Influence of feed mineral supplements on morphological and biochemical blood indicators of lactating cows

S F Sukhanova, N A Pozdnyakova and F V Yaroslavtsev
Kurgan State Agricultural Academy named after T S Maltsev, Kurgan region, Ketovsky district, village Lesnikovo, 6451300, Kurgan, Russia
E-mail: nina_ksaa@mail.ru

Abstract. The article presents data on morphological and biochemical blood parameters, the content of total protein and its fractions in the blood serum of lactating cows when using new mineral supplements at a dose of 100 g and 350 g per head per day. In experimental group 2, an increase in the hemoglobin index was 11.88% (P≤0.05), in inorganic phosphorus - 27.00% (P≤0.01), in globulins - 4.81% (P ≤ 0.05) compared to the control group.

1. Introduction
Full feeding satisfies the needs of animals in all nutrients and maintains vital and reproductive functions, preserves health and longevity, allows for maximum productivity with minimal feeding costs. Mineral nutrition conditions are important for increasing productivity, resistance to diseases and reducing production costs. The lack of mineral elements, their disproportion causes serious disturbances of metabolic processes and diseases [1, 2].

The blood composition reflects the health state and an ability to adapt environmental conditions. Various changes in feeding and maintenance are reflected in the blood. Therefore, the study of hematological parameters helps understand and link these changes with productivity [3, 4].

The purpose of the article is to study the effect of new feed mineral supplements on morphological and biochemical blood parameters of lactating cows.

2. Methods
The scientific and economic experiment was conducted at the Barabinsk farm enterprise of Dalmatov district. Black-and-white cows were divided into three groups according to the balanced group method. All experimental animals were clinically healthy. The animals of the experimental groups were fed according to the norms of feeding described by A.P. Kalashnikov.

Animals of the control group were fed according to the scheme used at the enterprise, of experimental group 1 - with RusMD No. 1 at a dose of 150 g, of experimental group 2 - with RusMD No. 2 at a dose of 350 g. The scheme of the experiments is presented in Table 1.

In forming the composition of supplements, bioavailability and technological properties of mineral salts, and their low aggressiveness were taken into account. When calculating the composition, the daily need of animals in minerals, productivity, biological and physiological characteristics of the animal were taken into account.
Table 1. Scheme of scientific and economic experiments

| Group             | Number of animals | Feeding features            |
|-------------------|-------------------|-----------------------------|
| Control           | 10                | BD                          |
| experimental 1    | 10                | BD +150 g RusMD 1           |
| experimental 2    | 10                | BD + 350 g Rus MD 2         |

Table 2 presents the recipes of mineral supplements for lactating cows. The composition of mineral supplements was designed to provide animals with trace elements - manganese, cobalt, zinc, copper, iodine and selenium. The basis of the mineral supplements (81.4%) is made up of traditional components - feed salt, lime (calcium carbonate), magnesium brucite and monoammonium phosphate. To improve the taste and palatability, molasses was introduced. It is a substance that binds particles when granulating a product. Consequently, the use of these supplements allows for meeting the needs of cows in salt, macro- and micronutrients.

Table 2. Composition of feed mineral additives (per 1000 kg)

| Component                | RusMD 1 | RusMD 2 |
|--------------------------|---------|---------|
| Monoamide phosphate      | 152.00  | 140.00  |
| lime                     | 40.00   | 10.34   |
| NaCl                     | 262.17  | 302.00  |
| Brucite                  | 60.00   | 64.00   |
| Sodium selenite          | 0.053   | 0.013   |
| Manganese oxide          | 24.00   | 6.50    |
| Cobalt carbonate         | 0.22    | 0.06    |
| Zinc sulphate            | 40.00   | 10.70   |
| Carbonaceous copper      | 2.40    | 0.65    |
| KI                       | 0.155   | 0.042   |
| FeSO₄                   | 19.00   | 5.70    |
| Molasses                 | 100.00  | 100.00  |
| Limestone                | 300.00  | 360.00  |
| Cost, rub               | 27820   | 20820   |

The basic diet of all groups met the standards for feeding cows with a live weight of 500 kg and a daily milk yield of 14-16 kg with a fat content of 3.8%. The physiological state of the animals was assessed by hematological and biochemical blood parameters which were taken 2 hours before feeding from three animals of each group at the beginning and end of the experiment. Biochemical and hematological parameters were determined in the department of veterinary and laboratory diagnostics of the testing laboratory of the Ural Veterinary Research Institute. The following parameters were determined: the number of red blood cells - in the Goryaev’s counting chamber; leukocytes – by the vitro method; hemoglobin – using the transforming solution; the color indicator - by calculation; the alkaline reserve - according by the Pozysyaiku’s method; total protein, residual nitrogen - by colorimetrication at FEC; total nitrogen - by the Kjeldahl method; serum protein fractions – using the phosphate buffer in turbidity solutions; calcium – by the de Waardu’s method; inorganic phosphorus, total protein - by FES colorimetry; protein fractions in serum with phosphate buffer – by turbidity solutions.

The experimental data were processed using the methods of biometrics described by G.P. Leshchuk et al, S.F. Sukhanova, Microsoft Excel and electronic online calculator www.Math.semestr.ru.
3. Research results
The blood composition reflects the state of the animal, and provides information about adaptation abilities. The blood picture allowed us to observe various changes in the body under the influence of feeding and maintenance. Therefore, the study of hematological parameters helps understand and link these changes with productivity.

Considering the important role of blood, we carried out its morphological and biochemical analysis (Table 3).

| Indicator                      | Norm   | control group | experimental group 1 | experimental group 2 |
|--------------------------------|--------|---------------|----------------------|----------------------|
| Erythrocytes, 10^{12}/l       | 5.0-7.5| 7.00 ± 0.07   | 7.16 ± 0.21          | 6.63 ± 0.34          |
| Hemoglobin, g/l               | 90-120 | 98.67 ± 5.84  | 108.00 ± 1.00        | 108.67 ± 5.36        |
| Hematocrit, %                 | 24-46  | 28.69 ± 1.74  | 30.86 ± 0.37         | 31.09 ± 1.18         |
| Color indicator               | 0.8-1.3| 1.03 ± 0.07   | 1.03 ± 0.06          | 1.07 ± 0.03          |
| Leukocytes, 10^9/l            | 4.5-12 | 9.51 ± 0.51   | 9.40 ± 1.21          | 10.26 ± 1.41         |
| Calcium, mmol/l               | 2.2-3.1| 2.77 ± 0.09   | 2.73 ± 0.23          | 2.70 ± 0.17          |
| Inorganic phosphorus, mmol/l  | 1.4-2.4| 1.87 ± 0.17   | 2.03 ± 0.24          | 2.27 ± 0.03          |
| Potassium, mol/l              | 4.0-5.8| 5.10 ± 0.12   | 5.07 ± 0.12          | 5.17 ± 0.09          |
| Magnesium, mol/l              | 1.1-3.5| 1.60 ± 0.15   | 1.47 ± 0.35          | 1.83 ± 0.18          |
| Chlorides, mol/l              | 85-100 | 93.57 ± 2.35  | 91.57 ± 2.09         | 95.57 ± 5.01         |
| Alkaline phosphatase, u/l     | 40-100 | 62.33 ± 4.67  | 79.00 ± 15.50        | 56.00 ± 10.02        |

The morphobiochemical blood parameters were within the physiological norm and did not have significant differences.

At the beginning of the experiment, the number of erythrocytes was higher by 2.23 and 7.40% in the blood of experimental group 1 compared with the control group and experimental group 2, respectively. The hemoglobin content was higher in experimental group 2 by 9.20% compared with the control group and by 0.62% - with experimental group 1.

The hematocrit shows the percentage of plasma and blood cells (erythrocytes, leukocytes and platelets). The increased content of the corpuscles was observed under the dehydration (vomiting, diarrhea) and some diseases. The decrease in the number of blood corpuscles was observed with an increase in circulating blood - this may be due to the edema. The hematocrit of all experimental animals was within the normal range and amounted to 28-31%.

The color indicator is saturation of red blood cells with hemoglobin. At the beginning of the experiment, this indicator was the same for all experimental cows. In experimental group 2, it was 3.74% more compared to the control group and experimental group 2.

The number of leukocytes was greater in cows of experimental group 2 by 7.31 and 8.38% compared with the control group and experimental group 1, respectively.

The level of calcium was maximum in the cows of the control group and amounted to 2.77 mmol/l which is 1.44 and 2.53% more than that for the experimental groups. The content of inorganic phosphorus in the blood of experimental group 2 exceeded this indicator in the blood of the control group and experimental group 1 by 17.62 and 10.57%.

The indicators of potassium, magnesium and chlorides in the blood of experimental group 2 were maximum. Thus, the difference in the content of potassium, magnesium and chlorides between experimental group 2 and the control group was 0.07 mmol/l (1.36%), 0.23 mmol/l (12.57%) and 2.00 mmol/l, respectively (2.09%), compared with experimental group 1, it was higher by 0.10 mmol/l (1.93%), 0.36 mmol/l (19.67%) and 4.00 mmol/l (4.19%), respectively.
Alkaline phosphatase in the blood of animals of experimental group 1 exceeded that in the control group by 21.10%, and in the blood of animals of experimental group 2, this indicator was lower than in the control group by 10.16%.

At the end of the experiment (Table 4), the morphological and biochemical blood parameters of experimental animals were within the physiological norm.

**Table 4. Morphological and biochemical blood parameters at the end of the experiment, (X±SX)**

| Indicator                  | Norm          | control group | experimental group 1 | experimental group 2 |
|----------------------------|---------------|---------------|----------------------|----------------------|
| Erythrocytes, 10^{12}/l    | 5.0-7.5       | 7.12 ± 0.18   | 7.26 ± 0.36          | 7.33 ± 0.17          |
| Hemoglobin, g/l            | 90-120        | 106.33 ± 3.84 | 118.00 ± 6.24        | 120.67 ± 1.86 *      |
| Hematocrit, %              | 24-46         | 29.17 ± 1.50  | 30.49 ± 0.92         | 31.13 ± 0.22         |
| Color indicator            | 0.8-1.3       | 1.14 ± 0.07   | 1.18 ± 0.03          | 1.22 ± 0.02          |
| Leukocytes, 10^{9}/l       | 4.5-12        | 9.10 ± 0.08   | 9.17 ± 0.50          | 9.66 ± 0.69          |
| Calcium, mmol/l            | 2.2-3.1       | 2.76 ± 0.07   | 2.67 ± 0.22          | 2.87 ± 0.12          |
| Inorganic phosphorus, mmol/l| 1.4-2.4    | 1.73 ± 0.09   | 1.97 ± 0.22          | 2.37 ± 0.03 **       |
| Potassium, mol/l           | 4.0-5.8       | 5.20 ± 0.12   | 6.00 ± 0.35          | 6.23 ± 0.38          |
| Magnesium, mol/l           | 1.1-3.5       | 1.70 ± 0.06   | 2.33 ± 0.12 *        | 2.37 ± 0.22          |
| Chlorides, mol/l           | 85-105        | 95.07 ± 2.07  | 94.40 ± 4.16         | 92.90 ± 2.34         |
| Alkaline phosphatase, u/l  | 40-100        | 70.67 ± 2.60  | 83.67 ± 4.91         | 78.33 ± 3.84         |

* P≤0.05, ** P≤0.01

The number of red blood cells increased as follows: in the control group - by 1.69%, in experimental group 1 - by 1.38%, and in experimental group 2 - by 9.55%. The greatest number of red blood cells was observed in the blood of experimental group 2. The counterparts of the control group and experimental group 1 increased by 2.87% and 0.96%.

The hemoglobin content in the blood is influenced by the mineral composition and quality of the protein. Simultaneously with an increase in the number of erythrocytes, the hemoglobin content increased in all the groups: in the control group - by 6.92%, in experimental group 1 - by 8.47%, and in experimental group 2 - by 9.95%. At the same time, this indicator in experimental group 2 increased by 14.34 and 2.67 g/l, or by 11.88 and 2.21% compared to the control group and experimental group 1.

By the end of the experiment, the saturation of erythrocytes with hemoglobin in the control and experimental groups increased by 9.65%, 12.71 and 12.30%, respectively. At the end of the experiment, the leukocytes content in experimental group 2 increased by 2.20% and 9.52% in the control group.

The number of leukocytes decreased by 4.31%, 2.45 and 5.85%, respectively. The maximum content of leukocytes was observed in experimental group 2. In the cows of the control group, this indicator was 5.79% lower; in the cows of experimental group 1, it was 5.07% lower.

During lactation, cows use up to 40% of mineral substances from the skeleton depot. The organism of high-milk cows cannot use calcium from the bones to compensate for the consumption of this element which sharply increases milk secretion. The content of calcium is usually reduced.

In the cows of the control group, there were no changes in the content of blood calcium. The calcium content in the blood of animals of experimental group 1 decreased by 2.20%. In experimental group 2, it was increased 5.92%. due to the use of RusMD No. 2. At the end of the experiment, the calcium content in this experimental group was 3.83% higher than in the control group and 6.97% higher than in the experimental group 1.
The similar pattern was typical of inorganic phosphorus. At the end of the experiment, in experimental group 2, this indicator exceeded that in the control group (P ≤ 0.01) by 27.00%, and that in experimental group 1 16.88%.

The use of feed mineral supplements increased the content of blood potassium and magnesium. In experimental group 1, these indicators exceeded the control ones by 13.33 and 27.04% (P≤0.05), and in experimental group 2, they exceeded the control ones by 15.53 and 28.27%, respectively.

Alkaline phosphatase provides phosphorus in the cells, which they need for normal metabolism. Alkaline phosphatase in the blood of animals of the experimental group 1 exceeded the control by 15.54%, and in the blood of animals of the experimental group 2, this indicator was only 9.78% higher than the control.

Proteins form the basis of all body tissues. The content of total protein in animals with high productivity decreases due to more intensive metabolic processes associated with milk synthesis. Table 5 presents data on the content of protein and its fractions in the serum of experimental animals at the beginning and at the end of the experiment.

| Indicator          | Group               | control group | experimental group 1 | experimental group 2 |
|--------------------|---------------------|---------------|----------------------|----------------------|
|                    | at the beginning of the experiment |               |                      |                      |
| Total protein, g/l | 81.70 ± 1.15        | 82.50 ± 0.20  | 84.03 ± 1.42         |                      |
| Albumin fraction, g/l | 34.40 ± 0.55    | 36.50 ± 0.96  | 36.83 ± 0.96         |                      |
| Globulins, g/l      | 47.30 ± 1.64        | 46.00 ± 1.01  | 47.20 ± 1.39         |                      |
| Protein ratio       | 0.73 ± 0.04         | 0.80 ± 0.04   | 0.78 ± 0.03          |                      |
|                    | at the end of the experiment |               |                      |                      |
| Total protein, g/l | 81.53 ± 2.50        | 83.13 ± 0.39  | 83.60 ± 1.19         |                      |
| Albumin fraction, g/l | 34.60 ± 1.91    | 37.07 ± 1.58  | 34.03 ± 0.91         |                      |
| Globulins, g/l      | 46.93 ± 3.17        | 46.06 ± 1.35  | 49.30 ± 0.42 *       |                      |
| Protein ratio       | 0.75 ± 0.08         | 0.81 ± 0.06   | 0.70 ± 0.02          |                      |

* P<0.05

At the beginning of the experiment, the total protein content in all experimental animals did not change. By the end of the experiment, the level of total protein in group 2 decreased by 4.50%. In the control group, this indicator did not change, while in experimental group 1, it increased slightly.

Albumins provide solubility and transport of intermediate products of metabolism from one tissue to another one; after preliminary hydrolysis, the amino acids used for the synthesis of specific proteins are released. Consequently, a decrease in the albumin fraction is related to the productivity of animals.

By the end of the experiment, in group 2, the level of albumin decreased by 7.60%. In the control group, this indicator did not change, while in experimental group 1, it increased slightly.

The globulin fraction of whey proteins transports lipids, estrogens, and fat-soluble vitamins. In highly productive animals, the globulin fraction increases the fat content of milk. The highest content of globulins was found in the blood of cows from experimental group 2; it increased by 4.81% (P ≤ 0.05). The content of globulins in the blood of animals of experimental group 1 did not differ much from the control group.

The protein ratio reflects the ratio of the albumin fraction to the globulin fraction. This indicator had no significant differences in all experimental groups.

4. Conclusion
Thus, changes in morphological and biochemical parameters of blood characterizing metabolic processes were observed in the experimental groups. Experimental group 2 fed with RusMD No. 2 had
better values of the blood parameters. At the same time, all the indicators were within the physiological norms.

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