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Improvement of Technology for Producing Extrudates Using Protein-Vitamin Coagulate

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Abstract

Development of modern feed production imposes the need for energy-resource-saving technologies that increase the nutritional value of finished feed. The extrusion of grain and other components included in the animal feed formulation is an additional resource of high-energy feed. Of practical interest is the production of extruded feed using protein-vitamin coagulate from green mass sap. Extrusion technology enables production of a high-quality product, provides bacterial purity of feed and ensures its high safety, which determines the effective use of extrudate in rations. Studies have been carried out to improve the technology for producing extrudates from a mixture of wheat grain and protein-vitamin coagulate obtained from alfalfa sap. An experimental production line for producing extrudates using protein-vitamin coagulate is proposed. The optimal ratio of grain and protein-vitamin coagulate was determined based on the analysis of the composition and energy value of the extrudate. It is noted that the protein content in extrudates from a mixture of wheat grain and protein-vitamin coagulate is 9%–24% higher than that in extruded wheat. The metabolizable energy in such feed is 1.4–3.1% higher than that in extruded wheat. The proposed technology for extrudate production using protein-vitamin coagulate provides feed and feed components with high protein content and metabolic energy. The mixture of wheat grain and 12% protein-vitamin coagulate is found to be optimal. Extrudates obtained on the basis of the optimal ratio of components contain 17.69% protein and 14.61 MJ/kg of metabolizable energy.

Keywords: extrudate, protein-vitamin coagulate, technology, mixture, feed.

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1. Introduction

To date, the technology for producing extrudates is widely used in agricultural production and food industry [1–3]. Processing of the initial product in the extruder activates physical and mechanochemical processes. The finished products are distinguished by high nutritional and taste qualities, and good preservation [3–5]. Both grain and mixtures of grain and various components can be extruded. The number of components

used is limited by the moisture content of the mixture supplied for extrusion and the recommended formulation for the diet of animals [6–8]. The general patterns of changes in the biochemical composition of the initial product during extrusion have been previously studied in detail [9–11]. However, the components used and their quantity, as well as the region, affect the composition and energy value of the finished product. As a rule, the rational percentage of the components and their energy value are determined empirically.

In the production of extruded feed, the use of protein-vitamin coagulates from green sap is of practical interest. To obtain a protein-vitamin coagulate, the technology of mechanical dehydration of green mass is employed, which is followed by protein coagulation. The high nutritional value of coagulate is not only due to its high protein content [12, 13], but also due to its amino acid composition [14, 15].

The development of a technology for extrudate production using protein-vitamin coagulate from green sap is relevant for both agricultural and food production. The use of extrudates from a mixture of grain and a protein-vitamin coagulate will solve the problem of increasing the nutritional and energy value of feed through the use of available raw materials and provide valuable components for use in food industry.

The purpose of the study is to improve the technology for producing extrudates using a mixture of wheat grain and protein-vitamin coagulate from green mass sap.

2. Methods and Equipment

The study was carried out on the instructional farm and in the Engineering Center of the FSBEI HE Krasnoyarsk State Agrarian University. The technology was developed on the basis of the extruded feed production line with a capacity of 300 kg/h. For the introduction of a protein-vitamin coagulate during extrusion, an experimental line has been created for mechanical dehydration of green mass, sap filtration, sap coagulation, coagulate isolation, and transportation to a screw mixer. Protein-vitamin coagulate was obtained on a patented experimental setup [15].

The resulting coagulate was mixed with wheat in the amount of 5.0%, 8.5%, 12.0% and subjected to extrusion. The protein-vitamin coagulate and finished extrudates were analyzed for the content of essential nutrients and energy value calculated for dry weight and compared with baseline extruded wheat.

The extrudate composition was analyzed by generally accepted methods in the Research Test Center of the FSBEI HE Krasnoyarsk State Agrarian University.

3. Result Sand Discussion

The technological scheme for the production of extrudates from a mixture of wheat grain and protein-vitamin coagulate is illustrated in Figure 1.

The technological process of producing extrudates from grain and protein-vitamin coagulate falls into three stages: preparation of grain for extrusion; production of protein-vitamin coagulate; mixing and extrusion of components.

The first and last stages are carried out using the baseline (Figure 1, 1–11). Pre-cleaned wheat grain enters hopper 1 and is fed into storage hopper 3 by screw conveyor 2 above crasher 4. The crushed grain is fed by means of air conveyor 5 into mixer 6 located on scales 7. After feeding the entire mass of grain, the protein-vitamin coagulate enters the mixer, according to the formulation. The mixture is fed by scraper conveyor 8 into hopper with agitator 9 and then into extruder 10. The finished extrudate is fed by conveyor 11 for storage.

In order to produce a protein-vitamin coagulate, an experimental production line is proposed in addition to the baseline (Figure 1, 12–22). The green mass is delivered and unloaded into green mass feeder 12 and is fed into hydraulic press 14 using scraper conveyor 13. The pulp formed after pressing is loaded using scraper conveyor 15 into freight vehicles for further delivery to the place of feeding animals or to the silage trench. The green sap is pumped by pump 16 into storage tank 17 for further coagulation.

First, green sap is sent to filter 18 for purification from fibrous plant impurities, and then to experimental coagulator 20. A total of 1 g/l of ascorbic acid is added to green sap as an antioxidant and for improved coagulability of proteins in the medium. In this regard, coagulation of the sap is performed under sparing heating modes. The resulting protein-vitamin coagulate and brown sap are pumped into separation vessel 22 by pump 21. After separation, the coagulate is fed into mixer 6 to produce a mixture for extrusion or is supplied for conservation. Brown sap is used to grow feed yeast or to fertilize soils.

Analysis of the protein-vitamin coagulate showed the presence of 37.1% to 42.44% protein in its composition, depending on the growing conditions and the harvest time of alfalfa. According to previous studies, the protein is characterized by a high content of carotene and essential amino acids such as valine, lysine, threonine, and tryptophan [15]. The data obtained allow us to recommend the use of protein-vitamin coagulate of alfalfa as a component for feed enrichment. Preservation or drying the coagulate is associated with additional costs. Therefore, the actual solution is to use it in the process of extrusion with grain. At the same time, high moisture content of the protein-vitamin

coagulate (85–89%) does not allow the creation of a mixture with its high content, since the moisture content before extrusion should not exceed 20%. In this regard, it is necessary to determine the optimal composition of the mixture.

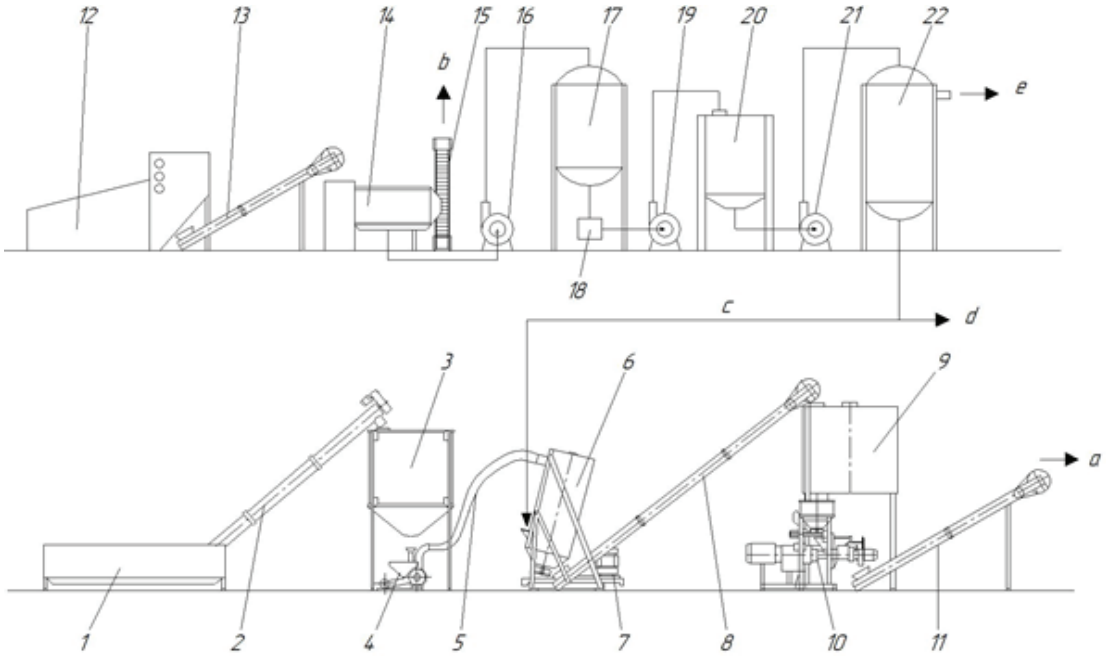
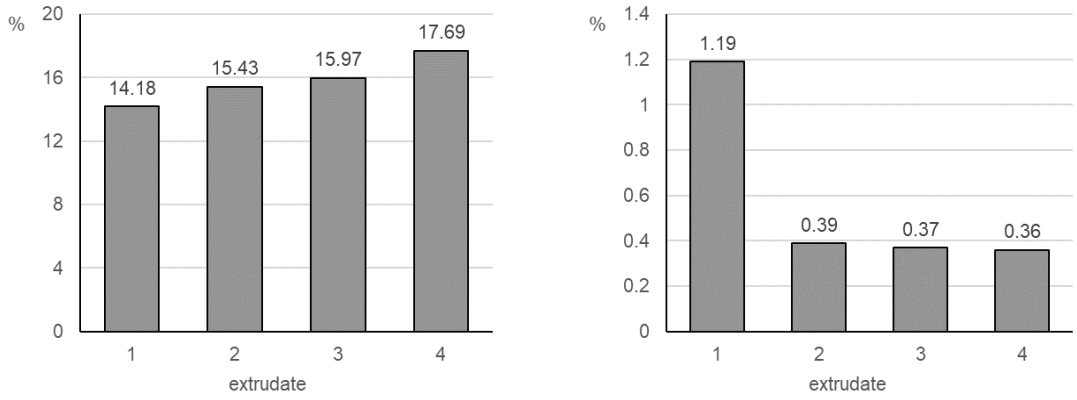


Figure 1: Technological scheme for production of extrudated feed with an experimental line intended for production of protein-vitamin coagulate: 1 – hopper for grain fodder; 2 – screw conveyor; 3 – storage bin; 4 – crusher; 5 – air conveyor; 6 – screw mixer; 7 – scales; 8, 11, 13, 15 – scraper conveyor; 9 – storage hopper with agitator; 10 – extruder; 12 – green mass feeder; 14 – hydraulic press; 16, 19, 21 – pump; 17 – storage tank for green sap; 18 – mechanical filter; 20 – green sap coagulator; 22 – container for separating coagulate and brown sap, a – extrudate, b – green mass pulp, c – protein-vitamin coagulate for extrusion, d – protein-vitamin coagulate for conservation, e – brown sap

Based on the preliminary calculation of the moisture content of mixtures, the protein-vitamin coagulate was mixed with wheat in the amount of 5.0%, 8.5%, and 12.0%. The analysis showed that the protein content in extrudates from a mixture of wheat grain and protein-vitamin coagulate is 9%–24% higher than that in extruded wheat (Figure 2, a). At the same time, the fiber content is 67–69% lower (Figure 2, b), which is due to replacement of part of wheat with components with low fiber content, and due to more active splitting of wheat during extrusion of the moist mixture.

The amount of metabolizable energy in the resulting extrudates shows a positive dynamics when the amount of protein-vitamin coagulate in the mixture grows up (Figure 3).

When 5.0% protein-vitamin coagulate is added to the mixture before extrusion, metabolizable energy increases by 1.4% compared to that in extruded wheat. When 8.5% and 12% coagulate is used in the mixture, metabolizable energy increases by 1.9% and 3.1%, respectively. A further increase in the amount of coagulate in the composition



a b

Figure 2: The content of protein (a) and fiber (b) in extrudates: 1 – wheat grain; 2 – wheat grain with protein-vitamin coagulate (5%); 3 – wheat grain with protein-vitamin coagulate (8.5%); 4 – wheat grain with protein-vitamin coagulate (12%)

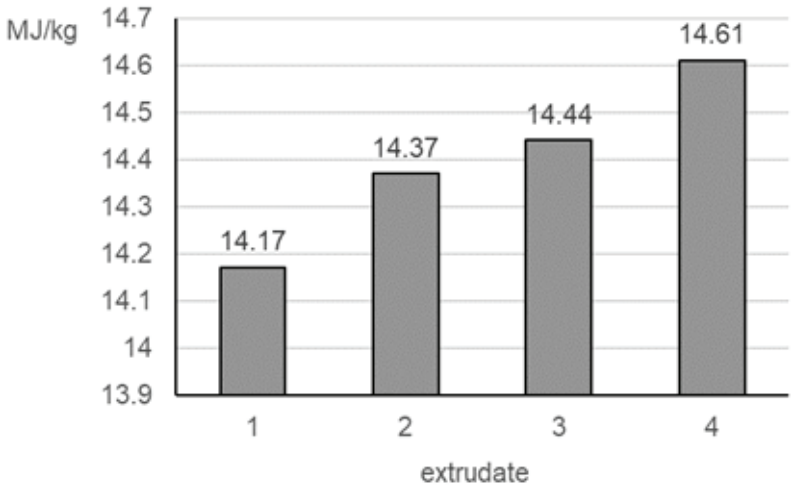


Figure 3: Metabolizable energy of extrudates: 1 – wheat grain; 2 – wheat grain with protein-vitamin coagulate (5%); 3 – wheat grain with protein-vitamin coagulate (8.5%); 4 – wheat grain with protein-vitamin coagulate (12%).

of the extruded mixture is not reasonable, since the increased humidity makes the extrusion process unstable

4. Conclusion

Thus, the proposed technology for producing extrudates using protein-vitamin coagulate is promising and provides feed and feed components with high protein content and metabolic energy. The optimal composition is a mixture of wheat grain and 12% protein-vitamin coagulate. Extrudates with the optimal ratio of components contain 17.69% protein and 14.61 MJ/kg of metabolic energy.

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Conflict of Interest

The authors have no conflicts of interest.

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