Global trends in agriculture development are increasingly moving away from intensive technologies towards organic production. This applies not only to crop production, but also to cattle and especially to milk. According to various sources, the total market for organic dairy products is estimated at USD 18 to 20 billion, with the largest production volume of USD 1 million recorded in the United States. Organic milk production in Europe has increased considerably over the last few years, reaching 5 million tonnes in 2020 (7, 12-16, 19, 22). Russia is also actively engaged in this process by following international experience and trends in the functioning of organic cattle. Moreover, Russia focuses on establishing internal legal regulations and special state measures to support domestic producers of organic products and promote their interests in the international market (1, 2, 4, 5, 21).

One of the priority directions of agro-industrial development in Russia is the formation of sustainable organic agriculture, allowing the involvement of small and medium producers in commodity chains and providing them with a market and an acceptable level of income from the sale of their products. As a fairly new agro-industrial direction with a relatively low competition level, organic livestock breeding makes it possible to develop effective technologies in housing, feeding, veterinary, care, and milk production. Global trends in the development and introduction of efficient feed additives for lactating cows offer a wide variety (20). At the same time, the focus is on both their energetic component and the presence of biologically active, probiotic and sorption characteristics. In this regard, research into the possibility of using formulas developed in cow diets, including those grown using biological technologies, is of scientific and practical interest. It is in such conditions the role and value of modern feed additives is revealed to the fullest and most effective taking into account the specifics of feeding the livestock grown on organic patterns (3, 8, 17, 18).

As is generally known, the quality of grass in the pasture maintenance of animals in Russia does not always ensure the fullness of the diet. Therefore, considering these peculiarities of feeding cattle, scientists of Voronezh State Agricultural University and MegaMix feed company created a sorption and probiotic feed additive based on local natural bentonite clay, dry live

**Use of a sorption-probiotic feed additive in the diet of cows**

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**Summary**

Sorption and probiotic feed additive composition was formulated following international experience and trends in organic livestock breeding, and its efficiency under conditions of organic milk production was evaluated. This research focused on the dynamics of organic milk quality and safety parameters in the context of a sorption and probiotic feed additive created by the authors. The study focused on sorption and the probiotic feed additive, as well as the milk of the cows participating in the experiment. During the study period, the mass fraction of fat in the milk of experimental animals increased by 0.1 abs.%, the mass fraction of protein by 0.21 abs.%, and the mass fraction of lactose also by 0.1 abs.% compared to the control values. The mean fat globule size in the experimental group was 3.5% higher, and their number was 7.8% higher than the control counts. In the experimental group, the proportion of casein increased by 10.5%. The rennet casein class increased to 1.7 ± 0.02 and heat resistance to 1.5 ± 0.02. Milk density was 1027.6 ± 0.30 kg/m³ and acidity was 16.9 ± 0.23 °T.

**Keywords:** livestock breeding, milk quality and safety, organic dairy products, organic milk, sorption and probiotic feed additive
probiotic yeast culture (*Saccharomyces cerevisiae*), and artificially dried vegetal apple fodder.

Considering the use of a sorption-probiotic feed additive in the diet of cows in organic production is proposed as a hypothesis.

This study aimed to establish the dynamics of the quality and safety indicators of organic milk produced by cows given the specially prepared sorption-probiotic supplement.

**Material and methods**

The methodological basis for the study was the work of Russian and international scientists in the area of organic livestock. The experimental part of the study was carried out on the Ayrshire livestock herd utilizing facilities of LLC Savinskaya Niva in the Kaluga area, Russia.

The objects of the study were:

1. dairy cattle of Ayrshire breed receiving experimental feed additives during lactation;

2. the experimental food additive consisting of natural bentonite clay, live dried probiotic yeast (*Saccharomyces cerevisiae*) and artificially dried apple feed 500 g per head per day;

3. milk of clinically healthy cows.

The animals were divided into experimental (n = 20) and control (n = 20) groups using the paired analogy principle. Sorption additives and probiotics were introduced in the base diet of lactating cows. Nutrition was given three times daily at equal intervals. Ten cows from the 2nd lactation were divided into one test group receiving the basic diet (BD) and two control groups: BD + sorption and probiotic feeding additive. The groups were formed according to the principle of paired analogues, taking into account age, time of calving, the number of lactations, live weight and productivity, fat and protein content in milk, with identical conditions of maintenance, milking and feeding. The feeding and drinking ration of animals in both groups was identical.

Clinical examination of the animals was performed with mandatory control of the general condition, thermometry, counting of respiratory movements and rumen contractions, and evaluation of the condition of the udder. For a more objective assessment of breast gland condition a feeding test was conducted.

The authors declare that the work is written with due consideration of ethical standards. The study was conducted in accordance with the ethical principles approved by the Ethics Committee of Voronezh State Agrarian University named after Emperor Peter the Great (Protocol No. 3 of 15.02.2019).

Data obtained in the experiments were processed using methods of variation statistics. The results are presented as arithmetic means and statistical errors. The reliability of the results was tested using a software program. For this biometric techniques were used.

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**Results and discussion**

Developing organic livestock not only increases revenues from the sale of more expensive organic products, but also provides quality food to the population. Therefore, the effectiveness of sorption and probiotic feed additives in the diet of cows was studied in the farms engaged in organic milk production. The recipe for the feed additive sorption probiotic is given in Table 1.

Artificially dried vegetative apple fodder is a heterogeneous loose mass, including particles of peel and seeds of apples with a possible slight (less than 2%) admixture of other fruits from light brown to dark brown with 10% moisture content, obtained by mechanical separation of the components after pressing and then drying and sifting. The flavour is typical of dried apple fruits.

Dry live yeasts *Saccharomyces cerevisiae* (beer yeast, baker’s yeast) is a type of microscopic single-celled fungi (5–10 µm in diameter) (yeasts) of the *Saccharomyces* class. *Saccharomyces cerevisiae* is one of the most studied model organisms to study eukaryotic cells, they are easy to cultivate and have low pathogenicity to the human body. Compared to *Escherichia coli*, the yeast cell contains several times more DNA and has a more complicated organisation than bacteria.

Bentonite clay is a homogenous loose powder of grey to light yellow colour, without flavour and tasteless.

**Tab. 1. Sorption-probiotic Food Additive Recipe, %**

| Component name                                      | %  |
|-----------------------------------------------------|----|
| Artificial dried vegetal apple fodder               | 85 |
| Live powdered yeast culture (*Saccharomyces cerevisiae*) | 1  |
| Bentonite clay                                      | 14 |

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**Tab. 2. Physicochemical properties of bentonite fodder**

| Indicator name                          | Values          |
|-----------------------------------------|-----------------|
| Appearance and color                    | Homogeneous gray, loose powder |
| Flavour                                | Not available   |
| Mass fraction of moisture, %, max       | 8.0             |
| pH of 2% suspension, not less           | 7.0             |
| Mass fraction of montmorillonite, % not less | 60.0         |
| Mass fraction of amorphous silica, % not less | 25.0         |
| Concentration of exchangeable cations, µg eq/100 g dry matter, % not less than | 60.0          |
| Mass fraction of potassium oxide, %, min | 2.0            |
| Coarseness: residue on the sieve with a mesh No. 1.2, %, max | 5.0 |
| Content of metallomagnetic impurities up to 2 mm in size, mg/kg, not more | 30.0          |
| Presence of metal particles with sharp edges, over 2 mm in size | Not allowed    |
| Mass fraction, mg/kg, not more: Fluorine | 2000           |
| Arsenic                                 | 50              |
| Lead                                    | 50              |
| Cadmium                                 | 0.4             |
| Mercury                                 | 0.1             |
| Total fraction of radionuclides, Bq/g, not more | 0.7 |

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It is not hygroscopic and forms a moisture-based gel. In terms of chemical composition, the natural bentonites from different deposits differ considerably. For the studies, alkaline bentonites of alkaline-earth deposits located in the territory of Voronezh-Nikolskoye and Kantemirovskoye region were used (Tab. 2). Chemical composition analysis shows that these bentonites contain a complex of macroelements and microelements that are vital to the cows’ bodies. These include silicon, aluminum, calcium, sodium, potassium, iron, copper, manganese, zinc, cobalt, and iodine.

The chemical composition of the feed additive is shown in Table 3.

The first step in evaluating the veterinary and health indicators of milk was its organoleptic and biochemical assessment. During the study, milk samples from both groups of cows were a homogeneous fluid without sediment or flakes. The taste and smell were clean, without foreign flavors and smells which are not characteristic of fresh milk. The colour of the milk produced was white.

When studying the biochemical composition of milk, the following elements were taken into account: mass fraction of fats, proteins and lactose. Protein and fat content are key parameters to determine the nature and quality of milk. It is the fat that determines the nutritional value of milk and milk products, gives them a sweet and pleasant taste, a homogenous structure and a consistency. Lactose plays an important role in determining the properties of milk and the quality of milk products. It determines the nutritious value of the milk. As a precursor to lactic bacteria, lactose is also implicated in the fermentation process. Its presence and quantity in milk are of great importance for veterinary and sanitary expertise and technology of lactic acid products. The presence of lactose in milk can cause a directed, alcoholic or combination lactic fermentation, which is widely used in industry (6, 9, 23).

The results of the study of milk from cows in the experimental and control groups based on these indicators are shown in Table 4.

In the experimental group, the percentage increase in the dry matter content of milk was significant. Compared to the control values, the mass fraction of fat and lactose increased by 0.1 abs.% each, while the mass fraction of protein increased by 0.21 abs.%

The structural characteristics of milk fats and proteins were also examined (Tab. 5). Fresh milk fat is represented as fat globules (1.5 to 3.0 billion in 1 ml) with a diameter of 0.5 to 22 µm. The fat globule is a nucleus of glyceride surrounded by a lipoprotein shell and carrying a negative charge, due to which the milk fat has emulsifying properties and colloidal-chemical stability. Phospholipids, like lecithin and ketylphalin, play a particularly important role in milk fat. Building a component part in the shells of fat globules, they stabilize fat emulsion in milk and can act as pro-oxidants (gas pedals of milk fat oxidation), as well as antioxidants.

The data obtained indicate a steady and reliable (P ≤ 0.01) increase in the number of fat globules and their average size in the experimental group relative to the controls. Therefore, the mean size of the experimental group was 3.5% higher. The number of fat cells in the experiment group exceeded the control values by 7.8%.

Milk proteins include casein and whey proteins. Casein accounts for 78-85% and is in the form of colloidal particles – micelles, which have charged groups

| Variable                  | Unit   | %    |
|---------------------------|--------|------|
| Water content             | %      | 10.0 |
| Metabolizable energy      | mJ     | 8.95 |
| Dry matter                | %      | 90.0 |
| Crude protein             | %      | 3.0  |
| Crude fat                 | %      | 2.0  |
| Crude fiber               | %      | 20.0 |
| Neutral detergent fiber   | %      | 34.0 |
| Acid detergent fiber      | %      | 23.0 |
| Organic acids             | %      | 3.0  |
| Crude ash                 | %      | 4.0  |
| Lignin                    | %      | 8.0  |
| Easily digestible carbohidrates | % | 30.0 |

| Indicator                          | Average value per lactation |
|------------------------------------|-----------------------------|
| Mass fraction of fat, %            | 3.92 ± 0.01                 |
| Mass fraction of protein, %        | 3.03 ± 0.02                 |
| Mass fraction of lactose, %        | 4.72 ± 0.01                 |
| Mass fraction of fat, %            | 4.02 ± 0.02*                |
| Mass fraction of protein, %        | 3.24 ± 0.01*                |
| Mass fraction of lactose, %        | 4.82 ± 0.01                 |

Explanations: * – P ≤ 0.01 compared to the control group

| Variable                  | Control | Experience |
|---------------------------|---------|------------|
| Size of fat globules, µm   | 2.72 ± 0.01 | 2.82 ± 0.02* |
| Quantity of fat globules, 10^9/ml | 3.33 ± 0.02 | 3.61 ± 0.01* |
| Casein, %                  | 2.12 ± 0.04 | 2.37 ± 0.01* |
| Whey proteins, %           | 0.91 ± 0.01 | 0.88 ± 0.01  |
| Rennet caseine, class      | 2.0 ± 0.02  | 1.7 ± 0.02** |
| Heat-resistance, group     | 2.0 ± 0.03  | 1.5 ± 0.02** |
| Density, kg/m³             | 1027.9 ± 0.20| 1027.6 ± 0.30|
| Acidity, °T                | 16.9 ± 0.17 | 16.9 ± 0.23 |

Explanations: *P ≤ 0.05 compared to the control group; **P ≤ 0.001 compared to the control group
and a hydrate shell on their surface. It prevents them from sticking together and coagulating when they approach each other. Casein provides milk with a white colour and opacity. Casein does not precipitate when milk is boiled, but it is coagulated by the rennet enzyme to form a thick, sweet-tasting clot and whey. Casein is subdivided into fractions: αS1-casein, αS2-casein, β-casein, κ-casein, that possess genetic variants. As for serum milk protein, its volume in milk is approximately 20%. These include β-lactoglobulin (52%), α-lactalbumin (23%), serum albumin (8%), immunoglobulin (16%) and proteosepeptone (1%). Total casein and serum protein fractions were examined (Table 5).

It was found that the increase in the protein mass fraction in the milk of the cows in the experimental group was caused by a significant increase in the casein fraction. At the same time, there was a trend towards decreasing the proportion of whey proteins. Within the experimental group, the casein fraction increased by 10.5%.

The technological properties of milk are properties that ensure that the technological process is conducted correctly and that a standard milk product is obtained. Milk rennet coagulation is a decisive factor in the relevance of milk to cheese production. The duration of protein coagulation and clot density depends upon the concentration of hydrogen ions in milk. The lower the pH in the milk, the faster the reaction and the higher the clot density. That is on account of the increased activity of the rennet enzyme. Heat tolerance is an important technology property that determines the relevance of milk to high temperature processing. The heat tolerance of milk is determined by its acidity and saline balance and depends on the balance between cations (Ca, magnesium) and anion (citrates, phosphates). Acidity is another important criterion in the assessment of milk quality and freshness. In milk, active and titrable acidity shall be determined. The results of the review of milk technology indicators are presented in Table 5.

As shown by the above data, in the experimental group, the rennet casein class increased to 1.7 ± 0.02 and the heat resistance to 1.5 ± 0.02. Milk density was 1027.6 ± 0.30 kg/m³, with an acidity of 16.9 ± 0.23 °T. This characterizes the milk of experimental group cows as technologically appropriate and of high quality in terms of its subsequent use as a feedstock for dairy products.

Based on scientific research, a formulation of multi-component food additives was first developed and tested on organic milk production with a positive outcome. The diet composition developed by the authors has known characteristics which are described in several authors’ works (10, 11-16, 19, 22, 24-26).

This paper discusses the possibility of enhancing the productivity and quality of livestock products through the use of natural and probiotic sorption stimulants in the diet. Such a result is achieved by normalization of ruminal digestion, minimization of acidotic and ketosis phenomena, activation of nonspecific immunity, intensification of secretory phenomena, and the prevalence of assimilation processes.

The developed supplement containing artificially dried apple food, dry live probiotic yeast culture (Saccharomyces cerevisiae), and bentonite clay of local origin provides a complex effect on the body of productive animals. In particular, dried apples are of crucial importance being a natural prebiotic and a source of fructooligosaccharides and trace elements (Fe, Cu, Zn, Mg, Mn, Cr) in organic form, which has strong sorption properties due to the organic sorbent pectin. The contained apple fiber acts like a scrub for the intestines even after a thermal treatment. It also contains adequate amounts of pectin, essential oils and dietary fiber and stimulates the development of microorganisms in the gastrointestinal tract. The action of this food is based on the binding of mycotoxins in the gastro-intestinal tract, which leads to the irreversible deactivation of mycotoxins. Biologically active substances in autolysed pectin, β-mannanes, β-glucans, etc., have a hepatitis protective immunomodulatory effect, hindering the development of pathogenic microflora. Probiotic yeast culture and the bentonitic component of the feed additive showed its efficiency in the digestive processes stabilization, synthesis of milk components in cows of the experimental group and, consequently, increasing its biochemical and technological value. This is particularly relevant considering the production of organic raw milk and its further transformation into organic dairy products for various functional purposes.

As part of the scientific research, the efficacy of the sorption and probiotic feed additive has been studied in conditions of organic milk production at LLC Savinskaya Niva in the Kaluga region. Cattle of Ayrshire breed were selected for the experiment. During the study period, the mass fraction of fat in milk of experimental animals increased by 0.1 abs.%, the mass fraction of protein by 0.21 abs.%, and mass fraction of lactose also by 0.1 abs.% compared to the control values. The mean fat globules size in the experimental group was 3.5% higher, and their number was 7.8% higher than the control counts. In the experimental group, the proportion of casein increased by 10.5%. The rennet casein class increased to 1.7 ± 0.02 and heat resistance to 1.5 ± 0.02. Milk density was 1027.6 ± 0.30 kg/m³ and acidity was 16.9 ± 0.23 °T.

Based on the present findings we suggest that the examined feed additive and dosage amount (500 g per day) can be successfully used in organic animal husbandry to enhance the components of organic milk.

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