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GRANULOMETRIC PARAMETERS OF COMBINED FEED

Abstract

The recommended storage methodologies require further refinement, as the amount of losses of individual components in feed mixtures is not economically justified. In this regard, it is important to study the interrelated processes of mixing and storage. The task is to establish the patterns of changes in the quality of compound feed while ensuring the minimum total cost. In this context, it is important to scientifically substantiate the influence of the level of homogeneity of the mixture on the results of storing bulk feed, which is a significant engineering and technological challenge. The scientific novelty of the research lies in the following: patterns of changes in the quality indicators of compound feed with different compositions, physical properties, and homogeneity coefficients during storage have been established; a key indicator for assessing the homogeneity of feed mixtures has been determined. Principles for forming homogeneous mixtures have been developed depending on the

properties of the components, technological parameters of mixing, and composition of raw materials, depending on the design features of the grinding machines used. In addition, important aspects of compound feed production are the development of diets that ensure maximum efficiency of animal feeding using grinding machines of various designs. The particle size when using equipment for grinding feed components significantly affects.

***Keywords**: compound feed, grinding, size, mixing, evaluation.*

Introduction. Mixed feeds are specialized mixtures formed from various components, such as cereal crops, protein sources, and vitamin and mineral supplements. Such diets are formulated taking into account the physiological characteristics of the organism and the age-specific features of animals of a particular species. The main requirement for ensuring high-quality compound feed is the uniform distribution of nutrients in each portion intended for consumption, which guarantees that the animals' needs for essential components are optimally met. The main direction of development of the compound feed industry is to solve pressing problems related to the improvement of production technologies and equipment. The priorities are to increase the efficiency of raw material use, improve product quality, expand the range of ready-made feed mixtures, and ensure long-term storage of products. Further growth in livestock productivity is based on the use of balanced feed rations that take into account the content of nutrients, vitamins, minerals, trace elements, fatty acids, as well as additional components such as antibiotics, antioxidants, and biologically active substances. Compliance of such diets with modern zootechnical requirements is a priority task for the industry. With regard to grain grinding, numerous studies have confirmed improved nutrient absorption and overall efficiency of livestock technologies when using fine grinding compared to coarser particle sizes. It is recommended to aim for an average particle size in the range of 600–700 μm, particularly for grain crops such as corn, barley, or sorghum. When processing wheat, it is important to exercise caution, especially when its content in feed is high. With this in mind, the optimal choice in pig farming is to maintain an average particle size between 600 and 700 μm. For better feed digestibility, it is necessary to carefully determine and adjust the grinding parameters. Although fine grinding can improve particle quality, typical mistakes such as incomplete grinding of already floury raw materials, such as soybeans, should be avoided. At first glance, such grinding may seem sufficient, but it turns out to be unacceptable. For example, the graph shows the particle size distribution curve of excessively coarse soybean meal. Analysis of feed grain size allows the size of its constituent particles to be assessed, which is closely related to the degree of grinding of the raw material. In the production of pig feed, grain crops are the main source of energy. Therefore, it is necessary to take into account not only their nutritional properties, but also the processing methods to which they are subjected. Even a properly balanced diet can lose its effectiveness due to insufficient attention to production technologies [1, 2].

Problem statement, analysis of current research. The problem of raw material preparation, namely the degree of grinding by machines of various designs to the optimal particle size for mixing components in order to achieve high-quality mixing, is relevant for solution.

Insufficient grinding of individual components, whether insufficient or excessive, negatively affects the technological properties of the mixture. This leads to increased energy costs and reduced efficiency of nutrient absorption. To objectively determine the quality of mixing in the production of compound feed, the coefficient of variation is actively used, which makes it possible to quantitatively assess the degree of homogeneity of the mixture. Studies [3, 4, 5] indicate the importance of the process of grinding and reducing the size of feed particles using hammer or roller mills, which perform a number of key tasks:

1) increasing the contact area with digestive secretions, improving the digestibility of proteins and other nutrients, since smaller particles have a larger surface area for interaction with digestive enzymes;

2) improving feed efficiency;

3) ensuring greater homogeneity of the feed mixture, which simplifies the work of personnel.

However, grinding feed too finely can result in economic losses for the farm. The negative aspects of excessively fine grinding include:

1) more frequent occurrence of stomach ulcers; As is known, when the average particle size reaches 4-500 μm or less, this creates favorable conditions for the development of stomach ulcers in pigs: fine flour increases the mechanical mixing of stomach contents, causing prolonged contact of the material with the low pH of the esophageal part (pars eosophagea). The second correlation is the acceleration of gastric emptying caused by fine grinding: this contributes to the rise of bile acids to the mucous membrane of the esophageal section, where they cause erosive processes;

2) a decrease in the volume of feed consumed;

3) increased dust levels, leading to impaired respiratory health in both humans and animals. Fine dust, particularly < 24 μm in size (respirable fraction), irritates the mucous membrane of the tracheobronchial tree, causing functional and structural disorders of the epithelium -it loses its ability to effectively cleanse itself with cilia and produces excess mucus.

In addition, these particles serve as the main route for infectious agents to penetrate deeper into the respiratory system, acting as an organic carrier that protects pathogens. The concentration of dust in the external environment is about 0.1 mg/m3: in piggeries, it varies from 1 to 10 mg/m3, which is 10-100 times higher [1 ,3, 5, 6]. This is influenced by stocking density, ambient temperature, relative humidity, ventilation intensity, as well as the composition and methods of feed preparation and distribution;

4) increase in feed production costs.

In conclusion, it is important to consider the size of the pellets, which should not be too small, especially when it comes to the problem of salmonellosis. This disease remains one of the main zoonotic diseases. A well-designed diet can significantly contribute to the control of this infection, while reducing the need for medication. Scientific studies, whether conducted in the laboratory or during analysis of disease prevalence, show a clear link between larger feed particle sizes and a reduction in the incidence and spread of salmonellosis in pig farms [2, 4, 8, 11]. However, the question of the effectiveness of

production processes remains open, as larger feed particles can lead to reduced productivity, particularly in terms of animal weight gain and feed conversion [3, 7, 9]. The recommended average particle size of pig feed should range from 500 to 800 micrometers and gradually increase as the animals age. At the same time, the proportion of very fine fractions (less than 150 micrometers) should be limited to a maximum of 2.5% [7, 9, 11].

Purpose of the study: The grinding level determines the particle size of the feed base after mechanical processing. It is assessed by the average particle size and their numerical representation in different size groups. The grinding process is a mandatory stage in the preparation of raw materials, as it ensures better absorption of vital elements and promotes uniform mixing of components. At the same time, it is important to determine the optimal particle sizes that guarantee effective mixing, taking into account their tendency to stratify.

Presentation of the main material. The main goal of preparing complete feed for use in the manufacture of piglet feed is to achieve maximum uniformity of the final product. The geometric parameters and physical characteristics of the particles play a key role in ensuring the effective movement of the constituent elements in the mixing equipment. Components with similar sizes and physical properties are much easier to distribute evenly throughout the mixture. If there are significant differences in particle size, stratification may occur, with denser or larger fractions accumulating in certain areas. This negatively affects the quality of the finished feed and leads to an uneven supply of nutrients to the animals. Optimizing the grinding process of feed components significantly contributes to increasing the efficiency of compound feed production. It reduces energy costs, shortens the time required for mixing, and ensures the desired level of homogeneity of the final product.

Table 1

Indicators of the effectiveness of mixing ingredients of compound feed using a hammer-type grinding machine with a particle size of 0.6-1 mm and a moisture content of 12-14.5%

No. , item	Time required to mix feed components (τ), s	Coefficient of variation (Vc), %	Segregation index depending on size difference
1	0	40	0,01
2	50	25	0.05
3	100	14	0.11
4	150	9	0,14
5	200	7	0,15
6	250	6	0,17
7	300	8	0,40

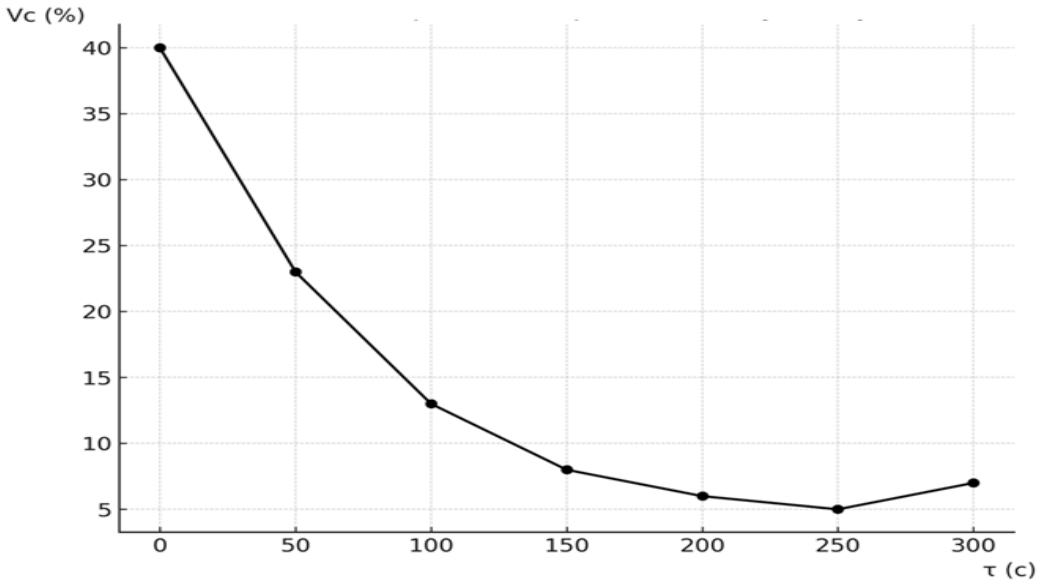

Fig. 1. **Dynamics of the formation of a mixture of feed components using a hammer-type grinding machine, particle size 0.6-1 mm).**

Table 2

Indicators of the effectiveness of mixing ingredients of compound feed using a hammer-type grinding machine with a particle size of 0.5 mm and a moisture content of 12-14.5%.

No. , item	Time required to mix feed components (τ), s	Coefficient of variation (Vc), %	Segregation index depending on size difference
1	0	40	0,01
2	50	24	0.03
3	100	13	0.10
4	150	8	0,12
5	200	7	0,13
6	250	5	0,16
7	300	7	0,39

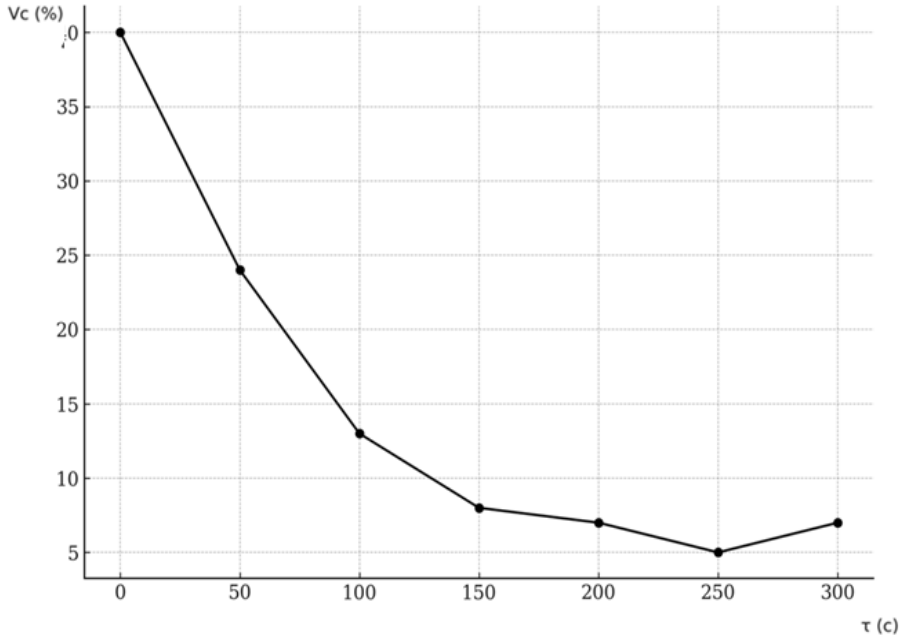

Fig. 2. **Dynamics of the formation of a mixture of feed components using a hammer-type grinding machine, particle size 0.5 mm.**

Table 3

Indicators of the effectiveness of mixing feed ingredients using a roller-type grinding machine with a particle size of 0.6-1 mm and feed moisture content of 12-14.5%.

No. , item	Time required to mix feed components (τ), s	Coefficient of variation (Vc), %	Segregation index depending on size difference
1	0	40	0,01
2	50	23	0.05
3	100	13	0.11
4	150	8	0,14
5	200	6	0,15
6	250	5	0,17
7	300	7	0,40

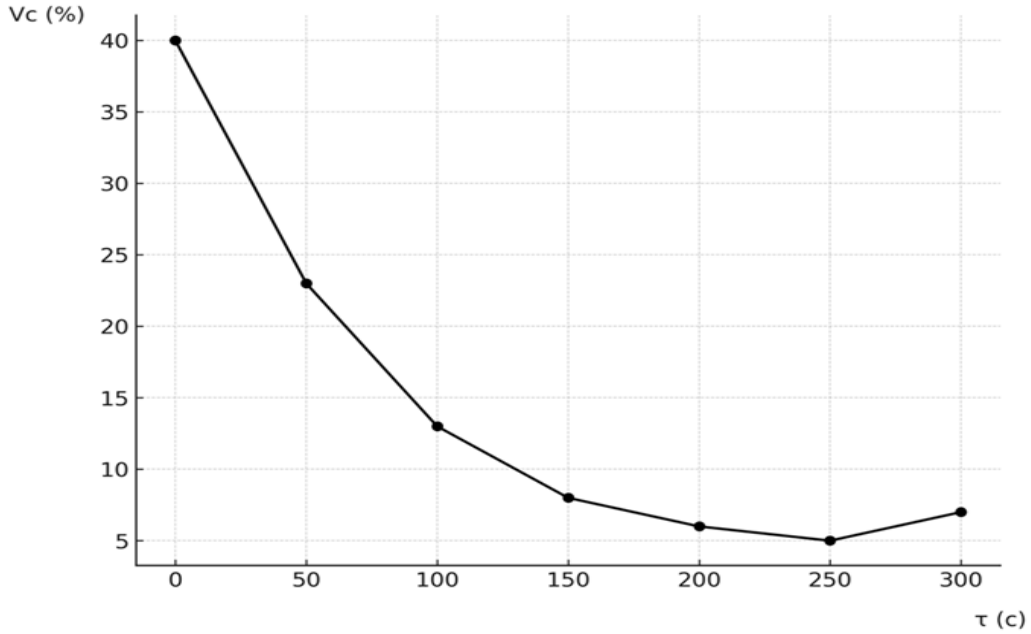

Fig. 3. **Dynamics of the formation of a mixture of feed components using a roller-type grinding machine, particle size 0.6-1 mm.**

Table 4

Indicators of the effectiveness of mixing ingredients of compound feed using a roller-type grinding machine with a particle size of 0.5 mm and a moisture content of 12-14.5%.

No. , item	Time required to mix feed components (τ), s	Coefficient of variation (Vc), %	Segregation index depending on size difference
1	0	40	0,01
2	50	22	0.02
3	100	11	0.09
4	150	5	0,10
5	200	4	0,11
6	250	3	0,15
7	300	5	0,35

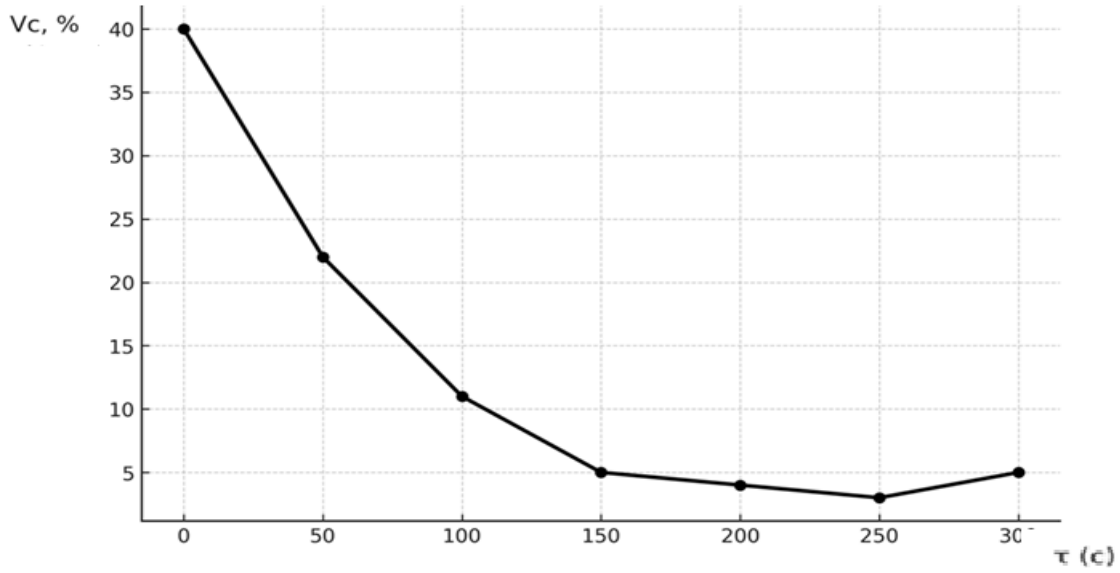

Fig.4. **Dynamics of the formation of a mixture of feed components using a roller-type grinding machine, particle size 0.5 mm.**

Conclusions and prospects for further research. During the operation of a roller mill, under similar technical parameters compared to a hammer mill, there is an improvement in the segregation coefficient and coefficient of variation. Roller mills provide more uniform grinding while retaining a larger proportion of 0.5 mm particles, while hammer mills produce a significant proportion of fine dust.

The simulation results indicate that an increase in particle size difference significantly slows down the process of achieving mixture homogeneity. The study revealed a linear dependence of the segregation index on the increase in particle size dispersion, which indicates an increased risk of material stratification during transportation. The authors consider the need for research on different feed recipes to be a promising area of research.

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ГРАНУЛОМЕТРИЧНІ ПАРАМЕТРИ КОМБІКОРМУ

Анотація

Рекомендовані методології зберігання потребують подальшого уточнення, оскільки величина втрат окремих компонентів у кормових сумішах економічно недостатньо обґрунтована. У зв'язку з цим актуальним є дослідження взаємопов'язаних процесів змішування та зберігання. Завданням є встановлення закономірностей змін якості комбікормів при забезпеченні мінімальної загальної вартості. У контексті цього важливо науково обґрунтувати вплив рівня однорідності суміші на результати збереження сипучих кормів, що становить значну інженерно-технологічну задачу. Наукова новизна досліджень полягає у наступному: встановлено закономірності зміни якісних показників комбікормів із різним складом, фізичними властивостями та коефіцієнтом однорідності під час зберігання; визначено ключовий показник для оцінювання однорідності суміші кормів. Розроблено принципи формування однорідних сумішей залежно від властивостей компонентів, технологічних параметрів змішування та складу сировини, залежно від конструктивних особливостей використовуємих подрібнювальних машин. Крім того, важливими аспектами виробництва комбікормів є розроблення раціонів, які забезпечують максимальну ефективність годівлі тварин з використанням машин подрібнення різних конструкцій. Розмір частинок, при використанні обладнання для подрібнення компонентів комбікормів значною мірою впливає на засвоюваність поживних речовин та ефективність травлення. Зменшення розміру частинок збільшує площу поверхні корму, доступну для дії ферментів травної системи, що сприяє кращому засвоєнню білків і поживних елементів. Це особливо актуально для білкової сировини, такої як шрот сої, соняшнику та ріпаку, де дослідження демонструють підвищення засвоєння амінокислот і енергії завдяки ретельнішому подрібненню. Надмірне подрібнення може спричинити збільшення клейкості корму, що, у свою чергу, знижує добровільне споживання їжі тваринами. У той же час, занадто дрібний помел (менше 500 мкм) може значно підвищити частоту виникнення шлункових виразок, особливо у поросят і дорослих свиноматок.

Ключові слова: *комбікорм, подрібнення, розмір, змішування, оцінка.*

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