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ENSURING THE QUALITY OF COMPOUND FEED DURING THEIR STORAGE

Abstract

Ensuring proper storage of feed stocks for cattle is a key factor in successful farming. Both animal health and farm productivity depend on this. Competently organized storage of feed allows you to preserve their nutritional properties, prevent quality losses and create a stable basis for the sustainable development of the farm business. The duration of feed storage significantly affects their quality and nutritional content. Over time, feed undergoes natural degradation, which negatively affects their ability to ensure proper development and health of livestock. One of the reasons for this is the process of lipid oxidation, as a result of which free fatty acids are formed. These substances not only reduce the energy value of feed, but also add an unpleasant taste to it, which can affect the readiness of animals

for their consumption. In addition, vitamin components, especially those that are sensitive to light and oxygen, gradually lose their activity. Protein structures also break down over time, resulting in a deficiency of important amino acids, these are the bases for building muscle mass and maintaining livestock vitality. The growing global demand for animal products such as meat, dairy products and eggs is driving the expansion of the livestock sector, which requires an increase in the number of livestock. This, in turn, increases the need for animal feed, where special emphasis is placed on their high quality and safety. In the materials of this work, the issues of the effect of the action of a dry synthetic preservative on the organoliptic quality indicator of loose compound feed, which is stored before its use, are considered.

Key words: *compound feed, preservative, action, storage, quality.*

Introduction. The use of special impurities helps farmers to eliminate the damage that long-term storage causes to feed. The infusion of additional vitamin complexes and amino acids into stored feed can fill gaps in lost nutrients that are inevitable over time. The addition of the same antioxidant substances as selenium, vitamin E or artificial preservatives allows to protect fats and vitamins from oxidation processes, which in turn increases the shelf life of the feed while preserving its nutritional value [1, 3, 4, 6].

This trend leads to an increase in the importance of effective feed storage methods, among which preservatives play a key role. They serve as a means of maintaining the integrity of feed throughout the logistics cycle. The global feed preservative market is expected to reach a volume of US$4.9 billion, and will continue to grow at an average annual rate of approximately 4.6% between 2023 and 2030. Such substances are represented by both organic and inorganic compounds, which are added to feed mixtures to extend their shelf life and preserve their nutritional value. The main task of preservatives is to prevent the development of pathogenic microorganisms, including bacteria, yeast and mold, which can threaten both raw material components and ready-made feed. Thanks to this, the risks of spoilage of products of microbial origin are minimized. Preservatives perform a critical function in ensuring high-quality and stable nutrition for animals. They ensure that the feed remains complete and safe throughout the entire period of use — from the moment of manufacture until the animals are fed. This not only helps to preserve the beneficial properties of the feed, but also prevents contamination of the product at all stages of supply, effectively extending its shelf life.The use of preservatives in animal and poultry feed is a complex and multifaceted process that plays a key role in ensuring both animal welfare.

Problem statement, analysis of modern research. Ensuring the storage conditions of compound feed without deterioration of its quality indicators is a modern requirement for the livestock complex. Scientific works have proven that the quality of feed in terms of the content of necessary substances can significantly deteriorate already due to a short storage period of – only a few months. For example, fat particles in corn can decrease by more than a tenth when it is stored for only two months. The use of special impurities helps farmers to eliminate the damage that long-term storage causes to feed. The infusion of additional vitamin complexes and amino acids into stored feed can fill gaps in lost nutrients that are inevitable over time. The addition of the same antioxidant substances as selenium, vitamin E or artificial preservatives allows to protect

fats and vitamins from oxidation processes, which in turn increases the shelf life of the feed while preserving its nutritional value [2, 3, 4, 6]. This trend leads to an increase in the importance of effective feed storage methods, among which preservatives play a key role. They serve as a means of maintaining the integrity of feed throughout the logistics cycle. The global feed preservative market is expected to reach a volume of US$4.9 billion, and will continue to grow at an average annual rate of approximately 4.6% between 2023 and 2030. Such substances are represented by both organic and inorganic compounds, which are added to feed mixtures to extend their shelf life and preserve their nutritional value. The main task of preservatives is to prevent the development of pathogenic microorganisms, including bacteria, yeast and mold, which can threaten both raw material components and ready-made feed. Thanks to this, the risks of spoilage of products of microbial origin are minimized. Preservatives perform a critical function in ensuring high-quality and stable nutrition for animals. They ensure that the feed remains complete and safe throughout the entire period of use - from the moment of manufacture until the animals are fed.

This not only helps to preserve the beneficial properties of the feed, but also prevents contamination of the product at all stages of supply, effectively extending its shelf life. The use of preservatives in animal and poultry feed is a complex and multifaceted process that plays a key role in ensuring both animal welfare and productivity. However, excessive dosing or improper use of these substances can harm the health of both animals and humans. In this regard, it is important to introduce preservatives into diets with caution, strictly observing regulated safety standards. Among the main types of preservatives actively used in the field of animal husbandry, a special place is occupied by organic acids, antioxidants, compounds to inhibit the development of mold and antimicrobial agents. Each of these groups performs a specific function aimed at maintaining the initial properties of feed components or finished products. These additives are classified as feed acidifiers, mold inhibitors, feed antioxidants and anti-caking agents. According to analytical data from leading research institutions, the segment of feed acidifiers dominates the world market of preservatives. Forecasts indicate that this segment will be marked by significant growth in the coming years, which will allow it to consolidate its leadership position in the global industry.

Feed preservatives are divided into:

- artificially synthesized ;
- natural.

Growing fears about the possible adverse effects of artificial additives on animal health are stimulating demand for both natural alternatives that contribute to extending the shelf life of animal feed and safe artificial ones.

Natural preservatives derived from sources such as medicinal plants, spices and plant extracts are perceived as a safer and more environmentally friendly option to preserve the high quality and reliability of feed [2, 5, 7, 11].

Development prospects show a significant increase in the dry food preservative segment in the coming years. Dry fodder has become extremely popular in animal husbandry and poultry farming due to their convenience in production, transportation and storage. However, it is the dry format that makes such feeds vulnerable to microbiological

contamination and rapid oxidation, which necessitates the use of effective preservatives for long-term preservation of nutritional value. The increase in the dry fodder segment is directly related to the expansion of world livestock and poultry farming, where processed and dried rations have become the standard. Among the forms of preservatives, the powder-like segment occupies more than 63.3% of the market.

The powder form holds the market lead, capturing the lion's share. In 2025, this format covered more than 63.3% of the total market volume [4, 9, 12]. The reason for the popularity of this condition lies in its benefit of application, ease of use and ability to integrate with a wide range of methods of preparing feed mixtures. The dry product makes it possible to measure the quantity required with great precision, guarantees a longer shelf life and better stability during carriage and storage, which is extremely essential for large agro-industrial livestock complexes [8, 10, 11].

It should be noted that preservatives in powder form are valued for their multifunctionality: their integration into feed formulations occurs without complications, ensuring the same distribution of ingredients and reliable supervision of microbiological changes. As a result of these positive aspects, the powder option becomes the main solution for feed manufacturers, which aim to improve production cycles and guarantee high quality and safety of the final product [1, 6, 8, 11]. It should be noted that the effect of the preservative is not separated from such factors as temperature during storage and humidity. Temperature is one of the key factors affecting the preservation of the stability of compound feed during its long-term storage. When the temperature rises, chemical reactions take place more intensively, including the oxidation of fats, which causes the feed to become rancid and reduce its nutritional value. Temperatures above +25 °C stimulate the activity of microorganisms and harmful insects.

Low temperatures, although slowing down biochemical reactions, can provoke condensation due to temperature fluctuations, which negatively affects product quality. Air humidity together with the moisture level in compound feed are determining factors for their long-term preservation. The optimal moisture content in bulk compound feed should usually not exceed 12–14 %. Excessive humidity promotes the reproduction of molds and bacteria. The risk of mycotoxins, which pose a serious threat to animal health, is also increased in humid environments. In addition, moistened compound feed coalesces faster, losing fluidity and uniformity of composition. Temperature and humidity have a close relationship. The higher the air temperature, the more moisture it can retain, which can cause an increase in the moisture level of compound feed. Sharp temperature fluctuations are especially dangerous, which cause the process of moisture condensation on the surface of the feed, significantly deteriorating its quality. The combined effect of high temperature and humidity significantly speeds up the spoilage of compound feed, shortens its shelf life and increases the risks of losses. Adherence to optimal temperature and humidity parameters together with the use of preservatives makes it possible to preserve their nutritional value, minimize economic losses and ensure stable animal productivity. Ignoring these requirements may cause serious financial losses and adversely affect the health of the stock [2, 5, 7, 11].

Artificial shelf-life enhancers, are a group of chemicals actively involved in increasing the shelf-life of goods because they contain spoilage caused by the vital activity of bacteria, mold or yeast. Their role is of paramount importance both in maintaining proper feed characteristics and in reducing the volume of food discarded. However, the use of artificial preservatives constantly causes lively controversy, especially when it comes to their legislative regulation and possible impact on the health of animals during their cultivation.

Given the difficulties associated with the supervision and management of these points, many companies are inclined to implement advanced solutions, for example, software complexes for compliance with regulations, as well as automation systems that allow to simplify and improve production stages. Despite the existence of contradictions, synthetic additives continue to demonstrate significant profitability and practical value in ensuring the protection of feed stocks from contamination and deterioration of their properties. At the level of compound feed production, synthetic preservatives are an indispensable element that guarantees the preservation of finished products, their stable quality and immunity to threats of microbiological origin. They retain their key importance in maintaining the reliability of the entire production system, which makes them indispensable in modern agriculture.

Preservation additives function through a variety of mechanisms that are fundamental to ensuring effective feed safety control. In the modern production of compound feed, preservatives play an important role, serving as a means to extend the shelf life of products, ensure their safe use and preserve the high quality of the final product. Within the compound feed industry, these chemicals are indispensable for preventing spoilage processes, as well as for protecting livestock from potential negative effects. The use of synthetic preservatives is based on a balanced and scientifically based approach, which includes a deep understanding of the composition of the feed matrix, an assessment of the type of microflora that needs to be suppressed, as well as the determination of the optimal shelf life of finished products. The microbiological characteristics of feedingstuffs are extremely important for the livestock industry, as they directly affect the animals' productivity, their general physiological state and their level of health.

Microscopic organisms such as bacteria, mold or yeast, as well as toxins that accumulate in feed, are of great importance because their entry into the body can lead to serious diseases. Thus, individual microbes and other harmful factors pose a significant threat to health, causing severe pathological conditions.

The majority of gastrointestinal disorders in domestic animals are caused by bacterial pathogens, for example, strains of *Clostridium* or *Campylobacter*, representatives of the enterobacteria family, including *E. coli*, *Salmonella* and *Proteus*, as well as miniature fungi such as *Aspergillus*, *Candida* or *Mucor*. These microscopic forms of lesions vary in location and level of their ability to cause disease. Bacteria are mostly the main causes that cause a significant frequency of diseases and deaths. While fungal infections are more often bothered when immunity is weakened due to excessive activity of pathogenic fungi.

When storing feed, their deterioration is classified into four main groups: reduction in quantity or weight, deterioration of quality (physical and chemical) characteristics, risks to the health and life support of animals, and financial losses.

These losses are caused by the following factors:

- failure to observe the required concentration of preservative when administered;
- the vital activity of microorganisms;
- mishandling of products;
- a set of physical and chemical changes.

The losses that occur on the current for the production of compound feed are primarily caused by the deterioration of the quality indicators of the raw material.

With significant damage, the volume of feed significantly decreases, which at the same time entails a decrease in their properties. Active reproduction of pests often causes the appearance of mold and unwanted odors, such as sweet. This not only destroys feed, making it impossible to use it, but also creates a serious risk to the health of livestock that consume these components. The three main types of storage losses are considered crucial for compound feed manufacturers. For example, mass loss due to moisture evaporation or large numbers of insects is a significant problem, especially in developing countries. This is because the harvesting process and its subsequent processing are often carried out carelessly. Insufficient supervision of compliance with quality standards (or their complete absence) leads to the release and sale of insufficiently prepared feed components that deteriorate faster.

The lack of proper standards suggests that less attention is paid to aesthetic or qualitative aspects in the commercial circulation of feed products in such regions. As a result, the financial costs associated with inspection, spoilage prevention and quality control (although this is a priority for many advanced industrial states) are giving way in countries in the development stage to these three main forms of damage that occur during storage.

In order for an antioxidant substance to perform its functions in animal diets, it must meet a number of requirements:

1. Make sure that it reliably protects fats of plant and animal origin, vitamin complexes and other components of feed that are vulnerable to degradation due to oxidation.
2. Its use should be harmless to both humans and animals bred in agriculture (for example, birds, pigs, fish, etc.), that is, it should not have any toxic effects.
3. Its ability to act should be preserved even when used in very small doses.
4. Its cost should be such that its integration into production remains financially justified.

Purpose of the study: Improvement of the optimal application of the preservative in the composition of compound feed for its preservation of quality indicators.

Presentation of the main material. Antioxidants are key in terms of maintaining the integrity of quality indicators. They contribute to the stabilization of the main nutrients, which are prone to oxidative processes in multicomponent feed. When color-adding components are introduced into the formulation, the use of antioxidants becomes an absolute condition for guaranteeing the high quality of the final product.

Quality was evaluated by controlling organoleptic indicators, which made it possible to monitor changes in the quality and appearance of malt smell during different

storage periods. Different doses of Paradigmox White dry preservative were used to store the compound feed under different conditions, and during the operational period, the condition and changes in the organoleptic properties of the feed were monitored.

Adding a preservative to compound feed is considered a promising approach, contributing to improved animal health, increased feeding efficiency and improved product quality. This process requires accurate dosing and careful quality control at all stages of production. During the research, we introduced a different amount of preservative during the storage and control period, and the obtained results were systematized and entered in Table 1, with the appropriate construction of graphs of changes in quality indicators during storage.

Table 1.

Change in the quality of loose compound feed before the appearance of a malt smell, when administered and without the presence of a preservative.

Storage conditions	without preservative	with preservative added not 20 g	with preservative added not 40 g	with preservative added not 60 g	with preservative added not 90 g	Condition of the preservative
Humidity , W%						
18	47	48	51	53	57	Dry
16	49	51	53	55	59	Dry
14,5	54	55	57	58	65	Dry
13	62	63	65	61	69	Dry
10	64	66	69	71	81	
Temperature t ^{0}C						
20	57	59	61	65	69	Dry
15	59	61	63	67	71	Dry
10	61	63	68	73	77	Dry
5	69	73	77	79	89	Dry
-5	75	77	83	87	97	Dry

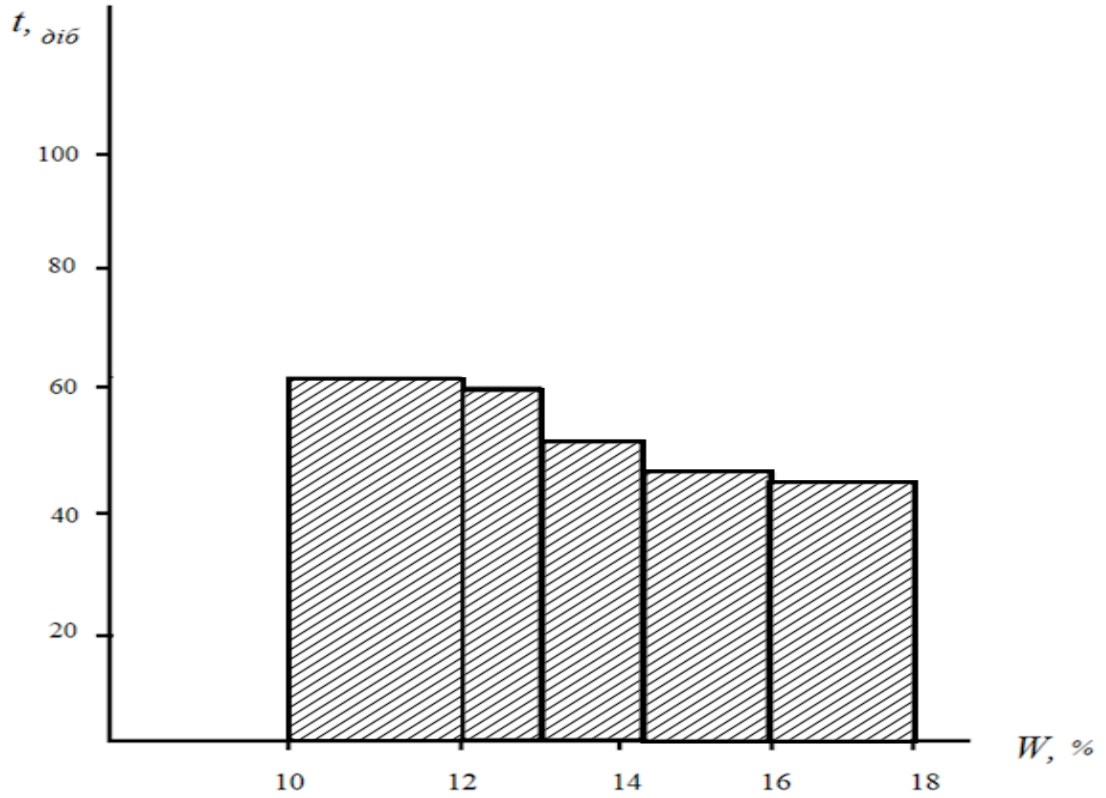

Fig. 1. Quality changes during storage without the use of an antioxidant.

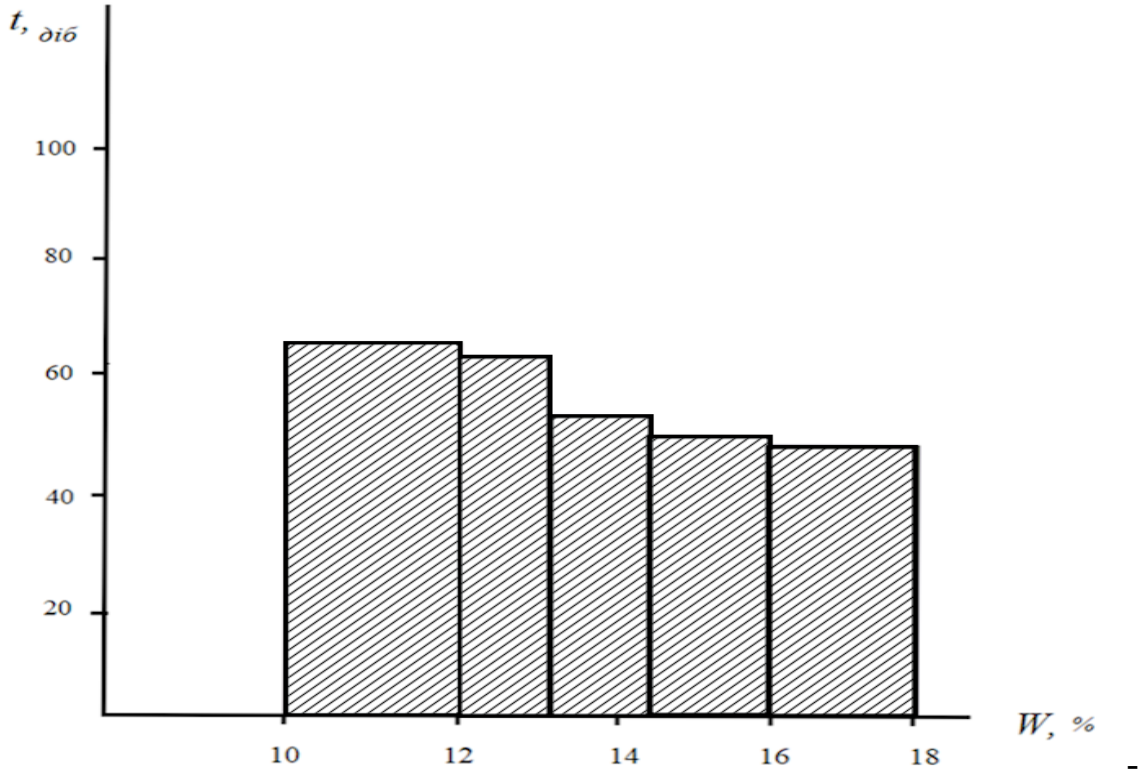

Fig. 2. Quality changes during storage with 20 g antioxidant (per 100 kg)

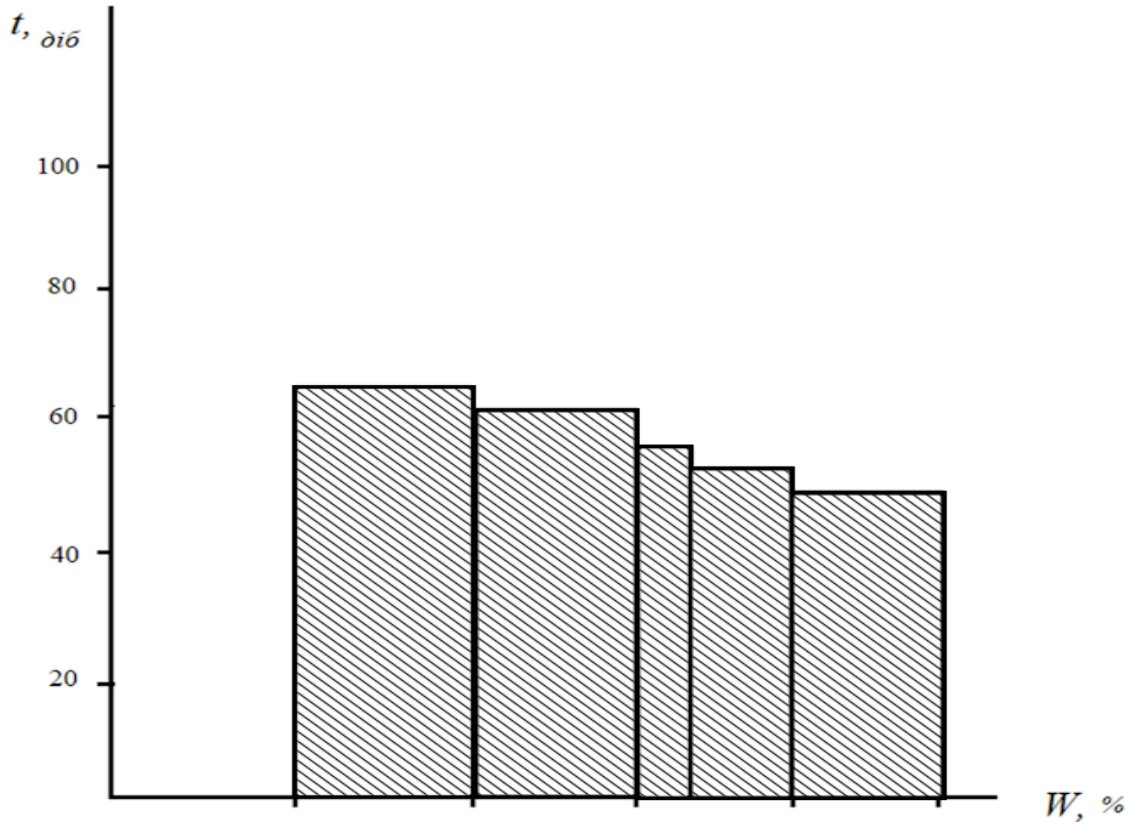

Fig. 3. Quality changes during storage with 40 g antioxidant (per 100 kg)

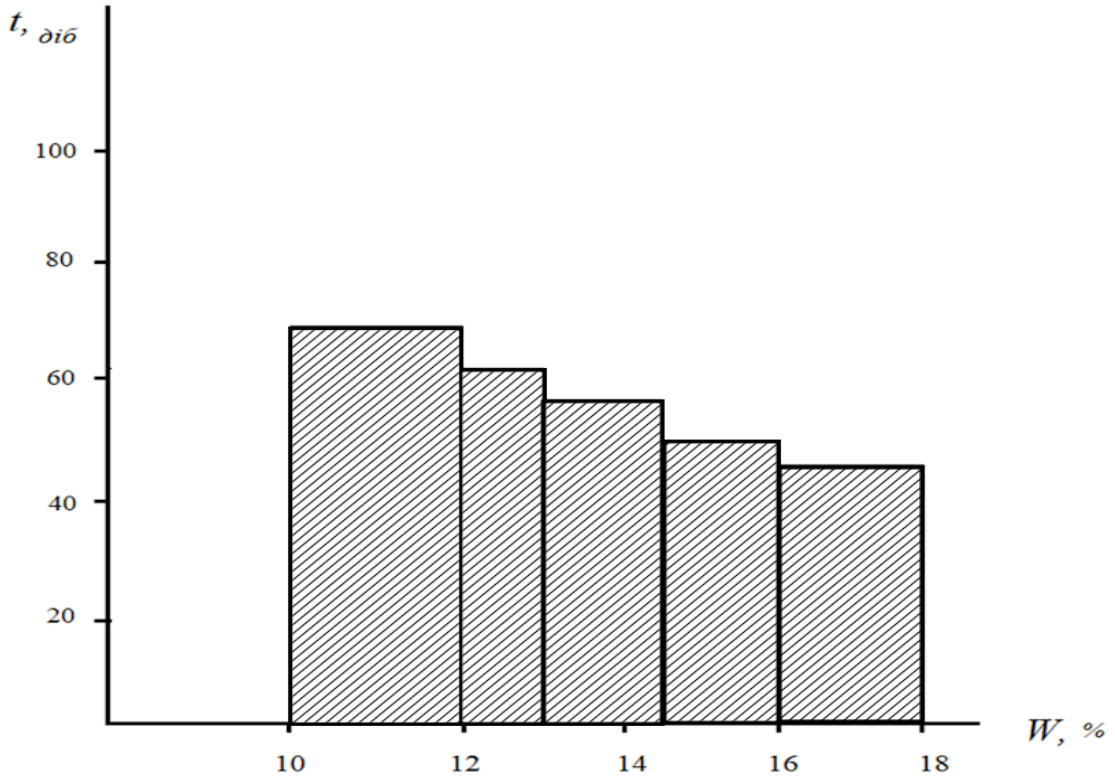

Fig. 4. Quality changes during storage with 60 g antioxidant (per 100 kg).

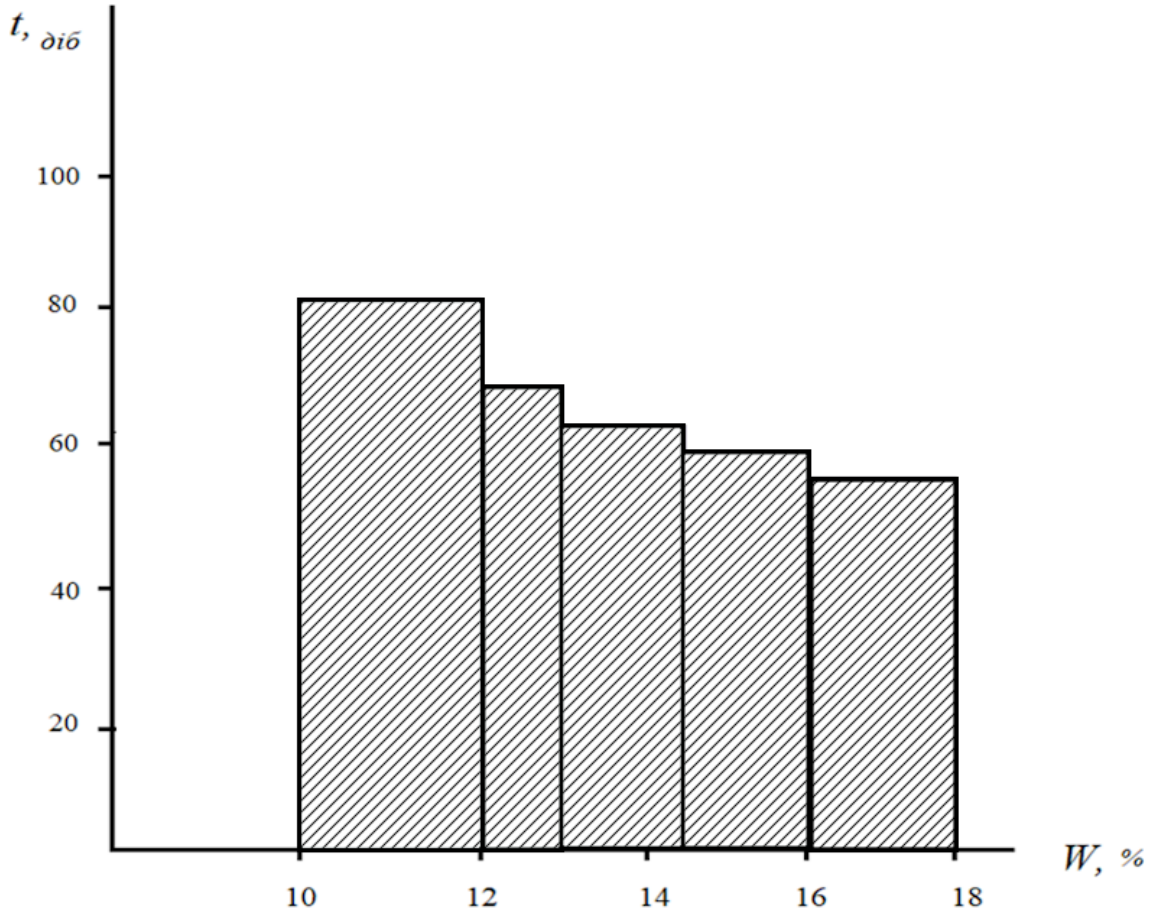

Fig. 5. - Quality changes during storage with 90 g antioxidant (per 100 kg).

Conclusions and prospects for further research. In view of the conducted research, it has been proven that the stability of compound feed during storage can be improved due to the introduction of a certain antioxidant into its composition. It is proposed to use the dry artificial antioxidant Aradigmox White Dry, produced by KEMIN, as such a stabilizer. Based on the collected information, the optimal application rate is defined as 90 grams for every 100 kilograms of finished products. It is advisable to carry out a similar analysis of preservatives of other groups of origin in further research.

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ЗАБЕЗПЕЧЕННЯ ЯКОСТІ КОМБІКОРМІВ ПРИ ЇХ ЗБЕРІГАННІ

Анотація

Забезпечення належного зберігання кормових запасів для великої рогатої худоби є ключовим чинником успішного ведення фермерського господарства. Від цього залежить як здоров'я тварин, так і продуктивність ферми. Грамотно організоване зберігання кормів дозволяє зберегти їхні поживні властивості, запобігти втратам якості та створити стабільну основу для сталого розвитку фермерського бізнесу. Тривалість зберігання кормів суттєво впливає на їхню якість і поживний вміст. З часом корми зазнають природної деградації, що негативно відображається на їхній здатності забезпечувати належний розвиток і здоров'я худоби. Однією з причин цього є процес окислення ліпідів, унаслідок якого утворюються вільні жирові кислоти. Ці речовини не лише знижують енергетичну цінність

кормів, а й додають їм неприємного смаку, що може вплинути на готовність тварин до їх споживання. Крім того, вітамінні компоненти, особливо ті, які чутливі до світла та кисню, поступово втрачають свою активність. Білкові структури також з часом розпадаються, що призводить до дефіциту важливих амінокислот, це основи для формування м'язової маси та підтримки життєдіяльності худоби. Зростання глобального попиту на продукти тваринного походження, такі як м'ясо, молочна продукція та яйця, стимулює розширення тваринницького сектору, що вимагає збільшення кількості поголів'я худоби. Це, в свою чергу, підвищує потребу в кормах для тварин, де особливий акцент ставиться на їхній високу якість і безпечність. В матеріалах даної роботи розглянуті питання впливу дії сухого синтетичного консерванту на органолиптчний показник якості розсипного комбікорму який зберігається до його застосування.
***Ключові слова: комбікорм**,* консервант, дія, зберігання, якість.

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