Efficiency of use of feed additives from local resources in cattle feed

L I Naumova, N F Klyuchnikova* and M T Klyuchnikov

Far Eastern Agriculture Research Institute, Vostochnoe, 680521 Khabarovsk, Russia

*E-mail: nauka1952@mail.ru

Abstract. The problem of inadequate feeding in livestock production and associated significant economic losses has increased interest in the use of local natural feed resources in the diets of farm animals. In the last decade, domestic and international practice has proved that the use of biologically active substances in animal and poultry feed allows to get more products while reducing feed costs. It has been established that diets that are balanced for amino acid composition, vitamins and minerals increase the productive indicators of cattle by up to 30%. We thus conducted research on the use of the following natural adaptogens in farm animal feed as sources of trace elements and vitamins: Patrinia scabiosolistnaya, pine nut husk flour, brown seaweed from the Okhotsk sea, and dioecious nettle. Positive changes were noted in the experimental group. During the experimental period a larger gross milk yield was obtained, and the content of the mass fraction of fat in milk was also higher in the experimental group. Due to higher productivity in the experimental group of animals, there was a decrease in feed costs per unit of production.

1. Introduction

One of the main aims of the State program for the development of agriculture and regulation of the market of agricultural products, raw materials and food for 2013–2020 is the development of animal husbandry. Compound feed, micro- and macroelements, vitamins and feed additives are one of the main elements used to solve many of the problems of animal husbandry and poultry farming.

The genotype + environment interaction means that parts of the genome of an animal can be activated by providing various components, one of which is feed. Therefore, to increase the productive indicators of cattle and laying hens, it is necessary to improve their diets and feeding schemes. For this purpose, feed specialists are searching for cheap non-traditional feed products that would not be inferior to expensive feed in terms of biological value.

According to the data of the NGO “Soyuz kombikormschikov”, in 2018 the share of complete feed in the total volume of production in the Russian Federation was: for cattle – 39%, for pigs – 53% and for poultry – 91% (in Europe, these indicators were 79%, 95% and 99%, respectively). The share of grain components in the total volume of feed is about 70% (in Europe it is about 48%). Due to the imbalance in protein content and in amino acid and vitamin composition in feed for farm animals and poultry, twice as much feed is used for the production of livestock products in our country compared to the standards of some other countries. When using compound feeds that are balanced in all nutrients, the productivity of the animals increases by 10–12%, and when they are enriched with vitamins, trace elements and other stimulating substances productivity increases by 25–30%,
compared to when animals are fed certain types of grain fodder. In this regard, strategies to increase the production of animal products in the Khabarovsk territory should focus on increasing the biological value of the diet of animals by enriching them with the missing nutrients. Compound feeds imported from other regions of Russia to the Far East do not always meet the required quality, and may vary in their chemical composition and nutritional value. As a result, one innovative approach involves the use of feed additives from local plant resources that contain a whole complex of biologically active substances.

In the last decade, domestic and international practice has proved that the use of biologically active substances in the diets allows to get more products from farm animals while reducing feed costs. The use of local natural feed resources in the diets of farm animals allows the need of animals for scarce food elements to be optimized and reduces the cost of feed per unit of production and rearing of young animals [1].

The effectiveness of animal husbandry is greatly influenced by veterinary measures aimed at preserving animal health, increasing productivity, and preventing and fighting diseases. As a result, one innovative approach involves the use of feed additives from local plant resources that contain a whole complex of biologically active substances.

The spread of heavy metals in the environment can negatively affect the human body and animals, but at the same time, trace elements, including heavy metals, are a necessary component of many enzymes, hormones and vitamins and are required for their activity [2]. A lack of such trace elements can limit the productivity of animals [3].

The occurrence of microelement deficiency is caused by the low content of certain factors of mineral nutrition in the soil, water and feed.

The dependence of the feed mineral composition on the climate, soil type, application of fertilizers, features of agricultural machinery, and technology of forage preparation is known. This affects the supply of animals with macro- and microelements, and their health status. In this regard, the lack of trace elements leads to the emergence of diseases and reduces the productivity of animals.

An excess of mineral elements in the diet (relative to needs) is also not desirable, since it causes additional energy expenditure for their excretion and possible violations of metabolic processes [4].

In recent literature, much attention has been paid to the problem of ecotoxins entering the environment. These affect the body of lactating animals through the endocrine glands and influence the activity of the pituitary, ovaries, pancreas and other glands. When feeding animals adequate amounts of trace elements their metabolism increases, and, as a result, productivity increases. The biological availability of trace elements in mineral form is significantly lower than that in organic forms. The most promising and safe feed additives are those created from natural resources [1].

The dependence of the feed mineral composition on the climate, soil type, application of fertilizers, features of agricultural machinery, and technology of forage preparation is known. This affects the supply of animals with macro- and microelements, and their health status. In this regard, the lack of trace elements leads to the emergence of diseases and reduces the productivity of animals.

An excess of mineral elements in the diet (relative to needs) is also not desirable, since it causes additional energy expenditure for their excretion and possible violations of metabolic processes [4].

In recent literature, much attention has been paid to the problem of ecotoxins entering the environment. These affect the body of lactating animals through the endocrine glands and influence the activity of the pituitary, ovaries, pancreas and other glands. When feeding animals adequate amounts of trace elements their metabolism increases, and, as a result, productivity increases. The biological availability of trace elements in mineral form is significantly lower than that in organic forms. The most promising and safe feed additives are those created from natural resources [1].

The experience of using plant extracts in animal husbandry shows that their full and rational use allows farmers to save money and increase the number of livestock, reducing the cost of expensive chemotherapeutic agents, antibiotics and vitamins, and therefore improving livestock production. Such extracts perform well in preventing, treating and increasing the productivity of animals. This makes it possible for farms to reduce the cost of purchasing chemical, microbiological and other industrial products [5,6].

The most promising way to eliminate the deficit of minerals and vitamins in animal feed is to enrich diets with premixes. The development of targeted premix recipes for each soil and climate zone allows farmers to maximize the productivity of their animals and increase the profitability of animal husbandry [7].

Unbalanced diets, low feeding levels and the poor quality of basic feed lead to metabolic disorders. Most metabolic disorders occur in highly productive dairy and beef cattle. Signs of these disorders include an increase in the number of eggs, the birth of weak offspring, a decrease in resistance to infectious diseases, body weight, and productivity, and a deterioration in the quality of the products produced. All this, in the end, leads to the premature culling of animals.

The effectiveness of animal husbandry is greatly influenced by veterinary measures aimed at preserving animal health, increasing productivity, and preventing and fighting diseases. This can involve the use of natural products, among which are biologically active substances contained in plant extracts [8,9,10].

The problem of stress in animal husbandry and the significant economic losses associated with it have increased interest in the use of plant adaptogens in animal husbandry.
We combined several components in one preparation to study their influence on the productive indicators of animals. The use of natural feed and medicinal additives in cattle feed as sources of vitamins and trace elements in the conditions of the Khabarovsk territory is scientifically justified on the basis of experimental data and an analysis of domestic and foreign literature. The positive effect of feeding experimental feed additives on blood parameters, growth, development, nutrient absorption and the productivity of animals has already been established.

The purpose of this study was to determine the effect of the addition of biologically active bioresources from the Far East on the productive indicators and metabolic processes of dairy cows.

2. Materials and methods
The study was carried out in JSC "Danilovka" of the Khabarovsk district of the Khabarovsk territory on two groups of dairy cows (10 heads per group) of the Simmental breed in the stable period (October-April). When selecting the groups, age, body weight, and calving date were taken into account. The study scheme is presented in figure 1.

![Figure 1. The study schemes.](image)

In addition to the standard diet, the experimental group received an additional complex feed additive, which included the above-named wild medicinal plants of the Far East, at the rate of 15 g per 100 kg live weight. During the entire experimental period (90 days), control milking was carried out monthly, and milk productivity was measured individually for each animal. The mass fraction of fat and protein was determined in the average milk sample. At the beginning and end of the experiment, blood was taken from each group of animals to determine their individual clinical and biochemical parameters. The digestibility of substances was calculated on the basis of what was actually consumed and extracted from the body using the VIZ method. Laboratory studies were conducted in the Far Eastern Institute of Agriculture. All the obtained material was processed by the biometric method according to N. A. Plokhinsky [11].

3. Results and Discussion
We attempted to enrich the diets of cattle with macro- and microelements and vitamins contained in plants of terrestrial and marine origin. Based on the monitoring of endemic plants in the Khabarovsk
territory for the content of biologically active biostimulators, we identified the most valuable plants for use in animal diets. Below is a description of the plants used in the product under development. *Patrinia scabiosifolia* contains: extractives – 28.8%; polysaccharides – 17.3%; saponins – 3.4% (patrinoside D accounts for half of the total saponins, being the main active substance); tannins – 5.4%; flavonoids (quercetin, kaempferol) – 1.1%; essential oils – 1.9%; oleanolic acid, vitamins A, C, D, as well as fructose, rhamnose, and xylose. *Eleutherococcus senticosus* contains: sterols (eleutheroside A), phenols (eleutheroside B), coumarins (eleutheroside B1), lignans (eleutherosides D and E), triterpene saponins (eleutherosides K, L, M), essential oils, anthocyanins, chromones, flavonoids, resins, lipids, pectin substances, free sugars and polysaccharides, and aralin alkaloid. Brown seaweed contains: fucoidan, laminarin, vitamins, micro- and macronutrients, in particular a large amount of iodine (up to 0.24% in air-dried matter), amino acids, and a large amount of fatty acids. Pine nut shell flour contains: fiber – 60%; cellulose – 38.6%; lignins – 23.8%; hemicellulose – 7.7%; pentonases – 22.6%; fats and resins – up to 3.4%; proteins – up to 1.8%; ash – up to 0.9%; vitamin C – 27 mg%; and resinous substances, which contain a small amount of essential oil and tannides (tannins). The shell has a peculiar amino acid and trace element composition, and increased content of glutamic acid.

The inclusion of a complex feed additive (CD) in the diet of dairy cows had a favorable effect on the indicators of milk productivity over 90 days of lactation (table 1).

The gross natural fat content of the milk was higher in the experimental group by 9.5% compared to the control group. The average daily yield of standard milk in cows in the experimental group exceeded the control by 9.4%, and the average daily yield of 4% fat milk is exceeded the control group by 8.1%.

**Table 1. Dairy productivity of cows for 90 days of lactation.**

| Indication                  | Group               |
|-----------------------------|---------------------|
|                             | Control group       | Experimental group |
| *Gross milk yield per head, kg* |                     |                    |
| Standard milk, kg           | 1259.9±54.8         | 1391.2±46.6*        |
| 4% fat milk, kg             | 1042.2±45.3         | 1126.9±37.8         |
| *Average daily milk yield, kg* |                     |                    |
| Standard milk, kg           | 14.0±0.6            | 15.5±0.5            |
| 4% fat milk, kg             | 11.6±0.5            | 12.5±0.4            |

*P< 0.1

Milk quality indicators such as protein mass fraction and fat mass fraction were slightly higher in the control group. This is due to the fact that there is a negative relationship between milk yield and the mass fraction of fat and protein in milk (r = -0.4 at P< 0.05). The highest yield of milk protein and milk fat was observed in the experimental group, at 10.0 and 7.9% higher than in the control group respectively (table 2).

The results of the study showed that feeding complex feed additives to lactating cows contributed to increased productivity and improved milk quality indicators due to more effective use of dietary nutrients, as can be seen when evaluating the haematological and biochemical parameters of animal blood (table 3).
show that according to the phosphorus in the blood experimental group): calcium − 2.45 mmol/l, phosphorus − 0.96 mmol/l. The ratio of calcium and phosphorus in the blood (2.45:0.96) was close to the ratio in feed. Data from haematological studies show that according to these indicators, the physiological condition of cows in the experimental group

### Table 2. Qualitative indicators of milk.

| Indication                      | Control group | Experimental group |
|--------------------------------|---------------|--------------------|
| **Mass fraction of protein in milk,** % | 3.16±0.01     | 3.15±0.01          |
| **Milk protein yield,** kg       | 39.8±1.7      | 43.80±1.4*        |
| **Mass fraction of fat in milk,** % | 3.31±0.02     | 3.24±0.01          |
| **Milk fat yield,** kg           | 41.7±1.8      | 45.0±1.5           |

*P< 0.1

### Table 3. Haematological and biochemical parameters of animal blood.

| Indication                      | Start of the experience | End of the experience | Start of the experience | End of the experience |
|--------------------------------|-------------------------|-----------------------|-------------------------|-----------------------|
| **Haemoglobin,** g/l           | 82.50±3.60              | 78.90±3.75            | 78.50±2.40              | 86.10±3.15*          |
| **White blood cells,** 10^9/l  | 10.33±1.42              | 10.47±0.66            | 9.60±1.45              | 11.14±1.33           |
| **Red blood cells** 10^{12}/l  | 6.57±0.24               | 5.31±0.18             | 5.82±0.18              | 6.61±0.15*           |
| **Total protein,** g/l         | 75.25±3.04              | 79.87±5.17            | 80.70±2.57             | 89.50±3.36*          |
| **Calcium,** mmol/l            | 2.71±0.40               | 2.44±0.63             | 2.80±0.53              | 2.45±0.46            |
| **Carotene,** mg%              | 0.450±0.005             | 0.700±0.045           | 0.500±0.030            | 0.960±0.030*         |
| **Inorganic phosphorus** mmol/l | 1.55±0.18               | 1.63±0.13             | 1.68±0.18              | 1.60±0.22            |
| **Reserve alkalinity,** %      | 55.19±1.67              | 50.68±4.11            | 50.49±2.47             | 47.83±3.97           |

*P< 0.1  
^b P< 0.001  
^c P< 0.05

The blood haemoglobin content of cows in the experimental group exceeded that of the control group by 9.1% (P<0.1). The number of red blood cells in the blood of animals receiving a complex feed additive was higher than in the control group by 24% (P<0.001). An increase in the content of red blood cells and haemoglobin in the blood of animals of the experimental group indicates higher metabolism and thus a better ability to absorb oxygen during breathing, improving the oxygen supply to the organs, which is especially important during strenuous lactation activity.

Cows in the experimental group had a 12% higher total protein content than those in the control group (P<0.05), which indicates an increase in the level of protein metabolism and balance of protein nutrition, as well as an increase in the binding capacity of trace elements.

The experimental group also had 6.3% more white blood cells than the control group, which was obviously a consequence of the body's defenses and is consistent with the literature.

We judged the intensity of the phosphorus-calcium metabolism by their levels in the blood serum. During the experiment, the amount of these components was within the normal range (in the experimental group): calcium − 2.45 mmol/l, phosphorus − 0.96 mmol/l. The ratio of calcium and phosphorus in the blood (2.45:0.96) was close to the ratio in feed. Data from haematological studies show that according to these indicators, the physiological condition of cows in the experimental group
was better than that of the control group. The improvement in the haematological and biochemical parameters of the blood can be explained by the stimulating effect of a complex feed additive.

Milk contains many elements of the Mendeleev periodic system. These are found in proteins, the protein shells of fat globules, carbohydrates, enzymes, vitamins, etc. [12].

In our study, cows in the experimental group had 48 mg/kg more Ca and 75 mg/kg P than the control group, a difference of 43.6% and 81.5%, respectively. The calcium content in milk decreases for the first three to four months of lactation, and then stays at the same level for up to 7 months, after which it increases until the end of lactation (figure 2).

![Figure 2](image2.png)

**Figure 2.** The content of macronutrients in the milk of experimental animals.

![Figure 3](image3.png)

**Figure 3.** The content of trace elements in the milk of experimental animals.
The milk of cattle that received CD had higher amounts of trace elements necessary for growth and reproduction, relative to control animals. These trace elements affect haematopoiesis, the function of endocrine glands, the body's defense reactions, and regulate metabolism, among other things. The amount of iodine in the milk of experimental animals increased by 322%, iron by 61%, manganese by 45%, copper by 112%, and zinc by 33% compared to the control (figure 3). The content of macro- and microelements in the milk of experimental cows was within acceptable limits [13].

4. Conclusion
Our results demonstrated a positive effect of a feed additive consisting of a mixture of vitamins, minerals and biologically active substances of plant origin on the productivity of lactating cows. Experimentally, it was found that the use of the studied additives in the diet stimulated the growth of cows, reduced feed costs and increased subsequent milk productivity.

We thus recommend that for the biogeochemical conditions of the Khabarovsk territory, when balancing rations for cattle according to normalized vitamins and trace elements, a complex feed additive containing endemics of the Far East is included.

The results of this study will be useful when developing recommendations for the use of additives in young cattle.

References
[1] Tuaeva E V 2018 After effect of the dissertation of the VIZ. Ernst (Dubrovitsy)
[2] Buryakov H 2019 Compound feed 3 52–55
[3] Kuznetsova T S, Kuznetsov S G and Kuznetsov A S 2007 Zootechniya 8 10–15
[4] Mamenko A M and Poryannik S V 2007 Problemi zoozhenerii and veterinary medicine: Zbirnik naukovikh Prats KHDZVA Harkiv 1 pp 118 –127
[5] Mezes M and Füleky G 2003 Proc. Int. Symp. Food Quality Management for Eastern European Countries (Cluj-Napoca) pp 49–52
[6] Varakin A T, Salomatin V V, Kharlamova E A and Stepurina M A 2014 Zootechniya 1 12–14
[7] Volgin V I, Komissarov I M and Protasov B I 2015 Zootechniya 5 5–7
[8] Podolnikov V E and Osipova A G 2018 Zootechniya 10 4–7
[9] Yarmots L P and Yarmots G A 2017 Feeding of farm animals and feed production 11 39–45
[10] Lykov A S and Kuzmina U Y 2017 Modern trends in the development of science and technology 3 123–128
[11] Plochinsky N A 1969 Guide to biometrics for zootechnics (Moscow: Kolos)
[12] Dolgaya M M, Rusko N P and Chushak E G 2016 Zootechnical science of Belarus 2 150–155
[13] Kalashnikov A P, Viktorov P I, Gruzdev n V, Kleymenov N I, Makhaev E A, Modyanov A V, Nikitin A V and Shcheglov V V 1988 Feeding of farm animals (Moscow: Rosagropromizdat)