Biologically active additives for cows as a factor in the production of environmentally friendly products in animal husbandry

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Abstract. The material presents the results of the analysis of the domestic market of feed additives for cows registered for use in Russia. It gives a brief overview of modern feed additives recorded in the state register following the international classification. Feed additives produced for cattle occupy an extensive segment among the entire range of registered feed additives - 54.3%. Among them, the zootechnical group occupies the largest part, it is 62.4%, followed by the technological group - 21.6%, then the nutritional group has 11.5%, and the group of flavouring (sensory) additives has 4.5%. Along with the use of synthetic feed additives, the authors emphasized the need to use additives of plant and natural origin in animal husbandry as a physiological source of biologically active substances closest to the animal organism, which allows obtaining environmentally friendly products of animal origin. They proposed a classification of feed additives according to the type of action on the body of cattle: affecting the functions of the central nervous system; affecting the processes of tissue metabolism; affecting mineral metabolism and the function of the musculoskeletal system; supporting functions of the immune system; affecting oxidation processes and energy metabolism; supporting functions of the digestive system; affecting lactation; affecting the detoxification process and contributing to the elimination of foreign and toxic substances from the body. The article systematizes the main indications for the use of FA: metabolic diseases - ketosis, hepatosis, myocardial dystrophy, alimentary dystrophy, osteodystrophy; immunodeficiencies; dysbiosis; intoxication.

1. Introduction

At the present stage of development of dairy farming, the main goal is to increase the efficiency and sustainability of agricultural enterprises, primarily by obtaining environmentally friendly products free of antibiotics, hormones and other xenobiotics. An effective, economically viable and scientifically sound method for achieving this goal is the use of biologically active substances (BAS) in the form of feed additives (FA). Biologically active substances participate in the regulation of the adaptive and protective functions of the body, lower the threshold of excitability due to adverse environmental factors, technological stresses and changes in the structure of diets in the direction of exacerbating the imbalance of its main components and the quality of feed. Prevention of the incidence of cows with deep metabolic pathologies requires systematic monitoring of the biochemical and immunological...
status of animals and timely pharmacocorrection of the revealed pathological condition with deficient BASs contained in FA or drugs.

2. Problem statement
The problem of ensuring the health of highly productive cows is an acute problem throughout the world. The results of studies of domestic and foreign scientists indicate that most cows in the herd have metabolic disorders, to varying degrees of severity, [1]. Report of Academician I.M. Donnik (2019) “Animal health as a factor in the realization of the animal genetic potential” emphasized the problem of the high incidence of breeding cows with non-infectious diseases. In the general structure of cow diseases, diseases of the digestive system are 28.7%, respiratory diseases are 19.2%, metabolic diseases are 10.8%, diseases of the reproductive organs are 36.4%, mastitis accounts for 18.4%, injuries have 4.2% and poisoning have 0.7%. The author of the report says that the main causes of poor health in animals include the low adaptive potential of cows to errors in the structure of diets and the quality of feed against adverse technological factors observed in dairy farms [2]. In this situation, the main effective way to restore and preserve the health of animals is to include biologically active substances in the form of FAs. Its functional significance is the ability to improve the absorption of nutrients, increase animal productivity and feed conversion, thereby preserving the economy of the industry as a whole.

Biologically active additives (BAA) for humans are analogues of FA used in animal husbandry. Some BAAs resemble medicines in their action, such as vitamins, minerals and enzymes. In medicine, the criterion for quantifying the final effect is a distinctive feature of BAAs from the drug. If a substance regulates or stimulates function within the physiological norm, then this is a BAA. If the response is outside the normal range, then this is a drug [3]. Besides, drugs for humans include biologically active substances in amounts exceeding the physiological needs of the body, while the route of administration into the body can be either enteral or parenteral. BAAs and FAs, in contrast to them, contain biologically active substances in amounts corresponding to the physiological needs of the body and are used only orally [3, 4]. The onset of the expected action depends on the route of administration and the concentration of BASs in feed additives, which is the cause of their preferable purpose to prevent impaired functions in animals.

Modern classification of feed additives (FA) uses division by type of animal: for pig, cattle, poultry and universal; in terms of functionality, it distinguished: technological, flavouring, food, livestock, combined; by structure: monocomponent, unicomponent, ternary, poly- or multi-component), etc.

Today, there is a wide range of FAs for the feeding of farm animals in the form of mono- and combined formulations containing mineral salts and vitamins, enzymes and amino acids, products of chemical, microbiological, biotechnological synthesis, sorbents, flavouring additives. To make the effective choice of FAs in a specific production situation, specialists of the veterinary and zooengineering services generalized and systematized the material on the range and role of FAs in the treatment and prevention of cattle diseases, identified pharmacodynamic groups and indications for the use of FAs in animal husbandry.

3. Materials and methods
The research objects consist of the State Register of Feed Additives (2019), scientific publications, including electronic resources on the research topic.

4. Results and discussion
At present, the modern market of FA in Russia offers 2585 thousand items, of which 1537 items are additives for cattle which is 59% [4].

Despite that there is no legislative definition of the feed additive term, various sources give the following definitions. A feed additive is a mixture of products added to a feed to improve its eatability, quality and the absorption of feed by animals [Reference agro-bursa.ru]. Feed additives are substances of organic, mineral and (or) synthetic origin used as sources of missing nutrient, mineral substances
and vitamins in the diet of animals [5]. EU Regulation No. 1831/2003 defines the term feed additives as substances, microorganisms or preparations (except premixes and feed materials) intentionally added to feed or water and performing one or more of the following special functions [6]:

- have a beneficial effect on feed characteristics;
- meet the feed needs of animals;
- have a beneficial effect on the environmental consequences of livestock farming;
- have a beneficial effect on livestock production, productivity and physiological condition of animals, in particular, by affecting the gastrointestinal microflora and digestibility of feed.

Despite the different approaches used to characterize the term feed additives, it is common that feed additives are substances of various origins added to animal feed to fill the deficit and/or increase the attractiveness, preservation, nutritional and digestibility of feed, as well as feed, to ensure their quality.

The international classification subdivides feed additives according to purpose and properties into the following categories (Article 6, Annex III of Regulation (EU) No 1831/2003) [6]:

- technological (preservatives, antioxidants, emulsifiers, stabilizers, thickeners, gelling agents, binders, adsorbents, anti-caking agents, acidity regulators, silage additives, denaturing agents);
- flavouring (colourants, flavours);
- zootechnical additives ensuring the biological usefulness of feed (vitamins, provitamins and their derivatives; trace elements; amino acids, their salts and analogues; urea and its derivatives; protein supplements);
- nutritional supplements - digestibility enhancers (enzymes, prebiotics, probiotics, substances that have a beneficial effect on the environment, etc.);
- coccidiostatics and histomonostatics (in the Russian Federation they are classified as drugs for the treatment and prevention of diseases of farm animals and birds).

Table 1 shows the share of individual FA groups for cattle as of December 2019.

Table 1. The share of feed additives for cattle registered for use in the Russian Federation

| No. | Group of feed additives according to the international classification | Absolute quantity, PCs. | Relative weight, % |
|-----|-------------------------------------------------|------------------------|-------------------|
| 1   | technological                                    | 334                    | 21.6              |
| 2   | flavouring                                      | 70                     | 4.5               |
| 3   | zootechnical                                    | 962                    | 62.4              |
| 4   | nutrient                                        | 177                    | 11.5              |
|     | Total                                           | 1537                   | 100               |

The analysis of the results indicates that most of the FAs are zootechnical additives that ensure the biological usefulness of feed (62.4%), technological additives are in second place (21.7%), nutritional (11.5%) is in third place, and fourth place belongs to flavour additives (4.5%). The significant predominance of the group of zootechnical additives over the remaining groups is due to the year-round need of animals for biologically active substances [7, 8]. Figure 1 presents the share of individual groups of livestock additives.

Vitamins, vitamin-mineral complexes, protein-vitamin-mineral complexes, proteins and amino acids occupy the largest part of the group of zootechnical additives or 82% (789 items). The high demand for them is obvious since BASs are involved in the regulation of the adaptive and protective functions of the body, helping to increase the natural resistance, milk production and reproductive function in animals, as well as the safety of young animals [8].
Figure 1. Zootechnical additives: 1 - vitamin and mineral complexes; 2 - proteins and amino acids; 3 - feed additives that increase the energy value of feed; 4 - protein-vitamin-mineral complexes; 5 - feed additives of plant origin.

Vitamins A, D₃, E, carotenoids, as well as proteins and amino acids are most in demand for the prevention of animal diseases. Cows with a high level of milk yield often have a deficiency in the body of thiamine, cyanocobalamin, niacin, choline, biotin, vitamin K and C [9]. To fill the deficiency with vitamins and minerals for animals, there are vitamin-mineral complexes used in the production of feed and premixes. As active substances, they use beta-carotene, vitamin E, choline chloride, D-biotin, nicotinamide, niacinamide, A, D₃, E, C, K, group B vitamins, calcium D-pantothenate, menadione, and also zinc salts, manganese, calcium, sodium, sulfur and other minerals. Vitamin-mineral complexes containing proteins and amino acids aim to correct the physiological status of cows after calving, as well as to increase the immunity and safety of calves [9].

Protein supplements allow enriching cattle diets with protein, essential amino acids, presented in the form of complexes or the pure form such as L-threonine, L-tryptophan, L-lysine and others, as well as in the production of substitutes for whole milk for calves. Feed additives with carbamide, ammonium bicarbonate, ammonium sulfate, ammonium acetate, as well as other ammonium salts and ammonia water can also compensate for protein deficiency in the feed. However, it is important to remember that violation of the regulations for their use can contribute to increased ammonia formation in the rumen, negatively affecting the quality of livestock products.

To fill the energy deficit in cows, manufacturers often use propylene glycol, glycerin, butyrates of calcium, sodium, palm oil fatty acid mixtures and fish oil as active ingredients of feed additives, its share in the register was 13.2% of the group of livestock feed additives. Pure propylene glycol and glycerin in pure form or as part of ready-to-use drugs are recommended in the treatment of ketosis in cows.

Plant-based feed additives are various herbal extracts. For example, thyme extract allows increasing milk productivity, chestnut tree extract (the active substance of tannin) allows regulating digestion, and grape seed extract allows normalizing metabolism in cows. This type of feed additives among the zootechnical group is also used with vitamins and minerals and amounts to 3.4%.

The technological group includes broad-spectrum adsorbents and feed additives used for the preparation and silage of feeds, occupies an essential part of the State Register of Feed Additives and is 21.7%. Due to the instability of the quality of the raw materials used for the preparation of feed, agricultural producers actively use butyrates, acidifiers and non-selective adsorbents as preservatives and pharmacocorrectors.

To adsorb mycotoxins and improve digestion in ruminants as active substances, feed additive manufacturers include hydrated aluminosilicates of potassium, sodium and calcium, natural clays bentonite and zeolite, walls of inactivated yeast cells Sacharomyces cerevisae, complex probiotic
preparations containing Bacillus subtilis, Bacillus subtilis, Bacillus subtilis, Bacillus subtilis, Bacillus subtilis, licheniformis [10]. They modify them with polyarginine and betulin to give sorbents additional immunostimulating properties [11, 12]. To reduce the level of pathogenic and conditionally pathogenic microflora, to prevent the growth of moulds, to disinfect water intended for animal watering, and to acidify feeds, manufacturers use organic acids: propionic, lactic, formic, citric, acetic, sorbic and fumaric. Feed additives containing live strains of lactic acid bacteria Lactobacillus buchneri, Lactobacillus plantarum, Bacillus subtilis, Enterococcus faecium are recommended for preservation, silage, and also haying of feed raw materials. This group contains supplements containing the antioxidants ethoxyvin, butylhydroxyanisole, which prevent the oxidation of fats and fat-soluble vitamins in feed raw materials and improve the granulation and extrusion of compound feeds. The calcium lignosulfonate obtained from sulphite liquor of coniferous wood allows preventing dust formation in granular feed during their production.

Recently, there has been an increase in demand for prebiotics, probiotics and enzyme preparations in the world, which can increase the digestibility of feed nutrients and non-specific resistance by normalizing the microflora of the gastrointestinal tract, and thereby maintain the health and increase animal productivity [10]. Probiotics and prebiotics are often used for young animals. The proportion of FA in this group was 11.5%. Nutrient supplements designed to optimize and normalize digestion processes consist of a dry culture of live yeast: Saccharomyces cerevisiae, inactivated lactic acid bacteria Lactobacillus acidophilus, Lactobacillus Plantarum, Lactococcus lactis, Bacillus subtilis, Enterococcus faecium, Propionibacterium shermanii, Cellulomonos flavigena-22, inactivated brewer's yeast, selenium-containing yeast. To increase the digestibility of feeds, there are additives containing enzymes separately and in combination: protease, xylanase, cellulase, glucose oxidase, alpha-amylase, beta-glucanase, beta-mannanase, and lipase for digestibility of fats. The list of this type of FA has 177 names [4].

Flavouring (sensory) feed additives include 70 items and make up 4.5%. Functionally sensory FAs improve the colour, smell, and taste of the food, are made in liquid and dry form and aim to increase appetite and eatability of feed. They contain aromatic components or a mixture of them in the form of essential oils, such as oregano, thyme, rosemary, eucalyptus, menthol, thyme, peppermint, anise; extracts of medicinal plants caper, chicory, nightshade, mandura, etc.; synthetic flavours, such as vanillin, ethyl vanillin, sodium saccharin, cinnamaldehyde, etc. [4].

One of the important groups that allow producing environmentally friendly livestock products is the natural feed additives or the so-called phyto-genics – natural plant growth stimulants. Phyto-genics are a wide group of substances derived from medicinal herbs and their extracts. These additives can increase the enzymatic activity of the digestive glands, increase the digestibility of nutrients, have antioxidant activity, reproductive efficiency. In addition, essential oils obtained from medicinal herbs improve the palatability of feeds, which makes them attractive to animals. Long-term studies have shown the high efficiency of phyto-genics in strengthening the health of animals and increasing their productivity [13]. For this reason, farmers need to pay special attention to the prophylactic and therapeutic use of plant and natural FAs, which allow physiological correction of functional disorders in animals and simultaneously ensure the absence of harmful drug metabolites from animal products.

FAs, like biologically active additives, have three groups: nutraceuticals, parapharmaceuticals, and probiotics [14]. According to this classification, nutraceuticals are essential nutrients, i.e. natural feed ingredients: vitamins and their precursors, polyunsaturated fatty acids, minerals, individual amino acids, mono- and disaccharides, and dietary fibre. The functional role of nutraceuticals is to compensate for the deficiency of essential nutrients that help to individualize the feeding of a particular group of animals, depending on age, productivity, physiological state and content technology: to obtain an immunomodulatory effect and increase in non-specific resistance. Nutraceuticals contribute to the elimination of foreign and toxic substances from the body. Thanks to these effects that we can consider FA nutraceuticals as a means of primary and secondary prevention, as well as a complex treatment of such common diseases as hypovitaminosis, ketoses, hepatoses, immunodeficiencies, osteodystrophy. Parapharmaceuticals are, as a rule, the minor components of the
feed: organic acids, bioflavonoids, biogenic amines, di- and oligopeptides, some oligosaccharides, as well as FAs that regulate appetite. The main indication for this group of FAs is to increase the productivity of cows and strengthen immunity. The third group includes probiotics proper: living microorganisms or the products they cultivate, and prebiotics that contributes to the growth of beneficial rumen microflora: indigestible oligosaccharides, some vitamins and their derivatives, lactoglobulins and glycopeptides. These and others have a beneficial effect on the animal's body due to the improvement of the gastrointestinal tract [9–12]. FAs of this group can help to prevent and to treat diseases with signs of diarrhoea.

There is an opinion that the use of FAs increases the productivity of animals and, accordingly, the profitability of production, which is why all-in-one feed should include the components of each group of additives [15]. The choice of FAs requires justification with a specific goal determined by violations of the function or system identified during the examination of animals, or by the achievement of the necessary production indicators. In this regard, it is necessary to regularly monitor the clinical status, biochemical and immunological parameters of cows of various technological groups, the results of which will determine the choice of FAs. According to the main effect on the body, FAs for cows include the following groups:

- affecting the functions of the central nervous system (B vitamins, vitamin-mineral complexes containing magnesium, calcium, potassium, methionine);
- affecting the processes of tissue metabolism (vitamins, minerals, methionine, amino acids);
- affecting the mineral metabolism and the function of the musculoskeletal system (Sme klaun top, Ruminiulks);
- supporting functions of the immune system (Alita D, Bustrum, Highlaysis);
- affecting oxidation processes and energy metabolism (First Energy; Energy 100);
- supporting functions of the digestive system (ZooLak +, ZooLak Feedgrade, OmniGen);
- affecting lactation (CRYSTALIX Trockensteher +);
- affecting the detoxification process and contributing to the elimination of foreign and toxic substances from the body (AnkoFIT, MiaMiko-Fit Trophy, Sorbitox)

The main indications for FA are the prevention and treatment of the following diseases:

- metabolic diseases: ketosis, hepatosis, myocardial dystrophy, alimentary dystrophy, osteodystrophy;
- immunodeficiencies;
- dysbiosis in young animals;
- intoxication.

Several researchers consider FA as a means against which the effectiveness of the pharmacotherapeutic action of certain drugs increases. There is evidence that the addition of the enzyme-probiotic preparation Cellobacterin + to the shungite mineral allowed researchers to create a mineral-probiotic FA and to experimentally confirm an additional increase in live weight of calves due to the normalization of digestion processes. Scientists have also proved the role of highly dispersed metals exhibiting a bacteriostatic or bactericidal effect in intestinal infections complicated by dysbiosis. Studies of pharmacological levels of minerals with bentonite clay in calves have proven the effectiveness of their use in diarrhoea.

It was found that the integrated feeding of skimmed acid with formic acid and compound feed enriched with bentonite clay positively affects the growth, development and biochemical parameters of the blood of calves of the milk growing period. FA based on dietary fibre (for example, pectins or alginates) can act as monotherapy for acute and chronic poisoning, including heavy metals. For example, biotechnologies actively use the unicellular green algae of Chlorella (Chlorella Vulgaris, Chlorella fusca) to produce protein and vitamins in the form of tablets or suspensions. Their use leads to the activation of metabolic processes and the elimination of certain toxins from the body [16–20].
5. Conclusion

Thus, the FA as a source of biologically active substances for the body in animal feeding opens up a safe non-drug way of regulating and maintaining the functions of individual organs and systems, maximally satisfies the altered physiological nutrient requirements in animals with signs of the disease, and also accelerates elimination from organism toxic metabolic products and residual xenobiotics. In the State Register of Feed Additives for 2019, the share of cattle intended for cattle is 59.4%. Zootechnical additives take the leading place (62.1%), followed by technological additives (21.7%), nutritional (11.5%) and flavouring additives (4.5%). The promising alternative to antibiotics is feed additives - phytogenic, as well as phytopreparations with proven pharmacological activity, which, due to the content of many multifunctional components, regulate the metabolic processes in the body, exerting a therapeutic effect and, meanwhile, obtaining high-quality livestock products [13, 21].

Numerous studies on the use of feed additives in animal husbandry make it possible to understand the importance and necessity of their use in achieving high productivity and production efficiency while maintaining the health and well-being of animals, improving the quality and safety of products, and reducing the environmental impact of the industry. Some FAs in the diets not only improve the health status of the livestock but also increase their value for human consumption, making it possible to obtain highly nutritious food [22]. Further identification of the positive effects of the additives and minimization of the negative effects that they may have if they are used improperly, especially with other additives, new feed components or pharmacological agents require additional work.

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