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To cite this article: A D Chernyshev *et al* 2021 *IOP Conf. Ser.: Earth Environ. Sci.* **848** 012101

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Research of the storage process of combined feeds in the environment of carbon gas

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Abstract. Combined feeds form the basis of the ration in pig breeding (up to 70% of the diet) and poultry farming (up to 90% of the diet) and serve as complementary feed in other branches of livestock and poultry farming. At the moment, there is a task to increase the shelf life of compound feed while maintaining their quality and nutritional value. The article discusses various ways of storing and preparing compound feed.

1. Introduction

Combined feed - compound feed is a mixture of products crushed to a certain extent: various types of grain, soybeans, sunflower meal, corn, premixes, meat and bone meal, vitamins, etc.

In pig and poultry farming, complete combined feeds are mainly used to cover the needs for nutrients and minerals, as well as biologically active additives.

Compound feeds for individual groups of animals are always made individually in small quantities. Therefore, for the rational loading of feed mills working with large, poultry and pig farms, there are certain production plans, which is not always consistent with the plans for the supply of individual components. In addition, separate batches of combined feeds are produced for small farms and farms, so there is a need to ensure long-term storage of compound feed. At the moment, the shelf life of compound feed for young pigs, cattle and poultry is about one month. Some types of compound feed can be stored for a longer period, for example, for adult cattle, horses, sheep, where the concentrate feed is only an addition to the main diet.

Compound feed containing antioxidants can be stored for three months. At the same time, it is necessary to create special conditions for storing compound feed without significant changes in its properties. For example, exclusion of fresh air access (vacuum) leads to the multiplication of enteropathogenic bacteria [1].

Therefore, at the moment there is a task to increase the shelf life of compound feed while maintaining their quality and nutritional value.

Combined feeds form the basis of the ration in pig breeding (up to 70% of the diet) and poultry farming (up to 90% of the diet) and serve as complementary feed in other branches of livestock and poultry farming.



Table 1. Composition of compound feed recipes for pig and poultry farming. (SK - pork compound feed, PC - poultry compound feed).

Name	The approximate composition of feed for pigs	Name	The approximate composition of compound feed for birds
Wheat	40.00%	Wheat	40.00%
Barley	36.18%	Corn	25.34%
Grain products	–	Soybean meal	24.58%
Full fat soybean SP 38%	–	Sunflower meal	–
Soybean meal SP 46%	10.65%	Corn gluten	3.95%
Meat and feather flour CTF SP 58	5.00%	Meat and bone meal	–
Sunflower oil	2.13%	Fish flour	2.50%
Yeast Agricorm	3.00%	Sunflower oil	–
Lysine monochlorohydrate 98	0.46%	Lysine sulfate	0.13%
Table salt	0.40%	DL-methionine	0.02%
Phosphate Defluorinated P	0.24%	L-threonine	0.04%
Limestone Flour	0.89%	Table salt	0.19%
BMW starter 15% 41415	–	Monocalcium Phosphate	0.46%
Vitamin No. 1	–	Limestone flour	1.10%
Vitamin No. 2	–	Sodium sulfate	0.19%
Vitamin No. 3	0.05%	Premix prestart	1.50%
Premix KS-4-1 (1%)	1.00%	Premix start	–

After preparing feed for storage, it is necessary to choose the method of placing it in the warehouse, there are 2 methods - storage in bulk or in different kinds of bags (canvas, polyethylene, kraft bags).

During long-term observation of feed, it was found that the total number of microorganisms during storage of loose compound feed in kraft bags was significantly less than during storage in bulk. This is especially noticeable over long periods. For example, you can cite the research data of M.G. Golik and I.P. Aleksandrova on the effect of the type of packaging on the loss of carotene during storage of non-granulated herbal flour (Table 2).

Table 2. Comparative characteristics of the storage of non-liquid herbal flour.

Name	Storage time			
	1 month	3 months	4 months	6 months
Embankment	21.5 %	45.0 %	52.0 %	54.5 %
Canvas bags	20.0 %	43.5 %	49.0 %	52.0 %
Kraft bags	18.5 %	33.5 %	38.0 %	39.5 %
Plastic bags	16.3 %	31.5 %	36.4 %	36.9 %

The following 4 groups can be attributed to the storage modes of crushed combined feed:

- storage of compound feeds in a dry state (humidity to a critical level);
- storage of compound feed at low temperatures;
- storage of compound feed without air access;
- storage of compound feeds in the environment of carbon dioxide.

When storing compound feed in an environment of carbon dioxide, all living components of the product pass into anabiotic state, because gas exchange, the development of microorganisms, bacteria and pathogenic flora slows down.

2. Research materials and methods

Storing feed in an environment of carbon dioxide creates conditions under which the cessation of the vital activity of microorganisms occurs. To ensure this storage mode, the placement of compound feed in sealed soft containers is most often used.

When filling the compound feed into a sealed soft container with the provision of an environment of carbon dioxide, a special device is used. The device (Figure 1) consists of a soft container 1 with an insert 2 which is inserted into the cassette 3. The cassette is a cargo platform 4 with walls made in the form of two rigidly fixed walls in pairs, which are hinged to each other, and rollers 5 are installed above the cassette forming the support surface. The cargo platform is equipped with a movable bottom 6, and its lifting is carried out by pneumatic cylinders 7. The device contains a loading hopper 8 and a sealing device 9. The device is also equipped with a gas cylinder installation 10 with an injector needle 11.



Figure 1. A device for packaging elastic agricultural products.

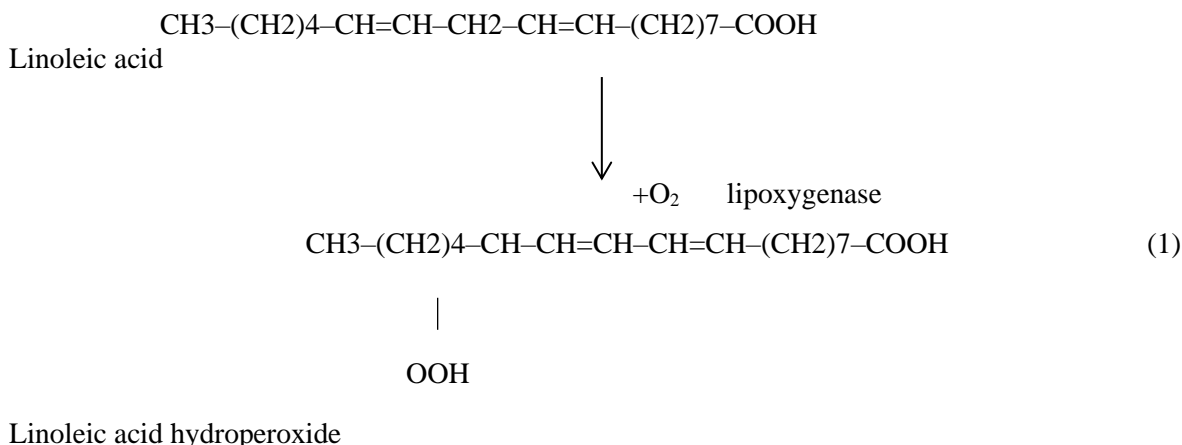
A soft container with a liner is inserted into the cassette. The cassette is a fixed bottom with a wall, on which the rest of the walls and the upper traverse are hinged. The bottom is equipped with a platform with pneumatic jacks, on which a pallet is installed for subsequent transportation of a flexible container. When installing a soft container in the cassette, all its walls are closed and fixed relative to each other and the bottom. The traverse is set aside and does not interfere with the loading of the product. The loading of the product is carried out simultaneously with the supply of carbon dioxide. After filling the container with the liner to the nominal volume, turn off the loading device and the supply of carbon dioxide, which, due to its larger molar mass, displaces oxygen. Then the traverse is installed, threading the liner neck into its hole, and the container in the cassette is squeezed. The compression speed is regulated by pneumatic jacks on the bottom of the chamber [2, 4].

Upon reaching the required compression ratio, the process of sealing the liner of the soft container begins. During the storage of compound feed, the oxidation of fats is possible, since the crushed particles do not have a shell, while the fatty acids come into direct contact with atmospheric oxygen, which leads to the oxidation of polyunsaturated fatty acids. The most active group is CH_2 , which interacts with atmospheric oxygen. As a result of fat oxidation, degradation products accumulate, which have an unpleasant taste and odor and may not be suitable for animal feeding.

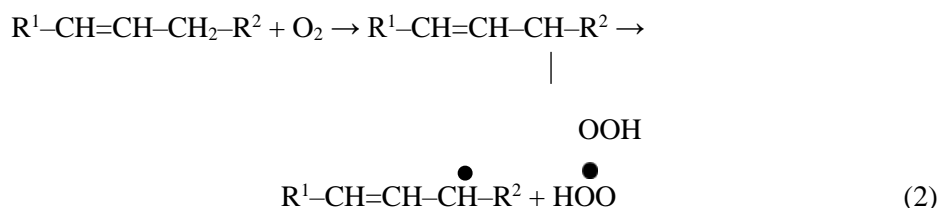
Thus, during the storage of compound feed, already at the initial stage, the oxidation of fatty acids of compound feed should be limited. It should be noted that the process of fat oxidation is significantly accelerated in the presence of metals of variable valence: cobalt, manganese, iron, copper.

Oxidation of unsaturated fatty acids can be described by the following chemical reactions:

a) fat rancidity:



b) spoilage of fats:



Considering that carbon dioxide dissolves well in fat, it partially replaces oxygen, which helps to slow down oxidation, in addition, under the action of carbon dioxide, the effect of microorganisms contributing to oxidative deterioration of fat is reduced. The presence of carbon dioxide slows down the formation of peroxides, which promote accelerated oxidation [3,4].

Decomposition products of fats in compound feed are stable compounds of aldehydes, hydroxy acids, ketones and other substances. The rate of saturation of compound feed with carbon dioxide during its storage in a container is determined by the phase equilibrium of the gas medium. The penetration of carbon dioxide into the tissues of the feed particles is based on the laws of diffusion and osmosis. The amount of dissolved carbon dioxide during the time $d\tau$ will be proportional to the surface [5] and is determined by the expression:

$$dp = -KF \frac{\partial c}{\partial x} d\tau, \quad (3)$$

where: K is the diffusion coefficient, which determines the amount of carbon dioxide passing through the surface area per unit time m^2/s ; $\frac{\partial c}{\partial x}$ - is the concentration gradient of carbon dioxide in the product.

By potentiating expression (3), we obtain:

$$\frac{c_0 - c}{c_0} = e^{\frac{4K}{h^2}\tau} \quad (4)$$

The absorption of carbon dioxide by compound feed is determined by the absorption coefficient and the partial pressure of carbon dioxide:

$$c_0 = \alpha \text{PCO}_2, \quad (5)$$

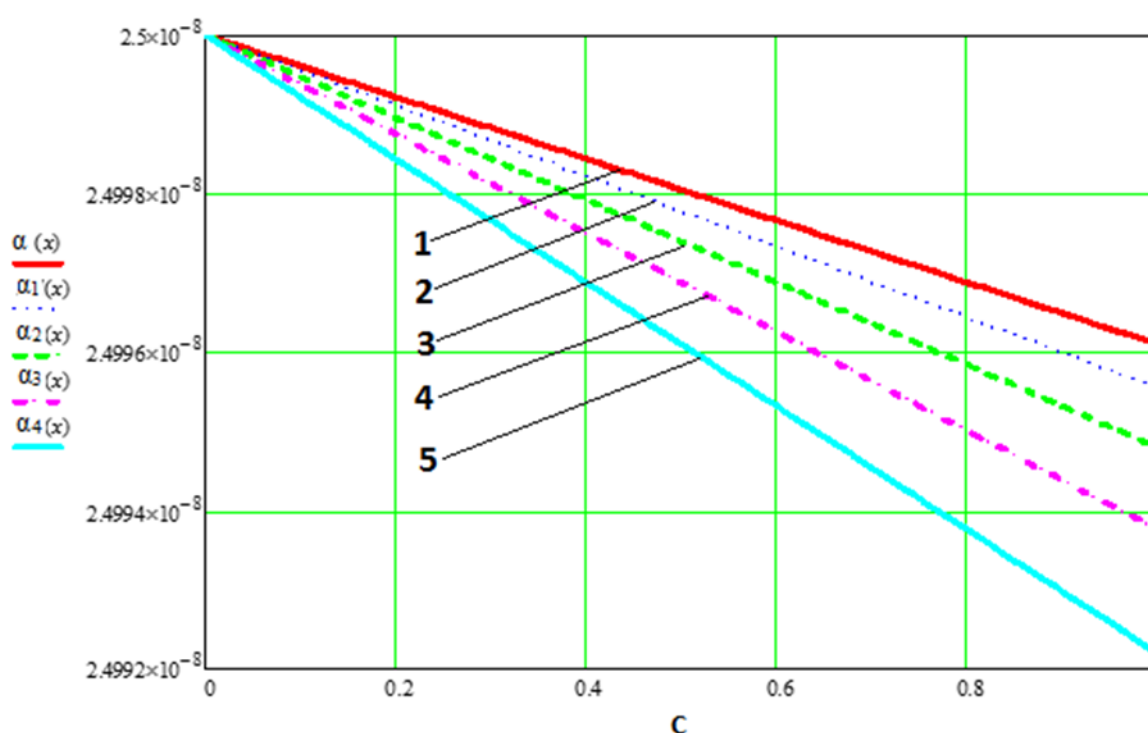
where, α is the coefficient of absorption of carbon dioxide by the feed particles; PCO_2 - partial pressure of carbon dioxide.

Then the amount of carbon dioxide passing per unit time through the surface area g/s m^2 will have the expression:

$$K = \frac{h^2}{4\tau} \ln \left(\frac{\alpha \text{PCO}_2 - c}{\alpha \text{PCO}_2} \right). \quad (6)$$

Considering that the average diffusion path of carbon dioxide into a particle of compound feed depends on its size (the degree of grinding of the particle that is part of the compound feed).

During the storage of compound feed, the oxidation of fats is possible, since the crushed particles do not have a shell, while the fatty acids come into direct contact with atmospheric oxygen, which leads to the oxidation of polyunsaturated fatty acids. The most active group is CH_2 , which interacts with atmospheric oxygen. As a result of fat oxidation, decay products accumulate, which have an unpleasant taste and smell, and may not be suitable for animal feeding [6].



$$1 - \alpha = 1.6; \alpha_1 = 1.4; \alpha_2 = 1.2; \alpha_3 = 1.0; \alpha_4 = 0.8$$

Figure 2. Graph of the dependence of the amount of carbon dioxide passing per unit of time through the surface area g/s m^2 .

Considering that in the process of chemical interaction the amount of a substance in a sealed soft container does not change, we determine the molar mass. Considering that during the storage of compound feed, oxidation of fatty acids is possible, then when fat is burned to oxidize linoleic acid to linoleic acid hydroperoxide, about 32 g/mol of oxygen is spent on the paint mass 280.44468 g/mol, which corresponds to a decrease in the volume of oxygen in a sealed soft container by 22.4 liters. Considering that the highest fat content in mixed feed for poultry is no more than 5%, then the possible fat content in a soft container is 35 kg. It should be noted that during storage, only part of the fats directly contacting with the oxygen of the gas medium is oxidized, and the volume of the gas mixture is limited, then it is possible to reduce the intensity of the oxidative process by replacing oxygen with carbon dioxide [7].

The oxidation of fats requires twice as many moles of carbon dioxide as oxygen, so the maximum amount of gaseous medium in a soft container is 160 liters and this corresponds to approximately 7

moles of carbon dioxide, which can potentially oxidize about 3 moles of linoleic acid. A decrease in the volume of the gaseous medium in a soft container will help to reduce the amount of carbon dioxide, and, accordingly, reduce the intensity of rancidity and fat oxidation. It should be noted that a part of carbon dioxide can dissolve in fatty acids without reducing their quality parameters [8].

3. Conclusion

When storing compound feed in an environment of carbon dioxide, fat oxidation is possible, since the crushed particles do not have a shell, which leads to the oxidation of polyunsaturated fatty acids. The most active group is CH_2 , which interacts with oxygen. As a result of fat oxidation, degradation products accumulate, which have an unpleasant taste and odor and may not be suitable for animal feeding. A decrease in the volume of the gaseous medium in a soft container will help to reduce the amount of carbon dioxide, and, accordingly, reduce the intensity of rancidity and fat oxidation.

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