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## INGREDIENTS INFLUENCE OF THE GRANULATION PROCESS ON THE QUALITY OF THE PROBIOTIC FEED SUPPLEMENT

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**Abstract.** The modern development of animal husbandry and poultry farming is impossible without compound feed, which is balanced in terms of energy indicators, nutrients and biologically active substances. The presence of biologically active substances in the rations of animals leads to an increase in the cost of compound feed, which affects the cost of livestock products. However, an insufficient amount of biologically active substances leads to the occurrence of diseases that exclude the possibility of further effective use of animals. Probiotic feed products based on live cultures of microorganisms are used to ensure the body's need for biologically active substances of farm animals. Probiotic feed supplement EnzActive based on active yeast *Saccharomyces cerevisiae* is widely used in feeding farm animals. This supplement is able to increase the assimilation of nutrients by blocking the negative impact of harmful microorganisms on the condition of the mucous membranes of the gastrointestinal tract, on the processes of digestion and removal of the end products of metabolism. Based on theoretical and experimental data, a structural scheme for the production of granulated compound feed using EnzActive probiotic feed additive is proposed, which involves stepwise dosing and mixing of microcomponents with EnzActive probiotic feed additive, further mixing with prepared and dosed components of compound feed to ensure high uniformity of EnzActive distribution in the finished product. The technology for the production of granulated combined feed products using the EnzActive probiotic feed additive has been developed, which allows for the production of highly homogeneous finished products with a fixed stable composition that meets the physiological needs of farm animals. The physical properties of loose and granulated compound feed with the EnzActive probiotic feed additive were experimentally determined, which indicate that, compared to loose, granular compound feed with the EnzActive probiotic feed additive, it has a smaller angle of natural slope, better flowability, and greater volume, which leads to space saving during transportation and storage. The main quality indicator of the granulated compound feed is the fragility of the granules, which was 27%. It has been established that the introduction of probiotic feed additive EnzActive into the compound feed does not affect the change in the physical properties of the finished compound feed products. Microbiological indicators were determined, which indicate that the number of yeast cells in the granulated compound feed with the EnzActive probiotic feed additive is 51.6% compared to the number of yeast cells in the loose compound feed with the EnzActive probiotic feed additive.

**Keywords:** technology, probiotic feed additive, yeast, granulation, quality indicators, microbiological indicators.

### Introduction. Formulation of the problem

The balance of compound feed in terms of energy indicators, nutrients and biologically active substances is the basis for the successful development of livestock, poultry and fish farming. However, the majority of agricultural enterprises and farms do not introduce biologically active substances into animal rations, which allows not to increase the cost of the feed

component in the cost price of livestock products. The body of an animal, a bird, especially an adult, is able to compensate for the lack of biologically active substances in feed for some time. However, after only a few weeks, it is possible to observe a decrease in the productivity of animals and poultry, and in many cases, the occurrence of specific diseases in this case, which exclude the possibility of further effective use of livestock. The lack of biologically active substances in

the diet has the greatest effect on young animals, highly productive breeds and crosses of animals and poultry, as well as on breeding stock [1].

Recently, scientists have paid special attention to the development of probiotic feed products, namely feed additives using live cultures of microorganisms that provide the needs of the body of farm animals in biologically active substances [2].

### Analysis of recent research and publications

The probiotic preparation "Bionorm P" produced by LLC NVP "Ariadna" when used in broilers showed high preventive effectiveness against diseases of the gastrointestinal tract. "Bionorm P" not only has a positive effect on the bird's body, but also increases economic indicators, including average daily gains and preservation of the bird [3].

The use of active yeast *Saccharomyces cerevisiae* in the diets of laying hens contributed to an increase in poultry productivity by 3.7–6.6% and an increase in egg weight by 0.95–1.1% [4-6].

The enzyme-probiotic supplement "Immunobacterin-D" contains *Bacillus subtilis*, *Bacillus licheniformis* and enzymes (protease and lipase), which provides a polyvector effect in the digestive tract in general and the rumen in particular. It was established that the components of the enzyme-probiotic supplement "Immunobacterin-D" accelerate the colonization of the intestine with microbiota and the development of scar digestion in calves by 2.5 times compared to calves of the control group [7].

Microbial supplement "Biosprint" contains live yeast cultures (*Saccharomyces cerevisiae*, strain MUCL, 39885) and performs probiotic functions in the gastrointestinal tract of animals, which allows to increase the general productivity of lactating cows, especially the quality indicators of milk [8].

Feeding Levucell SC and ActiSaf Sc-47 live yeast preparations helps to normalize ruminal digestion of high-yielding cows whose diet contains a significant amount of concentrated feed, increases the productivity of cows, namely an increase in average daily milk yield during the entire lactation period compared to a diet without the use of live yeast preparations [9].

The Enzym company produces animal feed additives under the EnzActive brand. These additives are made on the basis of a yeast cell, contain a complex of nutrients that can replace antibiotics and artificial growth stimulants in the feed of farm animals.

Feed additives of the Enzym company:

EnzActive – microbial highly effective probiotic feed additive;

EnzActive B is a probiotic that suppresses pathogenic microflora;

EnzActive MIX – a unique probiotic-enzyme complex;

EnzActive Protein Powder is a prebiotic absorbent with antioxidant properties;

EnzActive Pro is a combination of probiotic and prebiotic actions for the balance of intestinal microflora [8,9].

EnzActive MIX probiotic-enzyme complex contains a unique combination of live yeast of the genus *Saccharomyces cerevisiae* and a complex of 6 enzymes, including proteolytic, amylolytic, cellulolytic action. Biologically active substances, acting as catalysts of metabolic processes in the body of pigs, increase the coefficients of digestion and assimilation of feed nutrients, increase the productivity and preservation of animals. Feeding the EnzActive MIX feed supplement contributed to an increase in the live weight of piglets from birth to the time of weaning by 9.53%, an increase in the level of hemoglobin by 9.5% and the hemoglobin content in erythrocytes by 9.68% at the time of weaning of piglets [10-18].

In order to prevent self-sorting of the loose feed additive mixture and to maintain its stable composition during storage, granulation of grain raw materials with EnzActive probiotic feed additive is suggested.

### The purpose of the study

The purpose of the work is to investigate the effect of temperature on the quality of probiotic feed additive EnzActive during the production of granulated compound feed products.

In order to achieve the set goal, it is necessary to solve the following **research tasks**:

- conduct a screening of the use of probiotic feed additives in the feeding of agricultural animals;
- consider the technology of obtaining active fodder yeast;
- to analyze the methods of introducing EnzActive probiotic feed additive into the technological process of compound feed production;
- to develop a technology for the production of granulated compound feed products using EnzActive probiotic feed additive;
- to determine the physical properties and microbiological parameters of the granulated compound feed with the EnzActive probiotic feed additive.

### Research materials and methods

All experiments to determine the physical properties of feed were conducted at the Department of Grain and Feed Technology of the Odesa National University of Technology, in accordance with standard methods accepted for granulated compound feed according to DSTU 8024:2015. Granulated compound feed were assessed by the following physical properties: mass fraction of moisture, flowability, angle of repose, density, fragility.

The mass fraction of moisture was determined by drying the sample of the product in the weighing cup in the drying oven at 130°C for 40 min, and was calculated using the formula:

$$W = \frac{q_1 - q_2}{q_1 - q_0} \times 100, \% \quad (1)$$

where  $q_0$  – weight of the empty weighing cup, g;  
 $q_1$  – weight of the weighing cup with a sample before drying, g;  
 $q_2$  – weight of the weighing cup with a sample after drying, g.

The flowability was determined by pouring the product through a hole of a certain size (4 cm in diameter). The product was poured into a box with an outlet closed with a latch. To determine the product's flowability, the latch was opened and the time of pouring of the product through the outlet onto a horizontal surface was noted. The volume of the product poured was measured with a cylinder. The flowability was determined from the formula:

$$W = \frac{q}{S \times t}, \text{ cm/s} \quad (2)$$

where  $q$  – volume of the product that passed through the hopper outlet,  $\text{cm}^3$ ;  
 $t$  – duration of pouring of the product, s;  
 $S$  – cross-section area of the outlet,  $\text{cm}^2$ .

The angle of repose was determined by pouring the product out of the filler onto a horizontal surface. The product was poured through a metal funnel that had the cone angle  $60^\circ$ , until the top of the pile reached the height of the vertical walls of the device. The angle was measured with a protractor. To this end, the protractor was applied to the cone generatrix, and the angle  $\beta$  was determined with a plumb bob. Then the angle of repose  $\alpha$  was calculated as:  $\alpha = 90 - \beta$ .

The density of the granules was determined on technical scales by weighing 5 granules and placing them in a measuring cylinder with a capacity of  $250 \text{ cm}^3$ , filled to the mark with millet previously leveled on a  $2.2 \times 20 \text{ mm}$  sieve. Millet extruded by granules is the volume of the granules, and the ratio of the mass of the granules to their volume is the density, followed by calculation according to the formula:

$$W\rho = \frac{m}{V}, \text{ g/cm}^3 \quad (3)$$

where  $m$  – weight of the granules, g;  
 $V$  – volume of the granules,  $\text{cm}^3$ .

The fragility was determined by taking 2 pellets, pre-weighed (after determining the size, mass, density), placed in a metal cylinder with a capacity of  $250 \text{ cm}^3$ . Then they are subjected to abrasion on a shaking machine for 60 minutes at a frequency of 100 – 150 double strokes per minute and an amplitude of oscillations of 20 mm. Then all small particles are sifted on SD 1, and the remaining granules are weighed. The fragility of granules is determined by the formula:

$$W = \frac{M_1 - M_2}{M_1} \times 100, \% \quad (4)$$

where  $M_1$  – weight of the granules to be processed (rubbed), g;

$M_2$  – weight of the granules after processing, g.

Determination of microbiological indicators, namely the number of yeast cells, were conducted at the Department of Food Chemistry, Expertise and Biotechnology of the Odesa National University of Technology.

Quantitative accounting of the cells of microorganisms was carried out by counting cells in the Goryaev chamber. Yeast cells in liquid substrates are counted after preliminary dilution with water. Add 2, 4 or  $10 \text{ cm}^3$  of yeast suspension to a  $100 \text{ cm}^3$  volumetric flask, depending on the expected cell concentration. To stain dead yeast cells, add  $20\text{--}30 \text{ cm}^3$  of methylene blue (1:5000) or  $1\text{--}5 \text{ cm}^3$  of 1:40 concentration. Wash and dry the camera and special ground cover glass well. Apply a small drop of the prepared dilution to the surface of the grid and cover with a cover glass.

The number of cells in  $1 \text{ cm}^3$  is determined by the formula:

$$X = \frac{a \times 4000 \times \frac{b}{c}}{1000} \quad (5)$$

where  $a$  – the sum of cells counted in five (or ten) large grid squares;

$b$  – dilution of the original substrate;

$c$  – the number of small squares in which the calculation was carried out [19].

The calculation of recipes for compound feed products depends on the availability of the raw material base and the feeding standards of farm animals and is carried out according to the programs for calculating recipes for compound feed products [20]. The content of protein, fat, fiber, lysine, tryptophan, calcium, phosphorus, and sodium was determined by calculation based on the content of the respective compounds and elements in the feed recipe ingredients.

All tests were performed in triplicate, and the experimental results were processed by the software Mathcad Professional from Mathsoft, Inc. (USA) [20].

### Results of the research and their discussion

In the modern market of raw materials, there are many different components to increase the nutritional value of feed and the efficiency of its use.

Among these components, fodder and hydrolytic yeast play an important role in the compound feed industry, in the cultivation of which micromycetes of the genera *Saccharomyces*, *Candida*, *Torulopsis*, etc. are used as a fodder protein-producing strain. Fodder and hydrolytic yeast are a source not only of protein, but also of essential amino acids and B vitamins [21].

Usually, the raw material for the production of simple fodder yeast is food production waste, which contains a large amount of protein. Active fodder yeast consists of a live culture of yeast cells, they are antagonists of pathogenic microflora, contain a very small amount of protein and B vitamins, so they cannot

be used as a source of protein. Probiotics – active fodder yeas are used as a bio-additive for animals [21].

The technology for the production of active feed yeast (Fig. 1) includes a series of stages of propagation of a pure liquid culture in aerobic fermenters of increasing volume. In the final production fermenter, yeast is grown aerobically to 20–25% dry matter. Next, the yeast is collected by centrifugation, concentrated to about 32% dry matter by rotary vacuum filters and dried in a fluidized bed dryer, which ensures fast and uniform drying [21].

Dry active yeast is produced in the form of small granules, the surface layers of which consist of inactivated yeast cells, and the inner layers of active ones (Fig. 2). An inactivated layer of cells is formed in the process of drying yeast, this layer protects the internal cells from the influence of the external environment.

EnzActive is a highly effective probiotic supplement based on the active yeast *Saccharomyces*

*cerevisiae*, which can be used at compound feed enterprises in the production of compound feed products and farms in the feeding of agricultural animals. The optimal dose of EnzActive depends on the species, sex and age of animals: for broilers 50–100 g per 1 ton of feed, for piglets 200 g per 1 ton of feed, for adult pigs 500–1000 g per 1 ton of feed, and for dairy cows 5–15 g per animal per day. Research on the use of the EnzActive probiotic supplement in the feeding of farm animals was carried out by adding the supplement to the diet in loose form or individually to each animal separately [10].

According to the recommended norms for the introduction of active feed yeast EnzActive, recipes for compound feed products (Table 1) have been developed for piglets aged 2–4 months, pigs for fattening (40–70 kg) and laying hens older than 13 weeks.

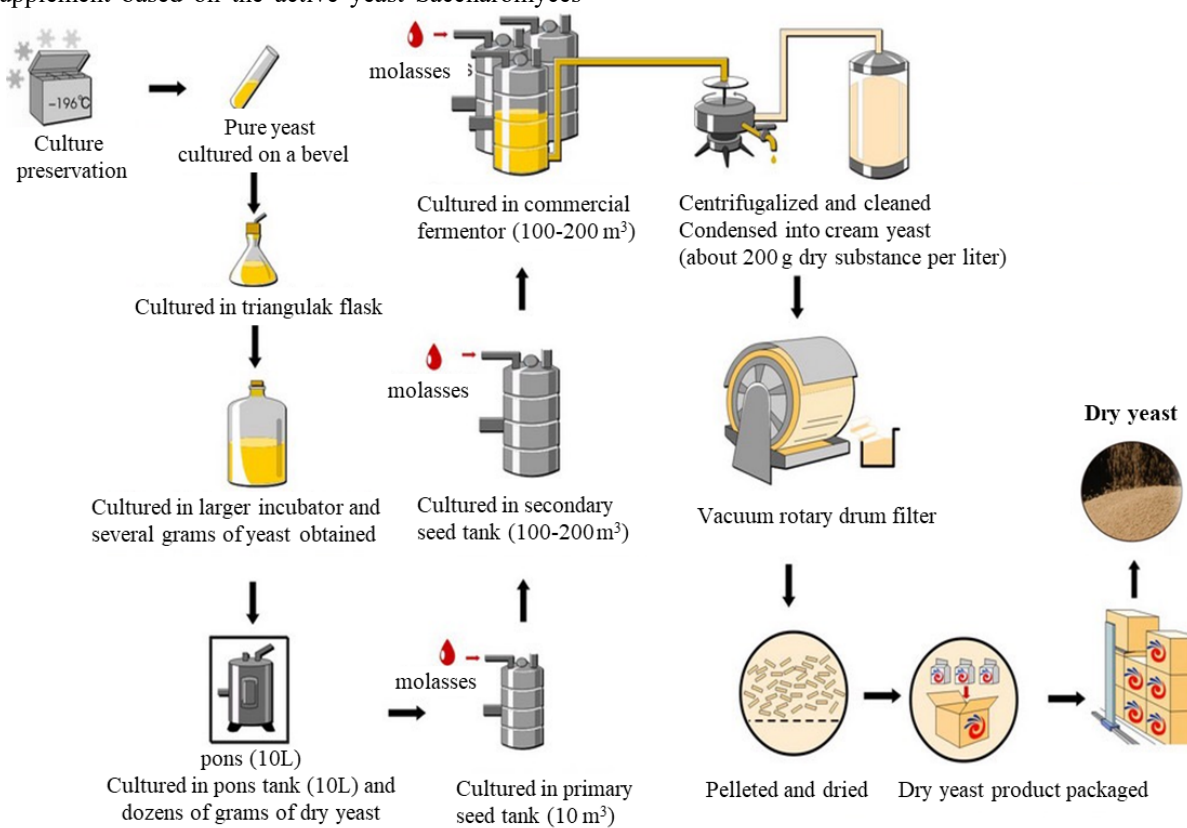


Fig. 1. Production technology of dry active yeast

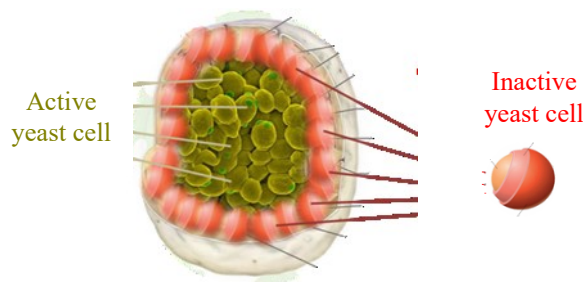


Fig. 2. Granule of active fodder yeast

**Table 1 – Recipes of compound feed products**

Components	for piglets aged 2–4 months	for fattening pigs (40–70 kg)	for laying hens older than 13 weeks
Wheat	30.9	48.8	36.31
Corn	16.7	20	16.4
Barley	14	5.7	15.1
Soy	–	19	–
Sunflower meal	9.9	–	6.3
Soybean meal	10	–	10.4
Wheat bran	8.4	–	–
Meat and bone meal	2.0	0.1	6
Fish meal	5.1	–	–
Feed yeast	1.0	3.8	–
Defluorinated phosphate	–	0.84	–
Dicalcium phosphate	–	–	0.7
Limestone	0.73	0.3	6.4
Table salt	0.25	0.41	0.1
Premix	1	1	1
Methionine	–	–	0.12
L-Lysine sulfate (98.5%)	–	–	0.17
Probiotic feed supplement EnzActive	0.02	0.05	0.01
Total	100	100	100
<i>Quality indicators</i>			
Exchange energy MJ/kg	16.2	13,4	11.5
Mass fraction, %:			
Raw protein	18.7	14.0	16.5
Raw fat	4.3	19.7	4.1
Crude fiber	3.7	29.7	4.5
Lysine	0.99	0.62	0.8
Tryptophan	0.24	0.21	0.19
Calcium	1.1	0.72	3.4
Phosphorus	1.55	0.6	0.46
Sodium	0.45	0.2	0.16

Mixing is the most important stage in the production of compound feed products. From a zootechnical point of view, it is important not only to develop a highly effective compound feed recipe, to choose high-quality feed raw materials for its production, to ensure its appropriate preparation, to precisely dose the prepared components, but also to ensure their uniform distribution in all microvolumes of the mixture in such a way that in each portion of compound feed, which is consumed, the ratio of components provided for in the recipe was provided [20].

In order to fix the composition of a highly homogeneous finished product, it is necessary to apply various technological processes in order to avoid self-sorting of the loose mixture. The use of heat treatment,

namely the process of extruding grain raw materials with EnzActive probiotic feed additive, increases the feed value of grain raw materials and allows maintaining a stable composition during the guaranteed storage and transportation period (Fig. 3). However, according to microbiological indicators, the activity of EnzActive yeast after the extrusion process was only 6% [22].

Granulation is one of the types of pressing, the essence of which is to compress an appropriately prepared loose product in a limited space for some time. Granulation is used for the purpose of forming compound feed into aggregates of particles of sizes that best meet the physiological needs of farm animals, poultry and fish. In Fig. 4 shows the advantages of granulated compound feed over loose feed [20].

For granulation, it is necessary to send a highly homogeneous compound feed with an even granulometric composition, which increases the efficiency of the press-granulator (Fig. 5). Loose compound feed with EnzActive probiotic feed additive is sent to the press-granulator after the main mixer. Steam-treated compound feed should have a moisture content of 15.0–18.0% and a temperature of +(60-90)°C. Steam pressure, as a rule, is 0.2–0.5 MPa, consumption is 50–80 kg/t. The resulting granules have a temperature of +(60–80)°C and are sent for cooling to a temperature that should not exceed the ambient temperature by more than 10°C. The moisture content of the cooled granules should not exceed 14.5% [20].

Taking into account the advantages of granulated compound feed over loose feed, samples of loose and granulated compound feed for piglets aged 2–4 months with EnzActive probiotic feed additive were obtained. The samples were examined according to the parameters that most characterize the technological properties of the finished products, namely the angle of natural slope, flowability, volumetric weight, and for granulated compound feed, the density and fragility of the granules were determined.

Table 2 shows the physical properties of loose and granulated compound feed for piglets aged 2–4 months with EnzActive probiotic feed additive.

**Table 2 – Physical properties of compound feed for piglets aged 2-4 months with EnzActive probiotic feed additive**

Indicator	Loose compound feed	Granulated compound feed
Mass fraction of moisture, %	11.5	13.2
The angle of repose, degrees	48	37
Flowability, cm/s	8.3	17.0
Volumetric mass, kg/m <sup>3</sup>	485	602
Density, km/m <sup>3</sup>	–	0.86
Fragility, %	–	27

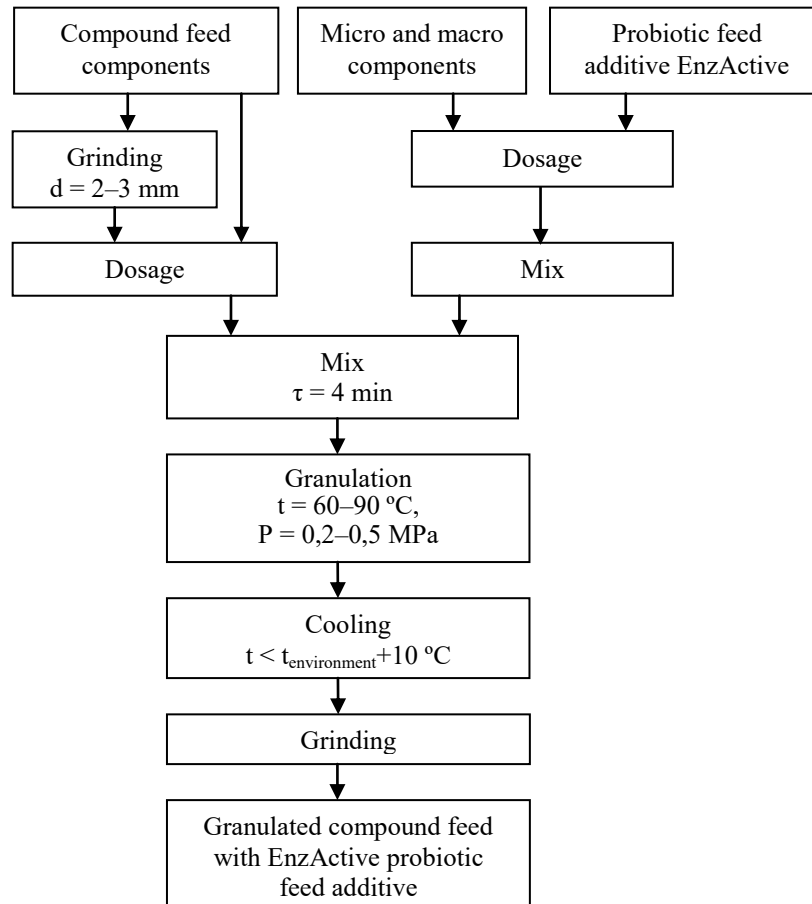


Fig. 3. Functional scheme for the production of granulated compound feed using EnzActive probiotic feed additive

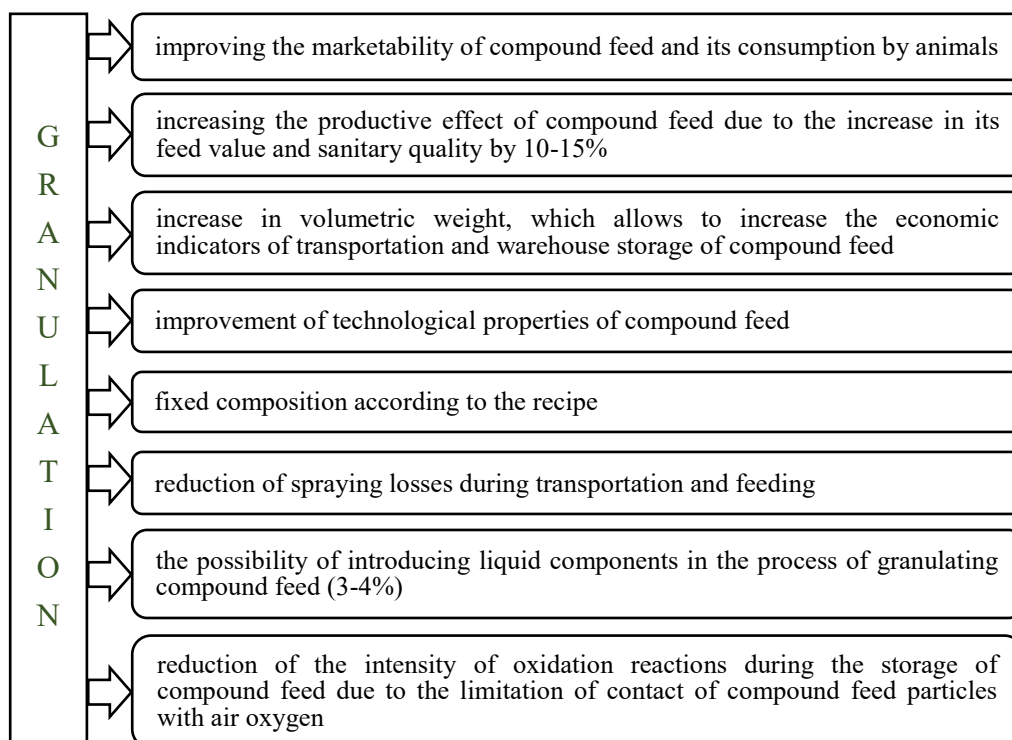
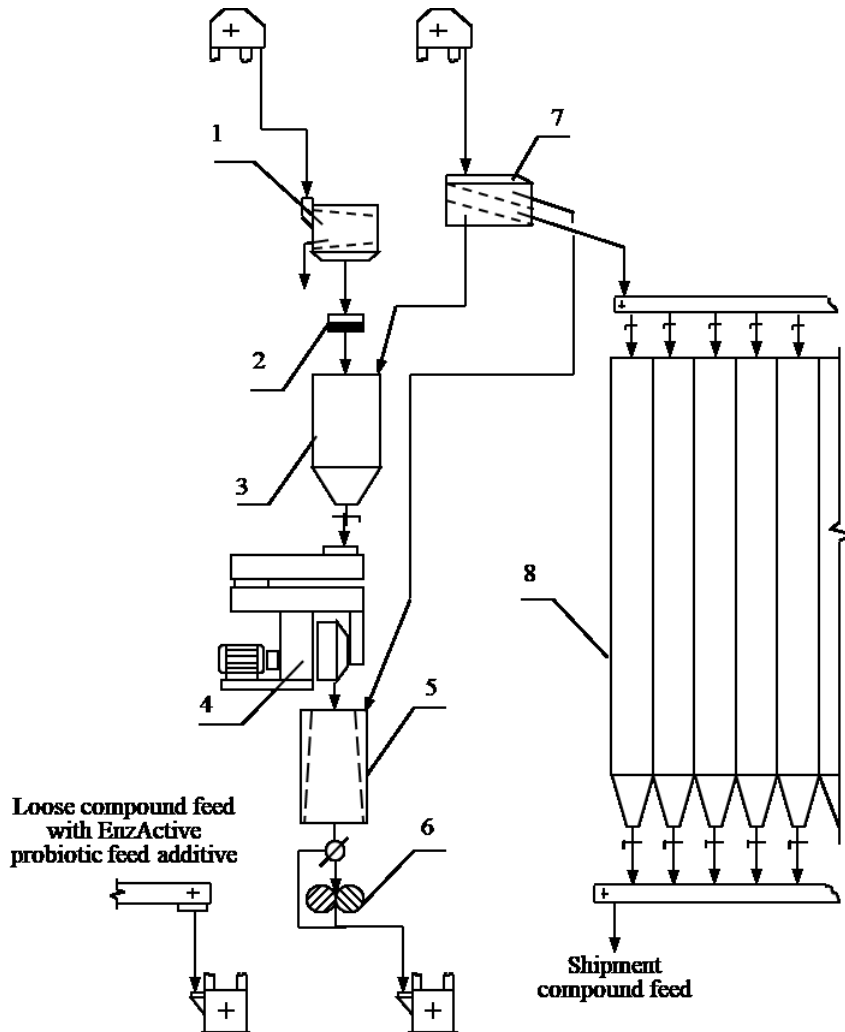


Fig. 4. Advantages of granulated compound feed



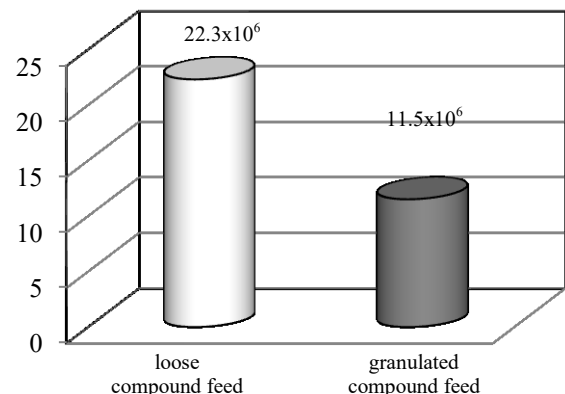
**Fig. 5. Technology of granulation of compound feed with EnzActive probiotic feed additive**  
 1 – scalper; 2 – magnetic separator; 3 – bunker; 4 – press granulator; 5 – cooling column;  
 6 – roll shredder; 7 – sieving machine; 8 – composition of finished products

Analysis of the data given in the table. 2, shows that loose and granulated compound feed is characterized by satisfactory physical properties. Granulated compound feed, compared to loose compound feed, has a smaller angle of natural slope, better flowability, greater volumetric mass, which leads to space savings during transportation and storage. The main quality indicator of the granulated compound feed is the fragility of the granules, which was 27%. It has been established that the introduction of probiotic feed additive EnzActive into the compound feed does not affect the change in the physical properties of the finished compound feed products.

Screening has shown that EnzActive yeast granules are temperature resistant. Our task was to investigate how the activity of EnzActive yeast changes under the influence of temperature during the granulation process.

To determine the total number of yeast cells, samples of loose and granulated compound feed with

EnzActive probiotic feed additive were taken. The number of yeast cells in the samples is shown in Fig. 6, which were determined by the method of direct counting of cells of microorganisms using the Goryaev counting chamber [19].



**Fig. 6. Number of yeast cells (pcs x 10<sup>6</sup>/g) in loose and granulated compound feed with EnzActive probiotic feed additive**

The number of yeast cells in the granulated compound feed with the EnzActive probiotic feed additive was 51.6% compared to the number of yeast cells in the loose compound feed with the EnzActive probiotic feed additive. Therefore, the effect of temperatures during granulation almost halves the number of EnzActive yeast cells.

### Conclusions

Probiotic feed supplement EnzActive based on active yeast *Saccharomyces cerevisiae* is widely used in feeding farm animals.

The technology for the production of granulated combined feed products using the EnzActive probiotic feed additive has been developed, which allows for the production of highly homogeneous finished products with a fixed stable composition that meets the physiological needs of farm animals.

Granulated compound feed with probiotic feed additive EnzActive compared to loose compound feed with probiotic feed additive EnzActive has a smaller angle of natural slope, better flowability, greater volumetric weight, which leads to space savings during transportation and storage. The main quality indicator of the granulated compound feed is the fragility of the granules, which was 27%. It has been established that the introduction of probiotic feed additive EnzActive into the compound feed does not affect the change in the physical properties of the finished compound feed products.

Microbiological indicators show that the number of yeast cells in granulated compound feed with EnzActive probiotic feed additive is 51.6% compared to the number of yeast cells in loose compound feed with EnzActive probiotic feed additive.

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## ВПЛИВ ПРОЦЕСУ ГРАНУЛЮВАННЯ НА ЯКІСТЬ ПРОБІОТИЧНОЇ КОРМОВОЇ ДОБАВКИ

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**Анотація.** Сучасний розвиток тваринництва та птахівництва неможливий без комбікормів, які збалансовані за енергетичними показниками, поживними та біологічно активними речовинами. Наявність біологічно активних речовин в раціонах тварин призводить до підвищення вартості комбікормів, що впливає на вартість тваринницької продукції. Проте, недостатня кількість біологічно активних речовин призводить до виникнення хвороб, які виключають можливість подальшого ефективного використання тварин. Для забезпечення потреби організму сільськогосподарських тварин в біологічно активних речовинах, використовують пробіотичні кормові продукти на основі живих культур мікроорганізмів. Пробіотична кормова добавка EnzActive на основі активних дріжджів *Saccharomyces cerevisiae* широко використовується в годівлі сільськогосподарських тварин. Ця добавка здатна підвищувати засвоєння поживних речовин за рахунок блокування негативного впливу шкідливих мікроорганізмів на стан слизових оболонок шлунково-кишкового тракту, на процеси травлення і видалення кінцевих продуктів метаболізму. На основі теоретичних та експериментальних даних запропоновано структурну схему виробництва гранульованих комбікормів з використанням пробіотичної кормової добавки EnzActive, яка передбачає поетапне дозування та змішування мікрокомпонентів з пробіотичною кормовою добавкою EnzActive, подальше змішування з підготовленими та здозованими компонентами комбікорму для забезпечення високої рівномірності розподілення EnzActive у складі готової продукції. Розроблено технологію виробництва гранульованої комбікормової продукції з використанням пробіотичної кормової добавки EnzActive, що дозволяє виробляти високооднорідну готову продукцію фіксованого стабільного складу, яка відповідає фізіологічним потребам сільськогосподарських тварин. Експериментально визначено фізичні властивості розсипного та гранульованого комбікорму з пробіотичною кормовою добавкою EnzActive, які свідчать, що в порівнянні з розсипним, гранульований комбікорм з пробіотичною кормовою добавкою EnzActive має менший кут природного укосу, кращу сипучість, більшу об'ємну масу, що призводить до економії площ при транспортуванні та зберіганні. Основним якісним показником гранульованого комбікорму є крихкість гранул, що склала 27%. Встановлено, що введення пробіотичної кормової добавки EnzActive до складу комбікормів не впливає на зміну фізичних властивостей готової комбікормової продукції. Визначено мікробіологічні показники, які свідчать, що кількість дріжджових клітин в гранульованому комбікормі з пробіотичною кормовою добавкою EnzActive складають 51,6% в порівнянні з кількістю дріжджових клітин в розсипному комбікормі з пробіотичною кормовою добавкою EnzActive.

**Ключові слова:** технологія, пробіотична кормова добавка, дріжджі, гранулювання, показники якості, мікробіологічні показники.