New natural feed additives: efficiency in pork production

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Abstract. This article presents the results of research on the technology of using microalgae and various prebiotics in the production of pork. The use of chlorella, LactuVet feed additive and their complex in the composition of granular compound feeds has a beneficial effect on the body of growing young pigs.

1. Introduction

Providing population with high quality food products, including food of animal origin is rightfully considered one of the most important problems of mankind. In many countries of the world, pig raising is the most promising branch of the agricultural sector for increasing meat production due to pig’s early maturity, prolificacy, and pantophagy. In terms of pork production, the Russian Federation ranked in the Top five countries – the world's largest producers. This trend is seen in the future, as the government of Russia has developed a strategy to further increase the pork production in the country until 2030 [1-4].

It is generally accepted that the greatest amount of nutrients (dry matter and protein) can be obtained from cereal-legume herbs. It should be noted that wheat on 10,000 square meters gives about 3.5 tons of dry matter and 0.4 tons of protein during the growing season, while green algae (Chlorella vulgaris) give about 60 tons of dry matter and 30 tons of protein on the same area over the same period of time. All this is indicative of a great potential of the feed resource. Russian researchers [5] found that piglets are fed with 200 ml of chlorella suspension at the age of 26-60 days, 300 ml at the age of 61-120, and up to 400 ml at the age of 121-160 days. Chlorella is most often used in the form of a suspension, since it contains the greatest number of vitamins [6-7].

Currently, much attention is paid to developing the so-called “biofuel” based on microalgae due to their great potential for processing solar energy and transferring it into chemical forms using phytosynthesis [8, 9].

Considering that one of the limiting factors for the pig raising is the insufficient provision of animals with nutritionally balanced rations, many feed mills produce complete feed added with vitamins, biologically active additives, and other components [10-13]. Moreover, in recent years, more and more attention has been paid to technologies, applying microalgae and various prebiotics in the production of pork, which is an urgent area of scientific research.

The purpose of the work was to study the efficiency of new natural feed additives in the rations of young pigs to increase their productivity and improve the quality of pork.
2. Materials and methods

Experimental studies were conducted on the Lenin stud farm in the Surovikinsky district, the Volgograd Region in 2020. For the experiment, experimental young pigs of large white breed at the age of 2 months were selected and 4 groups of them were formed according to the analogue principle, 15 heads each.

The pigs in Control group received the general ration (GR); their analogs in Test group I were fed with GR+chlorella (pigs at the age of 60-120 days received 300 ml; pigs at the age of 121-180 received 400 ml); Test group II was fed with GR+LactuVet in the amount of 0.4 g/kg of the live weight of the pig; Test group III received GR+chlorella and LactuVet. The research experiment lasted for the age period of 60 to 180 days.

Chlorella were granulated. The technology for introducing algae into granulated feed involves the following steps: the grain component (cereal-legume mixture) was extruded using an EK-40 feed extruder that performed a single-stage mechanochemical deformation by “explosion” under the heat treatment and high pressure; the feed components, requiring grinding, were ground on a hammer mill (ADM-0.3) to a particle size of 1.0-1.5 mm; all components of the compound feed were mixed in a vertical bunker-mixer (BSSH-0.5), i.e. they entered a horizontal mixer with the possibility of introducing liquid components (SGU-0.61), where the chlorella suspension was introduced into the mixture prepared for granulation according to experimental calculation; the prepared mass was homogenized, fed into the receiving hopper of the granulator (GM-100), and granulated; the granules obtained were dried and sieved on a device (AM-4).

The obtained compound feed had good taste due to various aromatic substances and increased digestibility due to the breakdown of complex components (proteins and carbohydrates) into simpler ones, neutralized toxins and their producers. The chlorella action was positive because it served as an optimal medium for the growth of lactic acid bacteria, mainly Lactobacillus that contained arginine, cysteine, glutamic acid, leucine, phenylalanine, tryptophan (5 μg/mL), tyrosine, and valine (40-100 μg/mL).

In addition to chlorella, we used a new prebiotic feed additive LactuVet that contained not less than 97.5% of dry substances, including lactulose (disaccharide) not less than 14.5%, lactose not less than 25.2%, monose (galactose, glucose) not less than 12.5%, calcium 7.5%, phosphorus 6.4%, other macro- and micro-macroelements, organic acids, dominantly citric acid 2.1% and lactic acid 4.2%, and nitrogen-containing peptide substances.

The effect was that lactulose taken orally entered the large intestine without being changed, where stimulated the growth of lactobacilli and bifidobacteria due to its strong bifidogenicity. Increased content of bifidobacteria in the microbiome suppressed pathogens and, ultimately, considerably increased the resistance of the host macroorganism (animals and birds) to external infections. It was important that the lactulose effect manifested itself already at very low doses. The product helped to meet the body's needs for nutrients and normalize metabolism. Lactulose was broken down only in the large intestine into low molecular weight organic acids.

In Control group, we used specialized compound feeds SK-5, SK-6, and SK-7 that were made according to the feeding standards for farm animals, taking into account the age, live weight, and breed characteristics. The pigs were fed twice a day, i.e. in the morning and in the evening. The animals had free access to water.

Blood for laboratory studies was taken from pigs from a vein located below the root of the tail, from 5 heads in each group at the beginning and at the end of the experimental period.

The experimental animals were weighed individually every month during the entire experimental period. The natural immunity level was established by standard zootechnical methods, studying the bactericidal activity of blood serum.

The amino acid content in meat samples was examined on the Aracus amino acid analyzer, MembraPure GmbH. The data obtained were processed, using the t-test method in variation statistics and determining three probability levels on STATISTICA-6 program.
3. Results and discussion

The studies showed that the feed additives in animal rations had a considerable impact on the growth and development of pigs. However, the overall live weight gain of the experimental pigs was found to be insignificant from the beginning of the experiment until their age of 3 months and to be significant at older ages (table 1).

| Age, days | Overall live weight gain, kg |
|-----------|-----------------------------|
|           | Control                     | Test I | Test II | Test III |
| 60-90     | 22.52±0.17                  | 22.74±0.18 | 22.77±0.16 | 22.82±0.15 |
| 90-120    | 23.44±0.21                  | 23.61±0.19 | 23.84±0.18 | 23.95±0.21 |
| 120-150   | 26.24±0.23                  | 26.66±0.20 | 27.34±0.21** | 27.81±0.22** |
| 150-180   | 27.95±0.16                  | 28.12±0.17 | 28.84±0.15** | 29.20±0.20** |
| 60-180    | 102.15±0.35                 | 104.21±0.40** | 104.72±0.45** | 106.34±0.39*** |

The table shows increased overall live weight gains from the age period 120-150 days in animals that received feed additives, namely, the pigs in Test groups I, II, and III surpassed their analogs in Control group by 0.42 kg or 1.57%; 1.1 kg or 4.02% (P≥0.99), and 1.57 kg or 5.98% (P≥0.99); in the age period from 150 to 180 days the difference made 0.17 kg or 0.60%; 0.89 kg or 3.09% (P≥0.99), and 1.25 kg or 4.47% (P≥0.99), respectively.

In general, over the entire period of the experiment from 60 to 180 days of age, the animals in Test groups I, II, and III had the live weight value greater than their analogs in Control group by 2.06 kg or 1.98% (P≥0.99), 2.57 kg or 2.45% (P≥0.99), and 4.19 kg or 4.10% (P≥0.999), respectively.

The results obtained indicated a favorable effect of the proposed additives on metabolisms of protein, vitamins, and minerals due to an increase in the content of bifidoflora in the gastrointestinal tract of pigs. All this had a positive effect on the growth, development, meat qualities of the experimental young animals, and their physiological states.

The tested feed additives had a positive effect on the liver functioning, as evidenced by the bilirubin content. In terms of the conjugated bilirubin concentration in blood of the experimental young animals, the pigs in Test groups I, II, and III exceeded their analogs in Control group by 0.37 mmol/L or 8.24% (P≥0.95); 0.54 mmol/L or 10.41% (P≥0.95), and 0.68 mmol/L or 23.35% (P≥0.99); their total bilirubin was higher by 0.36 mmol/L or 6.42%; 0.53 mmol/L or 9.67%, and 0.64 mmol/L or 10.26%, respectively.

The high contents of total and conjugated bilirubin in the animal organisms in Groups I, II, and III indicated an increased load on the liver and other hematopoietic organs, consequently, an increased metabolism in comparison with Control group.

One of the processes, influencing the increase in meat production, is the protein metabolism that is characterized by contents of aspartate aminotransferase (AST) and alanine aminotransferase (ALT) in the blood serum of animals. The experimental studies established that pigs in Groups I, II, and III had higher indices than their analogs in Control group by 1.78 U/L or 9.76%, 2.18 U/L or 11.05% (P≥0.95), and 2.42 U/L or 12.23% (P≥0.95) in terms of the AST content in blood; and by 10.34 units/L or 12.35% (P≥0.95), 13.45 U/L or 14.54% (P≥0.95), and 15.62 U/L or 16.23% (P≥0.99) in terms of the ALT content.

We calculated the Ritis coefficient (ALT/AST). It was equal to 0.66% in Control group, 0.63 in Test group I, 0.57 in Test group II, and 0.56 in Test group III; the AST to ALT ratio was 1.98, 1.64, 1.60, and 1.57, respectively.
Chlorella and “LactuVet” feed additive in the rations of pigs from 60 to 180 days of age, as well as their combined use, made it possible to reduce the Ritis coefficient in the blood serum to a physiological norm, which showed the stabilized tissue metabolism in the animal bodies.

A higher urea content in the blood of Test animals in comparison with their Control analogs indirectly confirmed a higher level of their metabolism.

Thus, the chlorella suspension in the rations of young pigs reduced the deficiencies of amino acids, vitamins, unsaturated fatty acids, minerals, and trace elements. This gave a positive effect, i.e. high growth energy at lower feed costs per unit of production, an increase in the live weight, overall and average daily gains, and an improvement in physiological health.

To study the amino acid composition of meat from experimental pigs, 5 meat samples were taken from each half carcass (table 2).

Table 2. The amino acid content in pork in comparison with the reference protein, g/100 g.

| Essential amino acids | Reference protein, FAO/WHO (1973), g/100 g | Control | Group I | Group II | Group III |
|-----------------------|-------------------------------------------|---------|---------|----------|-----------|
| Isoleucine            | 4.0                                       | 4.66±0.03 | 4.69±0.01 | 4.71±0.02 | 4.77±0.02* |
| Leucine               | 7.0                                       | 7.43±0.01 | 7.51±0.03 | 7.55±0.02** | 7.61±0.03** |
| Lysine                | 5.5                                       | 7.23±0.06 | 7.56±0.05** | 7.82±0.07** | 7.96±0.05*** |
| Methionine + cystine  | 3.5                                       | 3.61±0.02 | 3.71±0.01* | 3.75±0.03* | 3.82±0.02** |
| Phenylalanine + Tyrosine | 6.0                                      | 6.86±0.03 | 7.15±0.02** | 7.23±0.01*** | 7.42±0.03*** |
| Threonine             | 4.0                                       | 4.35±0.02 | 4.41±0.03 | 4.53±0.02** | 4.67±0.03** |
| Tryptophan            | 1.0                                       | 1.25±0.01 | 1.27±0.02 | 1.33±0.01** | 1.37±0.02** |
| Valine                | 5.0                                       | 5.35±0.02 | 5.53±0.03 | 5.66±0.02*** | 5.75±0.03*** |
| Total:                |                                           | 40.74    | 41.83    | 42.58    | 43.37    |

The pigs in Test groups I, II, and III surpassed their analogs in Control group by 0.03 g/100 g or 0.64%, 0.05 g/100 g or 1.07, and 0.11 g/100 g or 2.36% (P≥0.95) according to the isoleucine content in the meat; by 0.08 g/100 g or 1.08%, 0.12 g/100 g or 1.61% (P≥0.99), and 0.18 g/100 g or 2.42% (P> 0.99) according to the leucine content in the meat; by 0.33 g/100 g or 4.56% (P≥0.99), 0.59 g/100 g or 8.16% (P> 0.99), and 0.73 g/100 g or 10.10% (P> 0.999) according to the lysine content; by 0.10 g/100 g or 2.77% (P≥0.95), 0.14 g/100 g or 3.88% (P> 0.95), and 0.21 g/100 g or 5.82% (P>0.99) according to the methionine+cystine content; by 0.29 g/100 g or 4.23% (P≥0.99), 0.37 g/100 g or 5.39% (P≥0.999), and 0.56 g/100 g or 8.16% (P≥0.999) according to the phenylalanine+tyrosine content; by 0.06 g/100 g or 1.38%, 0.18 g/100 g or 4.14% (P>0.99), and 0.32 g/100 g or 7.36% (P>0.999) according to the threonine content; by 0.02 g/100 g or 1.6%, 0.08 g/100 g or 6.4% (P>0.99), and 0.12 g/100 g or 9.60% (P>0.99) according to the tryptophan content; and by 0.18 g/100 g or 3.36%, 0.31 g/100 g or 5.79% (P>0.999), and 0.40 g/100 g or 7.48% (P>0.999) according to the valine content.

The reference protein and experimental results compared, that is, the amino acid score, are presented in table 3.

The sensory evaluation of pork broths from Test pigs was conducted by 15 tasters on a 5-point scale.

When evaluating the appearance of the meat broths, the tasters found that the broth cooked from the Test group III pork scored the highest average score of 6.67, which was higher by 0.47 than in Control group, Test group I by 0.26 points, and Test group II by 0.16 points.
Table 3. The amino acid score of meat from experimental pigs.

| Essential amino acids | Control | Group I | Group II | Group III |
|-----------------------|---------|---------|----------|-----------|
| Isoleucine            | 116.50  | 117.25  | 117.75   | 119.25    |
| Leucine               | 106.14  | 107.29  | 107.86   | 108.71    |
| Lysine                | 131.45  | 137.45  | 142.18   | 144.73    |
| Methionine + cystine  | 103.14  | 106.00  | 107.14   | 109.14    |
| Phenylalanine + tyrosine| 114.33  | 119.17  | 120.50   | 123.67    |
| Threonine             | 108.75  | 110.25  | 113.25   | 116.75    |
| Tryptophan            | 125.00  | 127.00  | 133.00   | 137.00    |
| Valine                | 103.36  | 110.60  | 113.20   | 115.00    |

4. Conclusion.

Chlorella, “LactuVet” feed additive, and their combination used in the composition of granulated feed had a beneficial effect on the body of growing young pigs. The evaluation of the physiological states of animals allowed us to conclude that the pigs in Test groups I, II, and III had better combinations of biochemical parameters, as well as a more stable tissue metabolism in the body. Chlorella algae combined with a lactulose-containing feed additive contributed to an increase in the productive capacity of the livestock and improved amino acid composition of meat from animals in Test group III in comparison with their analogs in Control group and Test groups I and II.

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