of analog groups (taking into account sex, age, breed, origin and live weight of clinically healthy pigs 10 heads in each (5 gilts and 5 young hogs). The zoohygienic parameters of the indoor microclimate were maintained. The zoohygienic parameters of the indoor microclimate were maintained. Pigs of all groups were in the same conditions of feeding and keeping, the optimal ambient air temperature in the room was 22˚C-24˚C, the air humidity was not higher than 70-75% and they were fed compound feed in accordance with the developed recipes. Pigs were fed compound feed in accordance with the developed recipes. All indicators on the nutritional value of feed were taken and calculated from the reference manual ‘Norms and rations of feeding farm animals’ [18].

The compound feed of the second experimental group included barley – 49%, wheat – 20%, wheat bran – 11%, rapeseed cake – 9.5%, fish meal – 1.5%, fodder yeast – 3%, silicon containing zeolite – 3%, dicalcium phosphate – 1.1%, chalk – 0.4%, salt – 0.5%, premix – 1%. The composition of the compound feed of the third experimental group is barley – 49%, wheat – 20.6%, wheat bran – 9%, rapeseed cake – 10%, fish meal – 1.5%, feed yeast – 3%, silicon containing zeolite – 4%, dicalcium phosphate – 1%, chalk – 0.4%, salt – 0.5%, premix – 1%. The composition of the compound feed of the fourth experimental group is barley – 49%, wheat – 20.6%, wheat bran – 8%, rapeseed cake – 10.2%, fish meal – 1.5%, feed yeast – 3%, silicon containing zeolite – 5%, dicalcium phosphate – 0.8%, chalk – 0.4%, salt – 0.5%, premix – 1%.

All feeds are of domestic production. Grain feed was harvested by the farm where the experiment was carried out. Rapeseed cake, fish meal, fodder yeast, dicalcium phosphate, chalk, salt, premix are purchased by the farm. The manufacturer of silicon containing zeolite is JSC RPC ‘Nov’ Novosibirsk, Russia.

The experiment lasted for 120 days from March to June 2019.

A group feed count was carried out each decade, that is, the amount of compound feed allocated for feeding and the rest for the next day were taken into account. The scheme of the experience is presented in table 1.

Research were carried out for large white store pigs in order to identify the effect of silicon-based zeolite on feed palatability, the effect on gain, feed consumption, metabolic processes in the body.

The chemical composition of silicon containing zeolite in % by weight of dry matter: SiO₂ – 64.39; Fe₂O₃ – 3.25; Al₂O₃ – 3.42; TiO₂ – 0.45; CaO – 7.74; CaCO₃ – 14.70; MdO – 1.71; Na₂O – 0.03; K₂O – 1.81; other impurities – 11.9; P₂O₅ – 0.20. 1 kg contains Si – 300.0 mg; Mo – 0.25.0 mg; F – 90.0 mg; M – 510.0 mg; B – 75.0 mg. The mass fraction of the elements regulating the drug, namely fluorine, arsenic, lead, mercury, cadmium. Blood parameters were also studied – hemoglobin, red blood cells and total leukocyte count. The pigs' blood was taken from the vessel of the auricle. A determination of the number of red blood cells, hemoglobin, total leukocyte count was determined using an automatic veterinary blood analyzer PCE 90 Vet (High Technology Inc., USA). Veterinary fully automatic
hematology analyzer with 18 parameters for the study of animal blood samples, including the
differentiation of leukocytes by 3 subpopulations and the construction of histograms. The manufacturer
is the Company HTI (High Technology Inc., USA).

**Table 1.** The scheme of the experience.

| Control and experimental groups | Number of store pigs in each group, heads | Background of feeding experimental store pigs |
|---------------------------------|------------------------------------------|-----------------------------------------------|
| I                               | 10                                       | BD (basic diet) (economic compound feed No.1) |
| II                              | 10                                       | BD (experimental compound feed No. 2 with 3% silicon-based trepel (zeolite)) |
| III                             | 10                                       | BD (experimental compound feed No. 3 with 4% silicon-based trepel (zeolite)) |
| IV                              | 10                                       | BD (experimental compound feed No. 4 with 5% silicon-based trepel (zeolite)) |

The amount of total protein and its fractions was determined in the blood serum: albumin, globulins,
as well as total calcium, inorganic phosphorus and alkaline reserve. The total protein level in the blood
serum was determined with an IRF-22 refractometer (Kazan, Russia). Refractometer is designed for
direct measurement of the refractive index of liquid and solid bodies, for rapid qualitative determination
of concentrations of aqueous, alcoholic, ether and other solutions by refractive index. Using a
refractometer, the content of total calcium in the blood was determined by the Wilkinson
complexometric method, the content of inorganic phosphorus in a protein-free blood filtrate with
vanadate-molybdenum reagent was determined by Ivanovsky.

3. Results and discussion

Before the start of experimental research, 3 recipes of compound feed were developed and their nutrient
value was calculated. The composition and nutrient value of compound feed is shown
in table 2. Young pigs of the control group were fed with an economic compound feed without silicon-
based trepel. The experimental animals of II experimental group received an experimental compound
feed developed according to recipe No. 2 with 3% silicon-based trepel in the nutritional breakdown.
The young pigs of III experimental group in the experimental period consumed compound feed with
4% silicon-based trepel in the nutritional breakdown. The animals of IV experimental group also
consumed the experimental compound feed with 5% silicon-based trepel in the nutritional breakdown.
Silicon-based trepel was included in the compound feed, replacing grain feed.

The compound feed was allocated for feeding pigs of the control group and II, III, IV experimental
groups according to specified rates strictly based on the design of experiment. All experimental animals
were fed according to specified feeding rates [17]. At the beginning of the experiment, 2 kg of compound
feed was allocated per head per day for all groups. Pigs of I, II, and III groups fed the given compound
feed completely, nothing was left in the feed cribs the next morning, and by the end of the first month,
the pigs of IV group showed a decrease in feed palatability. In pigs of the II and III experimental groups,
from the second month, an increase in appetite was revealed, that is, the amount of feed consumed
increased to 2.2 kg, and in the following, after a month – to 2.4 kg. Pigs of IV group at the beginning of
the experiment (the first 30 days), consumed about 2 kg of feed per day, and from 2 to 3 months – 2.15
kg, at month 4 – 2.1 kg.

The experiment showed that the addition of silicon-based trepel in the second and third experimental
groups did not affect the palatability of compound feed, and in the fourth group we found a slight
decrease in its consumption.

At the beginning of the experiment, the weight of pigs of I, II, III and IV groups almost had no
discrepancies and varied between 39.5 and 41.0 kg. During the experiment, the dynamics of live weight
gain had some differences between the groups. It was found that in group I the absolute gain during the
The average daily gains of experimental pigs in groups during the entire experiment were not the same, varied within wide ranges: in I group – 472.5 g, in II group – 536.6 g, in III group – 506.6 g, in IV group – 451.6 g. The difference between the groups was significant.

Table 2. Composition and nutrient value of compound feed.

| Indicators               | Compound feed recipes, No. | 1   | 2   | 3   | 4   |
|-------------------------|----------------------------|-----|-----|-----|-----|
|                         |                           | 1   | 2   | 3   | 4   |
| Barley                  |                           | 49.0| 49.0| 49.0| 49.0|
| Wheat                   |                           | 21.5| 20.0| 20.6| 20.6|
| Wheat middling          |                           | 14.0| 11.0| 9.0 | 8.0 |
| Rape cake               |                           | 8.0 | 9.5 | 10.0| 10.2|
| Fish flour              |                           | 1.5 | 1.5 | 1.5 | 1.5 |
| Fodder yeasts           |                           | 3.0 | 3.0 | 3.0 | 3.0 |
| Silica-based zeolite    |                           | -   | 3.0 | 4.0 | 5.0 |
| Dicalcium phosphate     |                           | 1.0 | 1.1 | 1.0 | 0.8 |
| Chalk                   |                           | 0.5 | 0.4 | 0.4 | 0.4 |
| Salt                    |                           | 0.5 | 0.5 | 0.5 | 0.5 |
| Premix KS-4             |                           | 1.0 | 1.0 | 1.0 | 1.0 |

1 kg contains:

- Energetic feed unit (EFU) 1.26 1.23 1.21 1.20
- Crude protein, g 158.98 160.95 163.7 163.8
- Lysine, g 7.5 7.7 8.13 7.8
- Methionine + cystine, g 4.18 4.15 4.22 4.21
- Crude fiber, g 56.69 57.41 58.7 57.99
- Calcium, g 7.18 7.23 7.99 8.09
- Phosphorus, g 6.97 6.25 6.67 6.76
- Iron, mg 236.68 232.96 222.2 224.54
- Copper, mg 14.25 14.40 15.02 15.04
- Zinc, mg 114.23 113.92 116.91 116.29
- Manganese, mg 56.2 56.1 60.28 60.26
- Cobalt, mg 0.70 0.66 0.74 0.74
- Iodine, mg 0.48 0.48 0.51 0.51
- 1000 1000 1000 1000
- Vitamins: A, ME 0.97 0.97 0.99 0.99
- D, ME 2000.12 2000.14 2000.15 2000.15
- E, mg 23.43 23.09 25.2 25.29
- B1, mg 3.71 3.77 3.57 3.58
- B2, mg 7.06 7.07 7.02 7.02
- B3, mg 20.64 20.73 23.13 23.14
- B4, mg 978 915 980 971.6
- B5, mg 65.52 63.77 74.8 74.57
- B12, µg 29.8 29.8 29.8 29.8

It should be noted that the amount of silicon-based trepel in compound feeds has a quite good effect on the live weight gain of experimental pigs. This indicator turned out to be different for all experimental groups over the entire period of the experiment. At the beginning of the experiment, the live weight gain of pigs in II, III, IV groups, in comparison with the control group, increased by 14.2%, 8.7% and 4.5%, respectively.
respectively. By the end of the experiment, the absolute gain was 16.3% higher in II experimental group, 10.4% in III experimental group, and a decrease was 4.3% in experimental IV group in comparison with the control group.

According to the data obtained as part of the study, the indicators of a decrease in live weight gain in IV group were, in our opinion, due to the content of a large amount of silicon-based trepel in the diet. According to literary sources, silicon-based trepel tends to attract heavy metal salts and toxic substances. Therefore, the increased content of silicon-based trepel (5%) in the body of experimental pigs can add to itself the nutrients included in the compound feed. Therefore, when an increased amount of silicon-based trepel enters the gastrointestinal tract, the nutrients of the diet move without being digested and absorbed.

Table 3. Change in pigs weight and feed consumption.

| Indicators                              | Groups |
|----------------------------------------|--------|
|                                        | I     | II    | III   | IV    |
|                                        |       |       |       |       |
| Number of heads                        | 10    | 10    | 10    | 10    |
| Live weight at the beginning of the experiment, kg | 39.5±2.52 | 41.0±3.75 | 40.3±2.75 | 40.1±3.51 |
| Live weight at the end of the experiment, kg | 96.2±4.14 | 105.4±4.26 | 101.1±3.61 | 94.3±4.49 |
| Absolute gain, kg                      | 56.7±2.76 | 64.4±3.63 | 60.8±3.64 | 54.2±4.57 |
| Gain index, %                          | 100   | 113.5 | 107.2 | 95.6  |
| Average daily gain, kg                 | 472.5±18.26 | 536.6±15.69 | 506.6±13.71 | 451.6±18.64 |
| Total feed consumed, EFU               | 264   | 264   | 264   | 252   |
| incl. per 1 kg of gain                 | 4.65  | 4.09  | 4.34  | 4.64  |
| in %                                   | 100   | 87.9  | 93.3  | 99.8  |

Based on the experimental data the feed consumption for experimental pigs of all groups was calculated. The feed consumption in pigs of II, III and IV groups decreased by 12.1%, 6.7% and 0.3%.

Based on the analysis of indicators according to the data obtained from experimental studies it is found that an increase in live weight gain and a slight decrease in the compound feed consumption were in pigs of II group that received 3% silicon-based trepel in the compound feed.

During the experimental studies and based on the results obtained, it was proved that the quantitative composition of silicon-based trepel in compound feeds effect on the digestibility of nutrients and their absorption.

Increases in the digestibility and absorption of nutrients by the body were found in II and III groups. The digestibility of nutrients in II and III groups was higher than in the control group for dry matter by 5.8% and 4.7%, for crude protein – by 6.6% and 5.5%, for crude fat – by 6.5% and 5.3%, crude fiber – by 7.7% and 4.7%, free-nitrogen extract – by 7.4% and 5.7%.

The increased amount of silicon-based zeolite in the compound feed reduced the digestibility of nutrients. The digestibility of dry matter, in comparison with the control group, in IV group decreased by 4.51%, crude protein – by 8.8%, crude fat – by 7.67%, crude fiber – 8.5%, free-nitrogen extract – by 7.5%.

Based the studies carried out and the results obtained, an increase in the absorption of nitrogenous matter in compound feed into the body in II and III groups was established, but at the same time in IV group, a slight decrease in the use of nitrogen in the diet was established. The analysis of the digestion trial results showed that the nitrogen absorption available in the diet of pigs in group II is better than in the animals of I group– by 12.7% of the consumed one and 7.76% of the absorbed. The nitrogen absorption in the diet by pigs in III group was slightly higher than in I group: by 5.1% of the consumed and 3.2% of the absorbed. In IV group, as a result of the experiment conducted, it was proved that the use of nitrogen in the diet turned out to be much less – by 18.6% of the consumed and 8.5% of the absorbed in comparison with I group.
The research results for calcium and phosphorus exchange in the experiment showed that the absorption of calcium and phosphorus was the same in almost all groups. The highest indicators for the mineral substances development were in II and III groups in comparison with the control group, the lowest indicator was in IV group. It was found that in II group the use of phosphorus from the consumed one was at the level of 14.29%, and from the absorbed by 2.3% more than in the control group. In III group, the absorption of calcium and phosphorus was 3.4% and 1.4% higher than in the control group. In IV group, the percentage of phosphorus use turned out to be less than in I group - from the consumed one by 2.5% and from the absorbed one by 4.3%.

With an increase in the quantitative composition of silicon-based trepel in compound feed, the level of hemoglobin in the blood slightly decreased, and the number of red blood cells and white blood cells increased within the physiological standard. It was found that between the increase in the live weight gain of experimental pigs and the content of albumin in the blood serum, a pattern was observed, that is, store pigs with large gains contained a high amount of albumin fractions in the protein composition. At the same time, it turned out that gamma globulins increase. According to the indicators obtained as a result of the experiment, the effect of silicon-based trepel on the content of calcium and phosphorus in the blood of animals can be confidently noted. The experimental factor didn't have a definite effect on the alkaline reserve.

We propose to include silicon-containing zeolite in the amount of 3% by weight in the composition of compound feeds for fattening young pigs. This will help to increase the live weight, reduce feed consumption and improve metabolic processes in the body of fattening young pigs. This will increase the gross production of pork in the agro-industrial complex.

4. Conclusion
In conclusion, in our work, the effect of silicon-containing zeolite on the piglets' body was studied. Based on the study, we selected the optimal dose of the additive in the formulations of compound feeds for pigs and determined its effect on growth, feed consumption and economic indicators. The best indicators for increasing live weight and reducing feed costs per unit of increase were observed in animals of the second experimental group receiving compound feed with the addition of 3% silicon-containing zeolite. Analysis of the results of studies on the digestibility and use of nutrients of compound feeds shows that this was influenced by the feed factor, namely the quantitative content of silicon-containing zeolite in compound feed. The addition of 3% silicon-containing zeolite to pig diets will reduce feed consumption in agriculture and achieve high economic performance in the agro-industrial complex of the world.

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