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Innovative approaches to improving the quality of feed base of farm animal to ensure competitiveness of animal products

Abstract. One of the most promising areas in Kazakhstan at present is the production of feed additives based on plant materials with mineral components. This article describes the use of a feed additive made from green plant materials obtained by growing the traditional cereal crop *Hordeum vulgare* (barley) from the family Poaceae, and the non-traditional fodder crop *Rumex confertus* (sorrel) from the family Polygonaceae, with the addition of locally produced montmorillonite and additional ingredients – calcium phosphate, potassium iodide and urea, which are necessary for metabolic processes in a growing organism and improve the nutritional qualities of milk and meat. The effect of a combination of plant components with the addition of mineral additives on the biochemical parameters of young sheep is shown. A significant (2-3 times) increase in concentration of protein, glucose, cellular enzymes alanine aminotransferase (ALT), aspartate aminotransferase (AST), bilirubin, alkaline phosphatase and urea was noted, which may indicate a high calorie content of the additive and the absence of factors contributing to pathological deviations in the development of animals.
Key words: feed, farm animals, biochemistry, feed mixture, rumen fluid, protein-carbohydrate metabolism, fat metabolism.

Introduction

The socio-political stability and food security of a country depend on the level of development of the agricultural sector as the most important branch of the state economy. Ensuring the country's food security in the context of the aggravated situation on world food markets requires an active regulatory role of the state. Kazakhstan, a country with historically strong agricultural traditions, can become a leading world producer of agricultural products in the current conditions of global economic instability, climate change and an unstable price system. The natural conditions of Kazakhstan and its biodiversity create significant potential for the development of animal husbandry. Traditionally, the republic is engaged in sheep, horse, camel and cattle breeding. Livestock and crop products are produced in state, cooperative and joint-stock agricultural enterprises, in peasant and peasant households, and on private subsidiary plots. However, the competitiveness of agricultural enterprises in the Republic of Kazakhstan is still significantly worse than the requirements of the time [1].

The lack of investment in agriculture hinders the widespread introduction of effective technologies, modern equipment and the use of scientific achievements. Only in recent years has the industry begun to actively focus on increasing the efficiency and competitiveness of domestic producers, reducing food dependence and providing the country's population with high-quality and safe agricultural products [2].

The development of livestock breeding in Kazakhstan is the main direction of the agro-industrial sector and provides more than half of the gross agricultural production. Despite the measures taken, domestic livestock products often cannot withstand competition from foreign producers. One of the main reasons for this is the weak feed base. Although Kazakhstan is a grain producer and one of the world's largest flour exporters, its feed milling industry is underdeveloped. The feed produced by the enterprises does not meet the quality requirements

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of agro-industrial production. Feed mills are located in different regions of the country, and the lack of competition in this area makes them monopolists in the feed industry, which leads to higher prices for livestock products on farms [3].

Only in recent years, according to the Statistics Committee, the market for ready-made feed for farm animals, including feed production, has shown a gradual increase of 10-20% per year [4]. However, a major problem in the development of animal husbandry is the lack of nutrients in prepared feed, which disrupts the feeding conditions at different periods of the ontogenesis of farm animals [5]. The development of scientific approaches to the problems of industrial agriculture is often associated with the introduction of new technologies in feed production and an increase in productivity. For example, the acquisition of feed mixtures that promote more complete use of feed protein is of great importance [6].

The main objective of this study is to develop a cheap and cost-effective feed mixture based on the use of green mass of traditional and non-traditional forage plants, natural adsorbents, trace elements and vitamins that compensate for the lack of nutrients, activate the assimilation process and ensure the safety and quality of livestock products.

Materials and methods

Experimental material. The studies were conducted on 45 Degeres meat-and-wool fat-tailed sheep kept on fattening sites of 2 farms in the Karasai district of the Almaty region.

Design of the experiment. The rams were 5–6 months old, with an initial weight of 32–33 kg, and were divided into 2 groups: control (20) and experimental (25 rams). The control group was fed a standard daily diet, while the experimental group was supplemented with a standard feed supplemented with a granulated feed additive at a rate of 5-6 g per 1 kg of weight, an average of 180-200 g per day per sheep.

Obtaining feed additive. To obtain the feed mixture under laboratory conditions, we use the technology of using ionized water developed and tested by us, which allowed us to increase the germination of the plant mass of cultivated crops and quickly obtain green mass both in closed and open areas of farms. The main source of active compounds in the feed additive was the green mass obtained within 2-3 weeks from the germinated grain plant *Hordeum vulgare* (barley), Poaceae family, and the non-traditional forage plant *Rumex confertus* (sorrel), Polygonaceae family, with a height of up to 40-50 cm. Green barley is characterized by a high content of macro and microelements, as well as vitamins of group B. Forage sorrel of the variety "Rumex-K-1" provides the feed mixture with a high content of protein, ascorbic acid and essential amino acids. The complex of these plants contains protein, micro and macroelements, essential amino acids necessary for the growing organism of animals in sufficient quantities.

To obtain the feed mixture, bentonite, dried and crushed green mass, dry crushed barley grain and additional ingredients were mixed: calcium phosphate, potassium iodide, urea, to improve the absorption and digestibility of plant feed. The ratio of additional components was 150 g – 500 g of ground dry barley grain, 30 g of bentonite, 300 g of green mass, 20 g of ingredients with active substances. The feed granules were prepared in a special container with constant stirring until a wide mass was formed and passed through an extruder. The resulting granules were then dried on special stands in the open air. The degree of maturity of the raw materials was determined by the following features: the granules should be hard, easily crushed and crumble into pieces with light pressure. When storing the feed additive in bags, sanitary and technical conditions were observed – room temperature, containers used, humidity, in accordance with the requirements of the regulations developed in the country [7,8].

Blood collection. The collected blood is stabilized with heparin (2-3 U/ml), centrifuged (10 min at 1500 rpm), and the plasma is separated from the erythrocytes. In the blood plasma samples in vivo, the level of lipid peroxidation is determined by the content of intermediate (diene conjugates), final (malonic dialdehyde) peroxidation products and catalase activity. Blood was collected before and after 21 and 42 days of feeding the sheep with the feed additive, biochemical parameters in the blood plasma were determined [9,10].

Spectrophotometric analysis of animal blood plasma. The assay was performed on a biochemical analyzer Biosystems A-25 (Biosystem S.A., Spain) using test kits. Albumin – reagent code 12547, total protein – reagent code 12500l, ALT reagent code 12533, AST reagent code 11830, creatinine (Jaffe method) – reagent code 12502, glucose – reagent code 11803, bilirubin – reagent code 11510, triglycerides – reagent code 12528, magnesium – reagent code 11797, phosphorus – reagent code

12508. These reagents were purchased from the company Biosystem S.A., Spain.

Analysis of oxidative stress reaction in animal blood. The reaction was determined by the content of the final product of the lipid peroxidation – malondialdehyde (MDA), by the reaction with 2-thiobarbituric acid (maximum absorption at 535 nm) and the intermediate product of lipid peroxidation – diene conjugates (DC) [11]. The state of the antioxidant system was determined by the activity of the key enzyme – erythrocyte catalase (EC), which is involved in interrupting the chain of free radical processes [12]. Statistical processing of the results was carried out using Microsoft Excel 2007, the significance of intergroup differences was assessed using Student's t-test for independent variables. Differences were considered statistically significant at $p<0.05$. The data is presented as follows: arithmetic means ± standard deviation (M±SD) [13].

Ethical approval. In studies on farm animals, we were guided by the decision of the Local Ethics Committee, Institute of Genetics and Physiology, Protocol No. 6 from November 3, 2022.

Results and discussion

The average weight of sheep in the control and experimental groups at the initial level fluctuated within 34.03±2.8 kg. On the 42nd day of the experiment, the weight of the control animals (n=20) fluctuated from 37.5 to 40.5 kg, in the experimental group (n=25) – from 40.1 kg to 43.8 kg, averaging 39.3±1.4 kg and 41.8±1.8 kg, respectively (Figure 1).

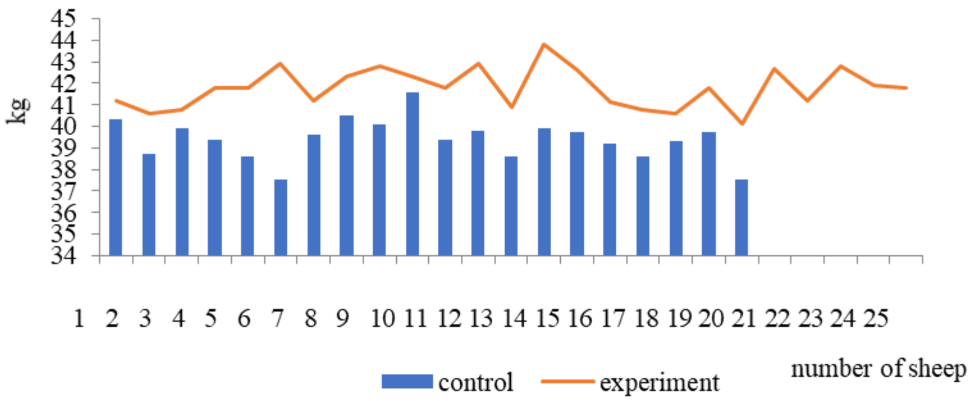

Figure 1 – Body weight growth of sheep in the control (n=20) and experimental (n=25) groups on day 42

As can be seen from the results presented in Figure 1, the daily weight gain in the control group fluctuated within 125 g per sheep, in the experimental group the average weight gain was 18 per sheep.

The initial level of cellular fractions in the blood (leukocytes, lymphocytes, erythrocytes, hemoglobin) in the sheep of the control and experimental groups fluctuated within the physiological norm. After the introduction of the feed additive into the daily diet of animals for 42 days, in the experimental group of sheep the number of erythrocytes increased by 30%, and the concentration of hemoglobin increased by 10%, which indicates an improvement in the functions of the cardiovascular system. An increase in red blood cells provides a sufficient level of oxygen in muscles and tissues and promotes the active development of adaptive mechanisms regulating metabolic processes during the growth of young farm animals [14,15].

The reaction of the rumen environment determines the state of enzymatic processes and the degree of absorption, with a neutral reaction pH = 7.0 units. In ruminants, pH fluctuates from 6.5 to 7.2 units, alkaline reaction – more than 7.0 units, acidic – less than 5.4 units [15].

The study of the rumen fluid of the control sheep showed a shift in pH to the acidic side (5.9 units), which is typical when feeding animals with easily digestible carbohydrates (grain concentrates). In the experimental sheep, on the 42nd day (validation is presented below) after adding the feed additive developed by us to the daily diet of the animals, some animals showed a restoration of the neutral pH level to 6.6 units, while others had a shift to 7.1 units to the alkaline side. An increase in dry matter and ammonia in the rumen fluid of the experimental sheep by 10-12%, amylolytic (carbohydrate digestion) activity by 8-10%, an increase in protozoan and microbial mass by 4-5% were noted, compared with the data of the control group (Table 1).

Table 1 – Changes in rumen fluid of experimental sheep before and after the introduction of the feed additive into the daily diet of sheep

Indicator Control 42 days pH 5.90±0.15 6.60±0.11 Dry matter, % 3.40+0.16 3.80±0.05 Degree of fermentation, cm3 /gas 1.16±0.26 1.11+0.09 Fiber digestibility, % 14.5+3.1 47.9±4.7* Ammonia, mmol/l 40.0+1.9 44.3±0.7* VFA, meq/100 ml 14.5+1.0 15.4±0.6* Proteolytic activity, % 14.6+3.6 30.3±3.5* Amylotic activity, %	Control Control 42 days pH 5.90±0.15 6.60±0.11 Dry matter, % 3.40+0.16 3.80±0.05 Degree of fermentation, cm3 /gas 1.16±0.26 1.11+0.09 Fiber digestibility, % 14.5+3.1 47.9±4.7* Ammonia, mmol/l 40.0+1.9 44.3±0.7* VFA, meq/100 ml 14.5+1.0 15.4±0.6* Proteolytic activity, % 14.6+3.6 30.3±3.5* Amylotic activity, %	42 day
pH	5.90±0.15	6.60±0.11
Dry matter, %	3.40+0.16	3.80±0.05
Degree of fermentation, cm^3/gas	1.16±0.26	1.11+0.09
Fiber digestibility, %	14.5+3.1	47.9±4.7*
Ammonia, mmol/l	40.0+1.9	44.3±0.7*
LFA, mEq/100 ml	14.5+1.0	15.4±0.6*
Proteolytic activity, %	14.6+3.6	30.3±3.5*
Amylotic activity, %	72.7±8.5	78.9±4.6*
Protozoan mass, mg	40.0±1.4	41.8±3.6
Microbial mass, mg	130.0+11.4	135.0±12.2

*Note: significant compared to control, p<0.05

In the rumen fluid of the control group of sheep, an increase in oxidative processes and fermentation activity, low digestibility of complex carbohydrates (fiber) and proteolytic (protein breakdown) activity are observed. In the experimental sheep, the pH was restored with a tendency to shift the pH to the alkaline side, the degree of fermentation decreased, and the ammonia level increased, which indicates an increase in proteolytic activity and absorption of ammonia into the blood. A slight increase in various microorganisms in the rumen of the experimental sheep indicates an increase in metabolism and synthesis of vital amino acids and vitamins [16].

The results of the studies of the sheep rumen fluid showed an improvement in amylolytic activity and an increase in microbial mass after using the feed additive compared with the data of the control group. Blood biochemical studies in the control group of sheep fed with standard diet showed low levels of albumin (by 15-16%), glucose (by 20%) and creatinine (by 35%), which is below the average normal value for sheep [17].

A 2.3-fold increased level of the cellular enzyme AST and a 1.4-fold increased level of bilirubin were observed compared to the maximum normal values, indicating a tendency to develop pathological abnormalities of the hepatobiliary and cardiovascular systems [18]. An acute deficiency of trace elements – magnesium, phosphorus and vitamins – was also noted. In addition, the lack of proteins and fats in the standard feed was reflected in the level of triglycerides, alkaline phosphatase, urea and cholesterol, the values of which fluctuated at the level of the minimum limits of the physiological norm, which is associated with the low nutritional value of the feed used daily. After adding the feed additive to the diet of the experimental sheep, the biochemical parameters of the blood of the animals showed a tendency to gradually restore the nutritional balance. An increase in the level of total protein due to the active growth of albumin in the blood by 15-16%, an increase in glucose concentration by 20%, creatinine, triglycerides and HDL cholesterol by 35%, a decrease in the enzymes LDL low density cholesterol, ALT, AST and the De Ritis coefficient to the average norm was noted [15, 17].

The level of triglycerides fluctuated at the level of the maximum norm, the level of alkaline phosphatase decreased, but remained 2 times higher than the maximum norm, the concentration of urea, reflecting the activity of protein metabolism and liver and kidney pathology, remained at the average physiological level, the concentration of trace elements magnesium and phosphorus reached the minimum level of the physiological norm (Figure 2).

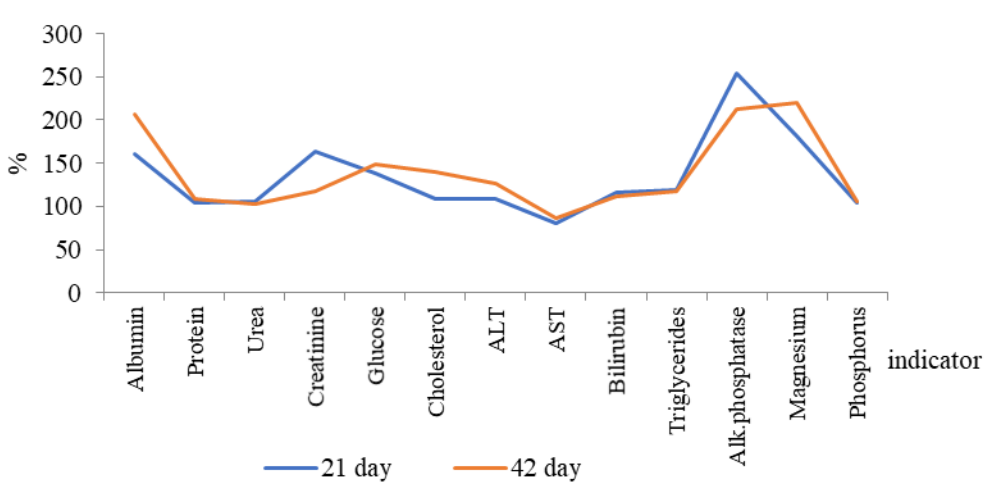

Figure 2 – Dynamics of changes in biochemical parameters (control – 100%) in the blood of rams on days 21 and 42 after adding the feed additive to the daily diet

It should be noted that the level of creatinine, which reflects the energy supply of cells, in the blood of sheep of the control group was below the minimum norm, which is typical for a deficiency of protein-carbohydrate-fat components in the daily diet of animals. The urea/creatinine coefficient (the norm is below 0.08) is 0.09, which allows predicting the development of renal and hepatic failure with the possible development of hepatosis or cirrhosis [19]. The level of trace elements in the blood of control sheep was 45% below the minimum value for magnesium concentration and within the minimum physiological norm for phosphorus level, which is typical for a deficiency of vitamin D and growth hormone [20].

Comparative analysis of biochemical data showed that the use of the feed additive provides protein saturation of the daily diet of sheep, increased metabolic processes in the liver and increased activity of excess cholesterol utilization. A tendency towards a stable increase in fat and muscle mass without the development of pathological abnormalities in the functioning of the hepatobiliary system, such as fatty liver disease – hepatosis or cardiovascular insufficiency, which are the main cause of death of young animals during fattening, was shown.

The study of the oxidative activity of the blood showed an increase in antioxidant protection at the cellular level in the experimental group of sheep (Figure 3).

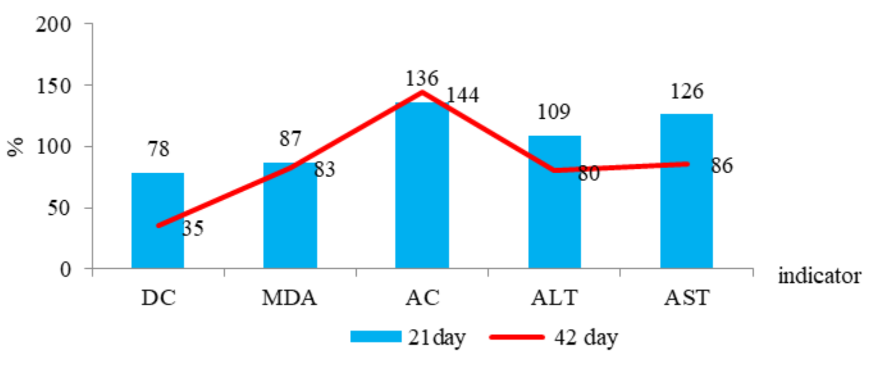

Figure 3 – Dynamics of changes in the indices of lipid peroxidation of plasma membranes of blood cells and enzymatic activity of blood plasma (%) after 21 and 42 days of introducing the feed additive.
Note: DK – diene conjugates, MDA – malonic dialdehyde, AC – catalase activity, ALT – alanine aminotransferase, AST – aspartate aminotransferase

The indicators of primary and secondary peroxidation products were below the control values by 10-20%, which reflects the low level of stress factors for the excitation of oxidative processes, and an increase in the catalase level by 12% ($p \leq 0.001$ compared to the control data) indicates pronounced protective antioxidant properties of the developed feed additive. Strengthening the antioxidant protection of blood cells is confirmed by a comparative analysis of data on lipid peroxidation and the enzymatic activity of ALT and AST.

A direct relationship is revealed between these indicators – a decrease in the level of diene conjugates as indicators of primary intoxication of the body and malonic dialdehyde – the final product of peroxidation, ensures a decrease in the concentration of cellular enzymes ALT and AST, that is, damage to the plasma membranes of hepatocytes and cardiomyocytes at a minimum.

An inverse relationship is also possible between enzymatic activity and an increase in the level of catalase in the blood, which prevents the development of oxidative stress.

To assume, raising young farm animals on fattening farms is associated with the nutritional value of the daily ration. At the final stage, the addition of feed additives enriched with proteins, fats and mineral and carbohydrate components improves the quality characteristics of animal products [21]. Biochemical blood tests of animals should be carried out as continuous monitoring.

Current study shows the effect of a feed additive obtained from the green mass of a well-known cereal crop (barley) and a widespread non-traditional forage crop (sorrel) with the addition of trace elements on the hematobiochemical parameters of animal blood. It was found that the addition of the feed mixture for 1.5 months has a positive effect on the growth and development of animals and ensures the adequacy of the daily diet. Biochemical studies create the basis for expanding the feed base to compensate for the lack of nutrients in the daily diet. According to the latest literature data, the assessment of biochemical parameters shows the influence of the environment, pesticide load and the value of various types of feeding with the inclusion of various biologically active additives on the productivity of farm animals [22, 23].

A recent biochemical study described the dependence of heavy metal concentration in the blood of sheep on the grazing season, which must be taken into account when feeding animals in fattening farms [24]. Based on the biochemical analysis of sheep blood, the use of an unconventional forage plant, daylily, as a partial replacement for traditional corn silage as a feed resource for sheep is recommended [25]. The use of licorice extract as a feed source of antioxidants is described, biochemical parameters were studied, which showed a positive effect of the extract on growth, nutrient digestibility, humoral immunity and antioxidant activity in cattle [26].

In recent years, prophylactic agents have been actively developed to prevent hepatosis and cardiovascular diseases in humans and animals, based on betaine, a glycine derivative obtained from grain [26].

The inclusion of young barley greens and sorrel in our feed additive provides the animal body with the necessary amount of glycine, antioxidants necessary for the growth and development of animals. In this work, biochemical parameters of blood plasma of sheep in the control group showed the presence of imbalance and deficiency of proteins, carbohydrates, fats and trace elements in the daily diet of fattening rams. A tendency to liver and bile insufficiency was noted, low creatinine levels indicate a lack of muscle mass in animals [27].

A study of the microelement composition of the blood of the control group of sheep revealed a deficiency of potassium, sodium, calcium, phosphorus, chlorine and especially magnesium, which slows down the growth and development of animals. The use of the feed additive developed by us for 42 days showed the restoration of the balance of nutrients in the daily diet, an increase in total protein, glucose and triglycerides, as well as a decrease in the De-Ritis coefficient, which reflects an increase in the activity of protein, carbohydrate, fat and mineral metabolism.

The shelf life of the feed additive from the green mass of rumex and barley at the initial stages of vegetation – stem formation, is short-term and, like other green fodder, does not exceed 2 months, after which a loss of the nutritional properties of the forage crops is noted [28-30]. The period of maximum biological value of the feed additive has been selected.

After 42 days, the level of lipid metabolism – both HDL and LDL cholesterol and creatinine – reflected the sufficient water supply of the body and moderate activity of protein-fat metabolism, which ensures a stable increase in muscle mass.

The level of triglycerides fluctuated at the level of the maximum norm, the level of alkaline phosphatase decreased, but remained twice the maximum norm, and the concentration of urea, reflecting the activity of protein metabolism, as well as liver and kidney pathology, remained at an average physiological level, and the concentration of trace elements magnesium and phosphorus reached the minimum level of the physiological norm.

Restoring the balance of nutrients is associated with the introduction of a new feed additive into the diet, which, in addition to the green mass of sprouted grain crops and sorrel, includes bentonite, calcium phosphate, urea and potassium iodide, the ions of which enter the blood through the gastrointestinal tract and are included in the metabolic processes in the body.

The study of lipid peroxidation on plasma cell membranes showed a consistently low level of oxidative processes in the blood after the use of the feed additive, which suggests a high antioxidant and protective effect of the compound feed. The introduction of the feed additive developed by us into the diet of farm animals will give farmers certain opportunities to obtain high-quality meat products from healthy animals.

Conclusion

The organization of a full-fledged diet for farm animals is the most important condition for increasing their productivity. Standard diets for farm animals are balanced in many respects, but the most important of them is protein content. In ruminants, protein is additionally supplied by microorganisms that synthesize protein from non-protein nitrogen compounds during digestion. For this, nitrogen compounds must be supplied daily in sufficient quantities with feed. In this regard, urea, which contains 42-49% nitrogen, is introduced into the composition of feed additives. The main advantage of urea is that it is readily available and much cheaper than natural protein. The difficulty of its use in animal feed is the formation of ammonia during its hydrolysis in the rumen of ruminants [31].

Rations containing green fodder, other concentrates and urea increase the ammonia content in the rumen and blood plasma, changing the ratio of essential and interchangeable amino acids [32].

The inclusion of urea in the diet of sheep, as well as green mass from germinated cereal plants, reduces the acidity and the amount of dry matter in the rumen fluid, which indicates increased fermentation of feed nutrients in the forestomachs. High-quality feed determines the profitability of production and high productivity of livestock farming.

The feed additive developed by us is based on dry and green mass of sprouted grain crop *Hordeum vulgare* (barley), family Poaceae, and non-traditional feed crop *Rumex confertus* (horse sorrel), family Polygonaceae, with the addition of bentonite, calcium phosphate, urea and potassium iodide in the ratio of 500 g of mixture – 150 g of ground dry barley grain, green mass of barley and sorrel – 300 g, ingredients with active substances 50 g; – after using the feed additive, biochemical analysis of the animals' blood showed an increase in the concentration of protein, fat, indicators of mineral-carbohydrate metabolism, a consistently low level of oxidative processes in the blood, which indicates a high nutritional, antioxidant and protective effect of this plant mixture and can be recommended for growing animals in fattening areas.

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Conflict of interest

All authors are aware of the article's content and declare no conflict of interest.

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