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Igor Dudarev,

Candidate of Technical Sciences, Associate Professor of the Department of
Agroengineering,

Odesa State Agrarian University, Odesa, Ukraine

ORCID ID 0000-0001-9509-6970

e-mail 247531@ukr.net

Serhii Uminskyi,

Candidate of Technical Sciences, Associate Professor of the Department of
Agroengineering,

Odesa State Agrarian University, Odesa, Ukraine

ORCID ID 0000-0002-7767-8405

e-mail ymoshi@ukr.net

Andriy Khomenko,

Assistant, Department of Automation of Technological, Electromechanical and Robotic
Systems,

Odessa, Ukraine Odessa National Technological University

ORCID ID 0009-0004-5661-9037

e-mail science23@ukr.net

Valentyna Makarchuk,

Senior Lecturer, Department of Agricultural Engineering,

Odessa State Agrarian University, Odessa, Ukraine

ORCID ID 0009-0007-0941-0670

e-mail 0487878617s@gmail.com

Serhiy Zhitkov,

Associate Professor, Department of Agricultural Engineering,

Odessa State Agrarian University, Odesa, Ukraine

ORCID ID 0000-0003-0598-9906

e-mail sergejzhitkov1983@gmail.com

TRANSFORMATION OF QUALITY INDICATORS AND PROLONGATION OF STORAGE OF COMPOUND FEED USING A PRESERVATIVE

Abstract

Nutritional optimization of farm animals and poultry is based on a balanced diet, which involves controlling nutrients, correcting the energy-protein ratio, and ensuring sufficient levels of amino acids, vitamins, macro and microelements. Analysis of changes in the chemical composition,

nutritional value and microbiological profile of compound feed indicates that the content of crude protein, fiber and ash remains stable during storage. However, during this period, the lipid fraction is degraded, and carotene and other biologically active compounds are destroyed. Preservatives are used to maintain the quality and extend the shelf life of compound feed. Preservatives that are part of compound feed perform a critical function for long-term storage of products, ensuring the immutability of nutritional value and safety for animals. They actively suppress the development of mold fungi, harmful bacteria and other pathogenic microorganisms that can negatively affect not only the quality of feed, but also the health of animals that consume it. The use of such substances allows you to avoid premature spoilage of the product and significantly reduce the risks of losing its valuable nutrients.

*One of the most important properties of preservatives is their ability to protect feed from mold and mycotoxins. These components create unfavorable conditions for the development of fungi of the genera *Aspergillus*, *Penicillium* and *Fusarium*, which are the main sources of the formation of mycotoxins — of extremely dangerous toxic compounds for animals and humans. Reliable prevention of the reproduction of such mushrooms helps to preserve the health of livestock and minimize the risk of negative impact on livestock productivity.*

Key words: *variation, storage, preservative, mixing, acid*

Introduction. In the context of the renewal of intensive animal husbandry, the technological reliability and sanitary cleanliness of complex feed compositions are becoming more and more significant. Among the key challenges in storing highly concentrated feed, microbial decomposition caused by the active growth of microscopic fungi and bacterial colonies stands out. To minimize losses of nutritional components, manufacturers of compound feed systematically use chemical stabilizers.

Propanoic acid, also known as propionic acid, occupies a prominent place among organic compounds due to its powerful antifungal and antimicrobial effects. This monobasic carboxylic acid is naturally synthesized in the body of ruminants as a metabolic product, and when used in appropriate concentrations, it does not pose a threat, which allows maintaining a high biological nutritional value of the feed [4, 6, 10].

The mechanism of inhibition of microorganisms by propanoic acid is based on its ability to easily overcome the cellular barriers of microbes. Penetrating inside the cell, it releases protons, which provokes a sharp acidification of the internal environment. To restore the balance, microorganisms are forced to intensively spend energy reserves on the removal of excess hydrogen ions, which leads to the depletion of their metabolic resources, disruption of the structure of enzymes and suppression of vital activity up to the complete destruction of harmful microflora.

One of the key features of this drug is its targeted effect, which is manifested in the selective effect on fungal microorganisms dangerous to health, in particular on aspergilli, penicilli and fusariums. These microbial species are known as the main sources of toxic mycotoxins capable of causing serious harm. At the same time, the useful lactic acid microflora, which has a positive effect on health, shows moderate resistance to minor acidification of the environment. This is of great importance, because thanks to the pronounced biostatic effect of the mixture, reliable protection

against unwanted self-heating is obtained during the storage of — both in high silage towers and in ordinary warehouses.

It is also worth noting that the transformation and stabilization of lipids, that is, fats, bring positive consequences. Compound feed, which contains large volumes of vegetable oils and animal fats, is often prone to peroxidation. This undesirable process is activated by the action of oxygen and moisture, as well as through the activity of fungi secreting lipolytic enzymes. Enzymatic hydrolysis causes the accumulation of free fatty acids, aldehydes and ketones, which ultimately leads to rancidity of the feed. The additive in the form of propanoic acid serves as an indirect antioxidant. It inhibits the growth of microorganisms that produce lipases, thereby preserving the integrity of the triglyceride structure. Due to a significant decrease in the accumulation of moisture and thermal energy (as a result of the respiratory activity of fungi), the involuntary process of lipid autooxidation is significantly slowed down. This enables polyunsaturated fatty compounds to retain their nutritional value without becoming harmful peroxides [3, 7, 9]. Preservation of protein components, in particular such key proteins and amino acids, is a process inextricably linked with the natural activity of various microorganisms. At the same time, putrefactive bacteria together with mold quite intensively contribute to the breakdown of feed protein structures. They effectively decompose valuable proteins, turning them into ammonia, hydrogen sulfide and toxic amines. Propionic acid is used to prevent this undesirable phenomenon of protein destruction, which is called proteolysis. It changes the level of acidity of the environment to indicators that become extremely unfavorable for the activity of bacterial proteases.

Scientific studies prove that the use of propionic acid for preserving feed mixtures significantly reduces losses of total nitrogen. For example, compared to rations that have not undergone conservation, such losses can be reduced by almost half. The structure of essential amino acids such as lysine, methionine and threonine remains unchanged and continues to be biologically digestible for animals, providing them with essential nutrients directly during digestion. Due to the fact that the destructive processes of protein breakdown stop, the compound feed retains a stable amino acid composition throughout the storage period. In addition, there is an effect on vitamins and other biologically active compounds. Studies of the interaction of propionic acid with vitamin complexes of premixes indicate the presence of a mutual effect. However, the overall result of such interaction is positive. Tocopherols and carotenoids, that is, vitamins E and A, which belong to the group of fat-soluble vitamins, are extremely vulnerable to oxidative processes when the fat component rancids. By stabilizing lipids, propionic acid serves as a synergist, protecting these vitamins from premature breakdown and thus prolonging their vital effects in the body [1, 6, 9, 10].

Vitamins of group B together with ascorbic acid, combined with moderate acidification of a dry medium, form a protective buffer that guarantees the stability of the vast majority of water-soluble compounds in the low-acid pH range (5.0–6.0). The direct destruction of these vitamins due to the influence of pure additives is

insignificant if the technological dosage norms are strictly followed (usually 0.1–0.5% by weight). In addition, industrial propionic acid is used as a raw material base for the chemical synthesis of synthetic vitamin E. As for the effect on carbohydrates and mineral elements, this compound inhibits the fermentation of easily digestible sugars and starch, reducing the activity of yeast and other unwanted fermentation microorganisms. This markedly reduces the loss of dry matter in the feed. In the case of macro and microelements, the acidic environment converts insoluble salts such as calcium and phosphorus phytates into a bioavailable ionic form, which facilitates their absorption by the digestive system of animals. When humidity indicators are kept at an average level in the range of 14–16%, there is a serious threat of mold formation, which can appear after 2–4 weeks. To prevent this, it is worth applying the preservative in an amount from 0.25% to 0.35%, which will make it possible to reliably store the feed mixture for 4–6 months without losing its quality. With high humidity, when this indicator reaches more than 17% or under conditions of poor ventilation, processing becomes even more urgent, because without it the feed can spoil for a few days. In such difficult circumstances, it is recommended to use increased doses of the preservative — from 0.5% to 0.8% or even higher. This makes it possible to effectively protect the mass and preserve its nutritional value for 2–4 months [5, 8, 10].

Problem statement, analysis of modern research. The addition of propionic acid to the compound feed formulation is a mandatory and key technological step in modern feed production. This chemical compound performs a number of vital tasks without which it is impossible to ensure stable high quality feed. It acts as a powerful preservative, antiseptic and agent that suppresses the development of mold, protecting the feed mass from harmful microorganisms and prolonging its freshness. It is worth emphasizing that the effectiveness of its use directly depends on the correct dosage, as well as the moment and stage at which the acid is added to the mixer.

In compound feed production, the mixing process is of central importance, and its main goal is — to obtain the most homogeneous product. This is achieved by controlling the coefficient of variation, which when liquid propionic acid is applied should not exceed five percent. It should be remembered that the addition of this ingredient significantly changes the physical and mechanical characteristics of the dry feed mixture, so that special care is required during its use. Propionic acid, also called propanoic acid, belongs to monobasic saturated carboxylic acids. In its pure form, it is a colorless caustic liquid with a pronounced pungent smell. In fodder production, it is used both in the pure liquid state and in the form of salts — of ammonium, calcium or sodium propionates. The latter are considered less volatile and cause significantly less corrosion of the equipment [2, 6, 10].

Suppression of microflora with propionic acid occurs due to the ability of its undissociated molecules to penetrate the cell membranes of molds, yeasts, and bacteria, including Salmonella and E. coli. Once inside the cell, where the environment is more neutral compared to the outside, the acid dissociates, releasing hydrogen ions. This stops the development of microorganisms and allows you to store the feed product at a high quality level.

A sharp drop in intracellular pH forces the body to spend ATP on removing excess protons to maintain homeostasis. Because of this, the cell's energy reserves are depleted, its metabolism is disturbed, which eventually completely stops the growth of microorganisms or causes their death.

In the fight against mold, acid successfully inhibits the development of *Aspergillus*, *Fusarium* and *Penicillium* fungi. This blocks the formation of dangerous mycotoxins, in particular aflatoxins, zearalenone and T-2 toxin, which is crucial in long-term storage of feed. Inhibition of microbial activity also prevents self-heating of the feed mass, avoiding caramelization of sugars and hydrolysis of fats, which allows to preserve the exchange energy of the compound feed. Once in the digestive tract of animals, acid-treated feed stimulates the work of the pepsin enzyme, improving protein absorption and maintaining healthy intestinal microflora. The dry compound feed is preferably composed of fine particles like cereal meal, vitamins, minerals and amino acids. The addition of liquid acid is accompanied by several important consequences:

- Increased adhesion: The acid moistens the dry ingredients of the feed, creating water bridges that help them stick together.

- Agglomeration: trace elements, such as vitamins or amino acids, attach to the acid droplets, forming lumps. This can negatively affect the uniformity of the distribution of components in the feed mixture. The change in flowability indicates an increase in internal friction in the material, due to which the feed mixture loses the ability to move freely. This can slow down the movement of raw materials inside the mixer. There is a danger of segregation and uneven distribution of components, especially when liquid acid is supplied in large drops or in a continuous stream: excessively moistened zones (pockets with increased concentration) are formed at the points of entry, which the mixer blades cannot effectively break. This can cause one part of the feed to receive an excess of acid, causing the animals to refuse to eat it due to the pungent smell, while the other part will remain unprotected from mold development. The acid should only be applied after the pre-dry mixing of all macro and micro components is complete, which usually lasts the first 60–90 seconds of the cycle. If the liquid is fed at the same time as the dry ingredients (premixes), the acid drops will cause lumps to form, which will disrupt the homogeneity of the mixture. After adding the liquid, additional time is needed for "wet" stirring (another 60–120 seconds) so that moisture is evenly distributed [6, 10].

In modern productions, the introduction of propionic acid is often taken outside the main mixer. This can be done in a mixer conditioner in front of the granulator, where the acid acts synergistically with the steam, improving the plasticity of the mass. However, the high vapor temperature is capable of causing partial evaporation of propionic acid. Another approach is — finishing spraying (Post-Pelleting Application), that is, applying a liquid preservative to ready-made cooled granules. This is the most effective point from the point of view of biological protection, since the acid covers the outer surface of the granules, protecting them from further contamination during transportation.

The purpose of research. Evaluation of the dynamics of changes in shelf life, mixing processes and variability with the use of propionic acid in compound feed indicates the critical role of accurate dosing of preservatives. The main subject of the analysis was compound feed intended for broilers at various stages of cultivation (according to recipes 6-9 and 6-2). Animal fat in the amount of 4% was included in the composition of the formulation № 6-2. To ensure the stability of the product, the preservative was added to it in concentrations of 0.1%, 0.2% and 0.3% of the total weight.

Experimental samples of compound feed were produced according to the established method and stored for four months. A number of indicators were measured: humidity level, crude fat content, acid and peroxide fat number, as well as the concentration of vitamins A, E, B4, B12 and carotene. During the study, the crude fat content of the № 6-9 formulation remained unchanged, while the № 6-2 formulation showed a decrease until the end of the storage period, which is probably due to the hydrolysis of the added fat.

The results of the experiment demonstrated a change in peroxide numbers: the use of antioxidants made it possible to maintain the level of peroxides at different marks. The highest efficacy was recorded at a preservative concentration of 0.3%. This formulation variant actively prevented peroxides from forming for three months. Analysis of the change in the acid number of fat during storage indicated that its initial value was 11.4–15.9 mg KOH/g, gradually increasing by the end of the fourth month and reaching a level of 34.6–105.9 mg KOH/g. In experimental batches of compound feed according to formulations № 6-9, it was established that the acid number increased by 5–6.7 times compared to the initial indicators before the end of the shelf life. In the control sample of compound feed according to the № 6-9 formulations, the loss of vitamin A was 49.5%, while in the batches treated with the preservative, this indicator ranged from 11.9% to 44.6%. At the end of the experiment, the level of vitamin A preservation reached 73.5% and 80.3%, respectively. At a diludin concentration of 0.05%, vitamin A activity reached 88.1% of its original value. In the control compound feed according to the recipe № 6-2, the loss of vitamin A during the three months of storage was 22.6%, and in the samples with the preservative — from 6.7% to 14.6%. Comparative analysis showed that vitamin A was best stored in compound feed according to the recipe № 6-2 with the addition of animal fat. This is confirmed by the data of studies of peroxide and acid fat numbers in compound feed. During storage of compound feed according to the № 6-2 formulation, a higher stability of vitamin B12 was observed for four months compared to compound feed according to the № 6-9 formulation. In the compound feed stabilized with the preservative, the content of vitamin B12 remained close to the initial values throughout the experiment. The use of the preservative prevents the oxidation of carotene, for which the minimum dosages turned out to be critical. In four months of preservative-free storage, vitamin E losses reached 15.8%, while in stabilized batches this figure varied from 0% to 8%. At the same time, the activity of choline in the control compound feed decreased by 26.3%, and the decrease was noticeable already after the first month of storage.

The coefficients of uneven distribution of the preservative in compound feed were determined by the method of its introduction and taking into account the calculated data of the coefficient of variation. When the preservative was added as a premix, this parameter fluctuated within 12.3–19.6%, while when directly applied to the mixture — 13.8–21.9%.

Table. 1

Methods of administering the preservative

Conventional designation of the party	Application of preservative	Inhomogeneity coefficient of the mixture, %
1	Compound feed without preservative	-
2	Compound feed with preservative + 0.1% through premix	19,6
3	Compound feed with preservative + 0.3% through premix	12,3
4	Compound feed with preservative + 0.1% directly into the mixture	21,9
5	Compound feed with preservative nom + 0.32% directly into the mixture	13,8

Changes in fat peroxide numbers in compound feed depending on the method of application are given in Table 2.

Table. 2

Change in the skew number of fat of compound feed with different methods of management

№ batch	amount of preservative	Skew number % during storage , by month				
		the beginning	1	2	3	4
1	Compound feed without preservative	47,2	26,4	38,4	71,2	43,2
2	Compound feed with preservative+ 0.1% through premix	41,6	16,0	8,8	30,0	23,2
3	Compound feed with preservative + 0.3% through premix	36,8	16,8	12,8	20,0	16,0
4	Compound feed with preservative + 0.1% directly into the mixture	39,2	17,6	9,6	27,2	21,6
5	Compound feed with preservative + 0.3% directly into the mixture	37,6	15,2	11,2	23,6	12,8

The obtained data show that the use of the preservative contributed to the reduction of the value of peroxide numbers. At the start of the study, this indicator in products without addition reached 47.2% I, and in samples with preservatives — 36.8–41.6% I. No significant differences were recorded during the entire observation period between the different variants of compound feedingstuffs with preservatives.

In addition, the preservation of carotene in compound feed was studied. In products with preservatives, its content after the first month of storage was 89.2–100%, after the second — 85.2–92.6%, after the third — 81.0–92.2%, and after the fourth — 75.1–88.7%. For comparison, in the non-preservative samples, these values were markedly lower and were 83.3%, 77.8%, 56.3% and 52.7%, respectively.

Table. 3

Analysis of mixing of components using a filler

№, p/p	Mixing time of compound feed components (τ), c	Coefficient of variation (Vs),%	Storage period (t), days,	Air humidity over %	Air temperature ° C	Combined feed moisture content %,
1	30	37	13	85	25-35	12-14
2	60	29	14	85	25-35	12-14
3	90	25	15	85	25-35	12-14
4	120	19	14	85	25-35	12-14
5	150	15	16	85	25-35	12-14
6	180	13	25	85	25-35	12-14
7	210	13	23	85	25-35	12-14
8	240	15	19	85	25-35	12-14
9	270	17	16	85	25-35	12-14
10	300	19	14	85	25-35	12-14
11	330	20	12	85	25-35	12-14

Table 4

Analysis of mixing of components without the use of filler

№, p/p	Mixing time of compound feed components (τ), c	Coefficient of variation (Vs),%	Storage period (t), days,	Air humidity over %	Air temperature ° C	Combined feed moisture content %,
1	30	37	13	85	25-35	16-18
2	60	31	12	85	25-35	16-18
3	90	27	11	85	25-35	16-18
4	120	22	10	85	25-35	16-18
5	150	17	9	85	25-35	16-18
6	180	14	21	85	25-35	16-18
7	210	15	20	85	25-35	16-18
8	240	21	12	85	25-35	16-18

9	270	23	10	85	25-35	16-18
10	300	24	9	85	25-35	16-18
11	330	25	8	85	25-35	16-18

The method of application of antioxidants and their concentration did not significantly affect the content of carotene in the compound feed during the first two months of storage. However, after the end of this period, the amount of carotene began to decrease rapidly in those batches of compound feed where the antioxidant was added directly to the finished products.

Conclusions and prospects for further research. Propionic acid performs not only the function of a preservative, but is also a reliable stabilizer of the entire compound feed system. It prevents the breakdown of fats, protects protein compounds from the destructive effect of microorganisms and maintains the vitamin complex at the highest quality level. The optimal use of this component makes it possible to extend the shelf life of ready-made feed mixtures by 2–4 times, minimizing the accumulation of toxins and ensuring high productivity of animals.

Experiments have shown that the best result is achieved when mixing the ingredients of the compound feed together with the filler for the recommended 180 seconds.

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Ігор Дударев,

кандидат технічних наук, доцент кафедри агроінженерії,
Одеський державний аграрний університет, м. Одеса, Україна
ORCID ID 0000-0001-9509-6970
e-mail 247531@ukr.net

Сергій Уминський,

кандидат технічних наук, доцент кафедри агроінженерії,
Одеський державний аграрний університет, м. Одеса, Україна
ORCID ID 0000-0002-7767-8405
e-mail ymoshi@ukr.net

Андрій Хоменко,

асистент кафедри автоматизації технологічних, електромеханічних і робототехнічних систем,
Одеський національний технологічний університет, м. Одеса, Україна
ORCID ID 0009-0004-5661-9037
e-mail science23@ukr.net

Валентина Макарчук,

старший викладач кафедри агроінженерії,
Одеський державний аграрний університет, м. Одеса, Україна
ORCID ID 0009-0007-0941-0670
e-mail 0487878617s@gmail.com

Сергій Житков

доцент кафедри агроінженерії,
Одеський державний аграрний університет, м. Одеса, Україна
ORCID ID 0000-0003-0598-9906
e-mail sergejzitikov1983@gmail.com

ТРАНСФОРМАЦІЯ ЯКІСНИХ ПОКАЗИКІВ ТА ПРОЛОНГАЦІЯ ЗБЕРІГАННЯ КОМБІКОРМІВ З ВИКОРИСТАННЯМ КОНСЕРВАНТУ

Анотація

Оптимізація живлення сільськогосподарських тварин і птиці базується на збалансованості раціонів, що передбачає контроль за поживними речовинами, корекцію співвідношення енергії та протеїну, а також забезпечення достатнього рівня амінокислот, вітамінів, макро- та мікроелементів. Аналіз змін хімічного складу, поживної цінності та мікробіологічного профілю комбікормів засвідчує, що вміст сирого протеїну, клітковини та золи залишається стабільним під час зберігання. Однак у цей період відбувається деградація ліпідної фракції, а каротин та інші біологічно активні сполуки руйнуються. Для підтримання якості та подовження терміну придатності комбікормів застосовують консерванти. Консерванти, які входять до складу комбікормів, виконують критичну функцію для тривалого зберігання продукції, забезпечуючи незмінність поживної цінності та безпеку для тварин. Вони активно пригнічують розвиток цвілевих грибів, шкідливих бактерій та інших патогенних мікроорганізмів, здатних негативно впливати не лише на якість корму, а й на здоров'я тварин, що його споживають. Застосування таких речовин дозволяє уникнути передчасного псування продукту та суттєво знизити ризики втрати його цінних поживних елементів. Однією з найважливіших властивостей консервантів є їхня здатність оберігати корм від цвілі та мікотоксинів. Ці компоненти створюють несприятливі умови для розвитку грибів

родів Aspergillus, Penicillium і Fusarium, які є головними джерелами утворення мікотоксинів — вкрай небезпечних токсичних сполук для тварин і людини. Надійне запобігання розмноженню таких грибів допомагає зберегти здоров'я поголів'я та мінімізувати ризик негативного впливу на продуктивність тваринництва.

Ключові слова: *варіація, зберігання, консервант, змішування, кислота.*

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