Prospects of applying sunflower sludge after cavitational processing in poultry breeding

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Abstract. Modern trends in science and technology, from the viewpoint of the concept of state policy on the field of nutrition, as well as the implementation of anti-crisis measures in the Russian agricultural sector, should be oriented towards the development of competitive food and feed products of a new generation that meet all international standards. The use of liquid media activated by variant ways in complex with the rational hydromechanical and ultrasonic exposure might be the most promising and the most modern methods of process optimization for feed production. Nowadays the technology of processing a high-viscous liquid media with gaining feed products of preset properties includes both electrochemical processing and cavitative disintegration. Our research revealed that addition of cavitation-treated products of sunflower sludge into the diet of broilers in the amount of 6% of the total feed mass positively affects the digestive extent in the growth period. Moreover, the introduction of cavitation-treated products of sunflower sludge with zeolite to the ration bears a positive effect on reducing consumption of feed per 1 kg of the live weight gain from 2.04 to 1.46 kg per capita, which improves the productive qualities.

1. Introduction

A topical direction of agricultural science development and the scientific support of the Russian agro-industrial complex in past ten years were associated with the development of high-tech industries aimed at finding innovative, secure, environmentally friendly, and highly effective methods, ways of technological process intensification, as well as the creation of a system of resource-saving production processes and machines. From the viewpoint of the concept of state policy on the field of nutrition, modern trends in science and technology, as well as the implementation of anti-crisis measures in the Russian agricultural sector should be oriented towards the development of competitive food and feed products of a new generation that meet all international standards, as well as act as the import substitution [1,2].

By-products of the fat-and-oil industry are characterized by the high content of fat and protein, which makes them indispensable when balancing diets. Fat production in the world reaches 65.1 million tons on the average, 40.0 million ton (or 65%) of which are of vegetable origin, i. e. (in mln ton): 7.9 of coconut origin, 14 of soybean oil, 3.7 of cotton, 3.2 of peanut, 5.7 of sunflower, 4.8 of rape, etc. Ground oil-cake is made after oil extraction – in a total of 107 million tons per year, 96 million tons of which are of soy origin. Hence a considerable amount of valuable fodder is an important component of contemporary animal husbandry. The nutrient content in sunflower, soy, and peanut ground oil-cake is
following: 42.5, 47.0, and 47.9% of protein and 0.9, 3.4, and 9.2% of fat, respectively [3].

Sunflower and soy ground oil-cake are of great interest to the world of animal husbandry. These wastes are valuable sources of protein, they are inferior to the protein of animal origin only in the content of lysine. One of the shortcomings of such feed, in particular, is a high crude cellulose content due to husks [4].

In addition to the listed waste products of the oil-producing industry, there are also generated other valuable byproducts; they are soap stock, protein phosphatidic complex, fat waste of technological processes, etc [5].

Sludge is among the wastes of the fat-and-oil industry. Understanding of the general name “sludge of vegetable oil” includes two types of waste generated in two different processes of oil-extracting production. The vegetable oil refining process makes impurities (oilcake particles, seed shells, etc.) sediment on the cloth of pressure filters and get removed while cleaning. Also, it usually includes the entire cleanup from presses, oil-bearing pipelines, bottoms of press parts, etc. Sludge is a thick, brownish-gray mass containing up to 45-60% ether extractable substances. A mass share of oil extraction production waste ranges from 1 to 5% of the weight of made products [6].

Another product also regarded as sludge is settled sludge, which gets formed during the storage of the finished oil in settling tanks. Settled sludge is a light-brown mass containing from 83% to 96% of ether extractable substances. The amount of generated settled sludge ranges from 3 to 12% of the produced product depending on the season and the quality of processed seeds. The chemical composition of sludge is a mixture of protein and neutral triglycerides. Fat in sludge is mostly dispersed. In most cases, this fact makes technological processing of sludge more complicated [7].

In addition to neutral triglycerides, sludge fats are represented as phosphatides and free fatty acids. Speaking of organic substances, they contain 0.6 to 1.3% cellulose and 5 to 7% proteins. The ash constituent content is estimated from 2 to 4%. The composition of the sludge mineral balance consists of magnesium oxide (19.2%) and calcium oxide (20.9%) [8].

The above data show that the application of waste products of the oil-extracting industry in livestock production is currently promising.

The basis of the creation of modern production processes should be laid by safe acoustic, physical and chemical, electrophysical methods for processing of agricultural raw materials allowing to regulate its functional and technological properties [9].

The most promising and the most modern methods of process optimization for feed production can be the use of liquid media activated by variant ways in complex with the rational hydromechanical and ultrasonic exposure. Nowadays the technology of processing a high-viscous liquid media with gaining feed products of preset properties includes both electrochemical processing and cavitative disintegration [10].

Containment of the implementation and usage rates of cavitative processing means of raw materials or waste products of oil-extracting industry in the technology of feed production is related to insufficient information on the mechanisms of impact on zootechnic and hematologic indices, as well as on the mineral metabolism of poultry.

2. Materials and methods
We used a specially designed device for processing high-viscous liquids as the main hardware to obtain cavitatively processed of fat foods industry. The device to obtain processed high-viscous liquids, on the example of fat-containing waste, includes an inlet connection (1) for the treated mixture entering, an outlet connection (2) for removal of the ready mixture, an input (3) and output (4) pipes for supply and tap of the heat-transfer agent, an internal working body (5), a body jacket (6) that provides the circulation of the heat-transfer agent, a cylindrical body (7), pipes (8) for air supply, a vibration exciter (9), power source (10), frame (11), and dampers (12). The general scheme of the device is shown in Figure 1.
The work of the device is described next. Components for the mixture formation are served through the inlet connection into the cylindrical body fixed on the frame via the dampers. The vibration exciter is coaxially pinned beneath the cylindrical body. The process of liquid stirring occurs as a result of the vibrations generated by the vibration exciter and the internal working body made as a piezoceramic converter in the form of a pentagonal star-shaped pyramid. During the process of stirring, the internal working body gets a flow of electricity through the power source. Passing through a layer of the piezoceramic material, the flow is converted into mechanical energy by creating ultrasonic vibrations. The ultrasonic waves are generated using an electroacoustic converter – piezoceramic material that converts forwarded electrical energy into mechanical vibrations by means of piezoelectricity or magnetostriction.

Passing of ultrasonic waves through a layer of stirring liquid heterogeneity causes the formation of cavitation bubbles, their popping leads to the disintegration of small inclusions of the mixture. Cavitation clouds are formed at the same time. Cavitation clouds are heterogeneous: they have the appearance of a small dense zone near the center; cavitation bubbles are distributed on the plane in the form of a kind of multigonal star-like shape. There are marked piezoceramic crystals forming a so lid rough surface on the inner surface of the cylindrical body for a more even distribution of ultrasonic waves and the creation of homogeneous cavitation clouds in the processed heterogeneous liquid.

When confronted with the rough surface of the cylindrical body, ultrasonic waves get reflected and scattered and also affect the components of the mixture. The rough surface of the cylindrical body leads to the equitable redistribution of ultrasonic waves, as well as to uniform processing of liquid. When processing emulsions, especially water-organic suspensions, it is preferable to stabilize the temperature regimes of the treated liquid because the processing efficiency decreases at high temperatures and organic compounds may decompose. In order to create the optimal temperature conditions, the device is provided with the body jacket that allows you to adjust the temperature regimes of technological processes. The heat-transfer agent is supplied or tapped away through the input and output pipes for this purpose.

Four pipes for air supply are mounted on halfway distance from the center of the cylindrical body and each other on the basement of the cylindrical body in order to improve the efficiency of stirring and the creation of additional conditions for the occurrence of homogeneous cavitation clouds. We proposed to implement zeolitized tuff powder (clinoptilolite) with a particle size of not more than 1 mm to improve the efficiency of fat-containing waste exposure to ultrasound.

We conducted a series of experiments on chicken broilers of the cross “Smena 8” for determining the effectiveness of cavitationally processed sunflower sludge in animal feeding. The method of pair analogs supposed us to form four groups (n = 30) that were in identical conditions of feeding and housing during a 14-day period.

After that, all animals in the control group received the starting mash, then the grower mash; birds of group 1 received the starter ration then the grower one with addition of raw sunflower sludge amounting 6% of the total mass; group 2 got the ration the same as the first group with just one difference
− 6% of the sunflower sludge were cavitation-treated. Group 3 was fed with the same ration as group 1 with 6% of the cavitation-treated sunflower sludge with the zeolitized tuff powder (clinoptilolite) in the amount of 1% with the particle size of not more than 1 mm. The experiment lasted for 42 days.

3. Results and discussion
The live weight of broiler chickens is one of the main indicators of the feeding balance. In the study, we evaluated changes in the weight of the birds by groups depending on the diet during the experiment period. For this purpose, we conducted daily individual weighing, starting from the age of 15 days.

The results show the live weight of broilers of the experimental groups was lower than that of the control group in the first period.

By the end of the first week, the live weight of broilers from the control group was lower than that of the first experimental group by 3.06 g (1.15%), of the second group by 118 g (22.69%) (p ≤ 0.05), of the third group by 44 g (8.4%).

The live weight of broiler from the control group at the end of the second week was lower than those of the first experimental group by 91 g (11.31%), of the second group by 184 g (22.88%) (p ≤ 0.05), of the third group by 284 g (35.32%).

After three weeks of the feeding experiment, the live weight of the first, the second, and the third experimental groups exceeded the live weight of the control group by 25, 89 (p ≤ 0.05), and 138 g (1.7, 6.0, 9.4%), respectively.

Thus, we can conclude that introducing cavitation-treated products of sunflower sludge into the diet of broilers in the amount of 6% of the total feed mass has a positive effect on the degree of digestibility in the growth period.

The research supposed measuring major morphological and biochemical indices of blood.

The study found that all the morphological blood parameters are within normal limits, however, the level of hemoglobin in birds of the first group was 3.7% higher, of the second one − 4.5%, of the third − 8.2% higher than that of the control group.

Compared to the control group, the experimental groups recorded an increase in the concentration of leukocytes, which amounted 6.5; 7.5; 8.0, but the changes were not statistically significant.

As demonstrated by the analysis of the obtained data, the indices of the differential white blood cell count were within the physiological norm. It should be noted the level of eosinophils and basophils in groups 1, 2, and 3 was higher than that of the control group by 2.4, 2.8, and 3.9%, respectively.

Based on the results of the research, it is worth noting that there were revealed higher contents of total protein in the third experimental group − 45.9 g/l, which exceeded the similar indicators of the first experimental group by 6.3%, of the second one by 5.2%, and by 7.1% in the control group.

The content of alkaline phosphatase in the second experimental group exceeded the control values by 13.1% and not more than 1% for the values in other experimental groups.

The creatinine level in groups 2 and 3 exceeded the values of the control group and group 1 by 7.2% and 8.6%, respectively (p ≤ 0.05).

The content of glucose in the blood of bird in group 1 and the control group surpassed the values of groups 2 and 3 by 10.3% and 11.9%, respectively.

The level of carbamide was 6.8% higher in the control group than that of group 1.

The morphological and biochemical blood composition of broiler chickens that received cavitation-hydrolyzed sunflower sludge and zeolite as part of the diet was within the physiological norm. Thus, on the basis of the foregoing, we can conclude that adding cavitation-treated products of sunflower sludge to the diet of broilers has a positive impact on reducing consumption of feed per 1 kg of the live weight gain from 2.04 to 1.46 kg per capita (down by 28.4%), which improves the productive qualities.

It is advisable to introduce cavitation-treated settled sludge in broiler feeding in the amount of 6% of the nutrient density instead of the concentrated part of the diet in order to replenish the energy and fat...
deficit in diets.

To confirm the safety of the products, we carried out a mineral analysis of the muscle tissue (meat) of the experimental animals. Changes in the level of metabolizable energy of the diet affected the content of mineral substances in the body of experimental birds. The element profile of an organism of broiler chicks looked as follows:

- essential and conditionally essential microelements  
  As, Cr, Cu, Fe, I ↑
  Co, Ni, Se ↓

- microelements  
  K, Na ↑
  Ca, P ↓

We found that increasing the level of metabolizable energy resulted in a slower accumulation of Co, Ni, Se, Ca, P, Pb, Sr in the tissues of the body of a bird against the background of an increase of As, Cr, Cu, Fe, I, K, Na, Al, Cd, which were within the norm.

4. Conclusion

Thus, adding cavitation-treated products of sunflower sludge to the diet of broilers has a positive impact on reducing consumption of feed per 1 kg live weight gain from 2.04 to 1.46 kg per capita (down by 28.4%), which improves the productive qualities.

The main morphological and biochemical parameters of blood in broiler chickens that received cavitation-hydrolyzed sunflower sludge and zeolite as part of the diet were within the physiological norm.

The increased level of metabolizable energy led to a slower accumulation of Co, Ni, Se, Ca, P, Pb, Sr in the tissues of the body of a bird against the background of an increase of As, Cr, Cu, Fe, I, K, Na, Al, Cd. The microelemental analysis of the animals’ tissues confirmed the innoxious content of the chemical elements in the products (meat).

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