Technologies and technical means of soybean processing

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Abstract. The article considers the method of processing soybeans in the production of feed for farm animals. The proposed technology can reduce the inhibitory activity of raw soy and reduce the activity of urease. Soybean treatment is carried out with an oxidizing solution containing hydrogen peroxide concentration of 9 % at a temperature of 18-20°C with simultaneous acoustic treatment from two ultrasonic emitters with an ultrasound frequency of 20 kHz, creating an intense cavitation for 10 minutes.

1. Introduction
The peculiarity of soy is the presence of proteolytic inhibitors that prevent the absorption of protein. Therefore, in the feed industry used soybean grain in pure form in mixtures of no more than 2-5%. Also the effect of urease is negative, which is a hydrolytic enzyme from the group of amidases, which has the property to catalyze the hydrolysis of urea into carbon dioxide and ammonia, leading to an unpleasant astringent taste, smell and low digestibility of feed. Raw soybeans require heat treatment, by which the extraction of beans is carried out, which leads to a significant change in their chemical and biological properties and significantly reduces the anti-nutritional properties. The aim of the work was to improve the technology of soybean processing by intensifying the process with the help of low-frequency ultrasound.

2. Materials and methods
For experimental studies were used soybean grain varieties "Zlato", "Bara", "Soer-4", "Soer-5". Urease activity was determined according to GOST 13979.9-69, activity of trypsin inhibitor by caseinolytic method of M. L. Kakeida (modified by I. I. Benken) [1].

3. Discussion of the results
Soy protein should be absorbed by the gastrointestinal tract of an animal or a person being absorbed into the blood in the form of free amino acids [2]. This should be due to enzymes involved in chemical interaction, but inhibitors form with proteolytic enzymes of animal origin, in particular with trypsin and chymotrypsin, stable complexes, in which the enzyme loses activity. Inhibitors dramatically reduce the efficiency of protein absorption, causing inhibition of growth and pancreatic hypertrophy [3].
It has been established that the proportion of water-soluble compounds accounts for up to 90% of inhibitory activity, since the mass ratio of water-and alcohol-soluble groups is approximately 2.3:1; therefore, for the removal of anti-nutrient substances, it is possible to extract inhibitors into a solvent [4].

Figure 1 shows the technological scheme of production of feed for farm animals.

![Figure 1. Technological scheme of production of compound feeds for farm animals.](image)

1-hoppers of raw materials; 2-block magnetic separators; 3-block crushers; 4-block dispensers; 5-screw mixer; 6-press granulator; 7-cooling column; 8-hopper accumulation and shipment of feed.

There are various methods of processing legumes that reduce the content of inhibitors, but since they are substances of a protein nature, any physical or chemical effects can cause a loss of biological properties. Soy is the most common forage crop. There are known methods of water washing of soybeans, soaking in a solution of alkalis, salts, acids [5]. However, chemical methods of processing soybeans are associated with the costs of treatment, wastewater treatment and waste disposal.

Known thermal methods of processing soybeans, when the grain is roasted, boiled, steamed, subjected to infrared or microwave processing [6, 7, 8, 9], this is also accompanied by significant technological costs.

Figure 2 shows the classification of methods of preparation of leguminous crops for fodder production
However, these methods are more adapted for the destruction of urease, and they do not affect inhibitors as actively. Prolonged heat treatment leads to the destruction of the grain structure and the formation of porridge, which is not advisable in feed production. Steaming soy, as a private method of heat treatment, also has significant drawbacks. Steam actively affects the surface layer of soybeans and does not penetrate deep and as a result, harmful substances are not removed uniformly.

When heat treated in autoclaves, urease is destroyed, and the trypsin inhibitor is destroyed only by 45%. With microwave treatment, the trypsin inhibitor is destroyed, and urease is only 40% destroyed [10].

Research conducted from 2013 to 2019, allowed one to improve the process of obtaining animal feed by selecting the degree of grinding of soybeans, processing it with low-frequency ultrasound, finding the optimal oxidizer to reduce anti-nutrients in soybeans.

The proposed technology reduces inhibitory activity and urease indices to normalized values (figures 3, 4). Grinding of soybeans allows reducing treatment time to 10 minutes.
Production of mixed feeds with processed soy according to the proposed technology is presented in figure 5.

The presented technological line for the development of high-protein feed based on soybean seeds includes the following equipment: feedstock hoppers 1; magnetic separator unit 2; crusher unit 3; the proposed device for intensive processing of crushed soybean seeds in the field of acoustic ultrasonic waves 4; pump 5; mixing tank 6; feeding tank with hydrogen peroxide 7; feeding tank with water 8; hopper accumulation and shipment of precipitated inhibitor 9; drum dryer 10; intermediate hopper 11; filter sump 12; storage tank capacity 13; dosing unit 14; screw mixer 15; press granulator 16; cooling column 17; hopper accumulation and shipment of feed 18.
Figure 5. Technological scheme of obtaining compound feed on the basis of crushed soybeans

In bunkers 1 loading of initial components of compound feed is carried out, which after separation of metal impurities on magnetic separators 2 are fed to the line of crushers 3, where they are crushed. In the future, purified and crushed soybean seeds are sent to the ultrasonic treatment device 4. There, with the help of a pump 5 and connected to it by a water supply of the feed tank 6, a working mixture is supplied, the components of which are hydrogen peroxide and water, pre-pumped into the corresponding tanks 7 and 8.

In the process of ultrasonic treatment is an intense hydration of the seeds, occurs due to the process of extraction of water-soluble inhibitors and implementation of active oxidation of the enzyme urease due to the impact made by acoustic cavitation cavities hydrogen peroxide. Saturated dissolved protein solution is removed from the working area of the device and accumulates in a container 13, where subsequently sent to the filter-sump 12. In the filter sump, the waste mixture is divided into liquid and solid phases, the first of which can be reused in the technological process, and the second-after collection in the hopper 11 should be dried in the drum dryer 10 and, in the future—comes for shipment to the hopper 9.

Other components of the produced feed pass through the ultrasonic processing zone in transit, immediately following the block of intermediate storage bins, from where they are then fed to the dosing line 14 and then-to the screw mixer 15. The finished feed mixture is again accumulated in the intermediate hopper, dosed and sent to the pelletizing zone 16. The obtained feed pellets are dried, cooled in the cooling column 17 and fed to the hopper 18, from where they are periodically shipped.

4. Conclusion
The proposed technology of animal feed production allows reducing the inhibitory activity of raw soy and reducing the urease index to the normalized values. Soybean treatment should be carried out with an oxidizing solution containing hydrogen peroxide concentration of 9 % at a temperature of 18-20°C with simultaneous acoustic treatment from two ultrasonic emitters with an ultrasound frequency of 20 kHz, creating an intense cavitation for 10 minutes.

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