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VITAMIN AND MINERAL NUTRITION OF DAIRY COWS AND ITS INFLUENCE ON RUMINAL METABOLISM AND MILK PRODUCTIVITY

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Abstract

The key to the intensive course of metabolic processes in the body of ruminants, and therefore to their high productivity, is the balance of rations according to the optimal level of vitamin and mineral nutrition, which is achieved through the use of balancing feed supplements. Providing the animal body with the necessary nutrients and biologically active substances determines not only the level of productivity, but also the amount of feed costs per unit of production, which ultimately determines the profitability of the industry. Therefore, the basis of the planned research was to find out the influence of different levels of vitamin and mineral nutrition on the ruminal metabolism of cows and their milk productivity. Based on the results obtained in the course of the research, the prospective use of the improved vitamin-mineral supplement in the composition of compound feed K 60-32-89 (optimized for Phosphorus and Sulfur) was experimentally confirmed in the feeding of dairy cows during the summer grazing period. A balancing feed supplement is enriched with biologically active substances that are deficient for Pre-Carpathia in a complex with improved compound feed it provides the optimal level of vitamin and mineral nutrition of ruminants in accordance with the physiological need, which contributes to increasing the nutritional value of feed and has a positive effect on the studied indicators of ruminal metabolism. In particular, feeding dairy cows with optimized vitamin-mineral supplement contributes to an increase in the number of microorganisms (amylo-, cellulose- and proteolytic) in the forestomachs and their enzymatic activity. This causes intensive hydrolysis of feed carbohydrates and increases the level of volatile fatty acids by 14.1% while reducing ammonia nitrogen by 11.8%, which is evidence of the activation of metabolic processes involved in energy and synthetic reactions. By analogy with the increase in the intensity of metabolic processes in the rumen of ruminants as a result of a balanced diet by the limiting biologically active substances due to the use of vitamin-mineral supplement, the level of milk productivity increases by 10.8% and the chemical composition of milk improves (dry matter, fat, protein, milk sugar, calcium) compared to the P 60-5M premix.

Key words*: dairy cows, milk productivity, premix, rumen content, vitamin-mineral supplement.*

INTRODUCTION

Animal husbandry is a strategically important branch of agriculture that saturates the market with food products, industrial enterprises – with the raw material base for production, that is, it acts as a guarantee of food independence and security of the country (Bryk, 2018). The most effective industry, which provides the population with more than 2/3 of animal protein, is dairy farming (Bozhydarnik, 2010).

The profitability of dairy farming is determined by the body's ability to effectively transform feed nutrients into products, which is closely related to the intensive course of metabolic processes in the body at all levels of vital activity (Yanovych & Solohub, 2000; McDonald et al., 2011; Antypin et al., 2014). The key to achieving maximum conversion of feed substances into products is a complete and balanced livestock nutrition system according to scientifically based norms, which would create the most optimal conditions for stimulation of anabolism processes (Spears, 2011; Kozyr et al., 2014; Diachenko et al., 2015). An important role among nutritional factors is the issue of providing rations with the optimal amount and ratio of biologically active substances, in particular, mineral elements and vitamins, etc. The latter affect energy, protein, carbohydrate and lipid metabolism, act as catalysts and cofactors of biochemical processes, contribute to the degradation, assimilation and reduction of consumption of

feed nutrients associated with the process of their conversion into products (Nocek et al., 2006; Suttle, 2010; Vorobel & Pivtorak, 2011). The analysis of literary sources shows that the deficiency, excess and imbalance of mineral elements and vitamins in the rations of ruminants negatively affects the functioning of the entire physiological and biochemical system which ensures the vital activity of the organism as a whole (Antypin et al., 2014; Prylipko & Koval, 2021). Numerous scientific studies indicate a deficiency in the soils of most farms in the Western region of a number of macro (phosphorus, sulfur) and microelements (copper, zinc, cobalt, iodine, selenium) and fat-soluble vitamins (A, D), which, accordingly, affects their content in feed, and therefore also in ruminant rations (Kravtsiv et al., 2001; Rusyn, 2009). The solution to this problem is due to the inclusion in the structure of livestock rations of multi-ingredient feed supplements, enriched with these elements and developed taking into account zonal features and the specifics of the forage base structure (Voitovych & Vovk, 2009; Kafliovska & Bihun, 2012; Sosnovska, 2017; Savchuk et al., 2019). Considering the above, the development and application of feed supplements in the feeding of dairy cows, balanced according to the deficient nutrients of a specific biogeochemical province, is of important scientific and practical significance and requires in-depth study and scientific interpretation.

The purpose of the research was to find out the effectiveness of different levels of vitamin and mineral nutrition on ruminal metabolism in the body of dairy cows in the conditions of Pre-Carpathia and their relationship with the level of milk productivity.

MATERIALS AND METHODS

In order to establish the effective action of different levels of vitamin and mineral nutrition a study was conducted at LLC "Litynske" of the Lviv region during the summer grazing period on two groups of Simmental cows, 10 cows in each: I - control group, II - experimental group. Animals in groups were selected by the method of analogues, taking into account origin, age, live weight, lactation and productivity. The ration of cows - grass-concentrate type. Animal feeding was provided in accordance with scientifically based norms (Bohdanov et al., 2012). Fodder was fed to the animals twice a day: in the morning and in the evening (50% of the total nutrition of the ration). Cows were milked twice, by machine.

The experimental part of the research lasted 120 days, of which the equalization period was 30 days and the main one was 90 days. During the equalization period the animals of both groups received the standard combined feed K 60-32-89 in a complex with the premix P 60-5M along with the feed of the main ration - pasture grass, green mass of cereal-legume mixtures of the green conveyor, cereal-various grass hay and molasses. Combined feed K 60-32-89 was represented by the following ingredients - cereal grain (wheat, barley, oats) and wheat bran. The macroelement composition of the combined feed includes monocalcium phosphate, magnesium oxide and common salt. Premix P 60-5M contains fat-soluble vitamins (A, D), trace elements (Zinc, Cobalt, Iodine) and wheat bran as a filler.

In the main period, dairy cows of the control group were on the ration of the equalization period. The animals of the experimental group received similar feeds with the only difference that the combined feed K 60-32-89 (improved in terms of phosphorus and sulfur) included vitamin-mineral supplement in a similar amount (1%) (to replace the premix P 60-5M). The constituent components of the experimental combined feed are identical to the control, with the additional inclusion of Glauber's salt and a larger amount of monocalcium phosphate. The vitamin-mineral supplement contains copper and selenium and is adjusted for the content of microelements limited in the Pre-Carpathian zone - zinc, cobalt, iodine and fat-soluble vitamins: A, D and the filler is wheat bran.

The material for research was feed, rumen content and milk. In the fodder of the ration, level of macro-, microelements and vitamins were studied. In the ruminal content the following were determined: the content of raw biomass and absolutely dry matter of bacteria, the number of amylo-, cellulose- and proteolytic microorganisms and their activity, the level of volatile fatty acids, pH, the concentration of nitrogen fractions (total,

residual, protein and ammonia) and phosphorus (total acid-soluble, inorganic and organic, ribonucleic acid (RNA) and deoxyribonucleic acid (DNA)). The investigated indicators in the selected samples were determined according to generally accepted methods (Vlizlo et al., 2012).

Statistical analysis of the research results was carried out using the methods of variational statistics in the standard Microsoft Excel and AtteStat application program package using the Student's t-test. Arithmetic mean values (M) and arithmetic mean errors (m) were calculated. Differences between mean arithmetic values were considered statistically significant for: *P<0.05; **P<0.01; ***P<0.001.

RESULTS AND DISCUSSIONS

Based on the obtained results it was established that during the main period no significant deviations between the groups in the amount of physical feed consumed by dairy cows were found. There is also no difference in a number of nutrients - metabolic energy, dry matter, crude and digestible protein, crude fat, crude fiber, sugar at the optimal ratio of sugar to protein (1.0: 1.0), carbohydrates to protein (2.0: 1.0), calcium to phosphorus (1.9-2.0: 1.0), nitrogen to sulfur (11.2-12.0: 1.0), however, there is a different biologically active substances supply in rations. Therefore, it should be noted that the main factor of the productive effect, i.e. the level of metabolic processes in the animal body and their connection with productivity, in the list of ration components were compound feed K 60-32-89 (standard and improved), premix P 60-5M and vitamin-mineral supplement.

Analysis of the chemical composition of feed in the rations of cows of the control group indicates a lack of phosphorus, sulfur, copper, zinc, cobalt, iodine, selenium, vitamins A and D, i.e. combined feed K 60-32-89 in a complex with premix P 60-5M does not provide optimal level of vitamin and mineral nutrition. At the same time, in the rations of animals of the research group, their deficiency was replenished by feeding vitamin-mineral supplement, adjusted for the content of limiting microelements and fat-soluble vitamins in the composition of compound feed, improved for phosphorus and sulfur. each of the above feeding factors, individually and in combination, plays a certain role in the chain of exchange processes in the livestock organism, and this, accordingly, affects the level of its productivity.

The efficiency of feed utilization by ruminants depends significantly on the nature of ruminal fermentation. It is known that organic feed compounds that enter the gastrointestinal tract of livestock are in a complex form and are broken down into simple compounds (which, in turn, are assimilated by microorganisms) are disposed of in the forestomachs (Antypin et al., 2014).

The key factor determining the intensity of ruminal metabolism in dairy cows is the pH value. This indicator in the animals of the experimental group (Table 1) is slightly lower compared to the control (by 1.7%), i.e. shifted to the acidic side.

The analysis of the level of metabolic processes in the rumen of ruminants indicates an increase in the concentration of microorganisms during feeding of vitamin-mineral supplemen. In particular, the number of amylolytic bacteria in the rumen content of the experimental group exceeds the control group by 16.7% (P<0.05). In the rumen environment of animals of the II group, an increase in the number of cellulolytic microflora is observed - by 20.5% and, according to statistical data, it is probable (P<0.05). The concentration of proteolytic microorganisms in the cows of the experimental group increases by 14.7%, compared to the control.

An increase in the number of ruminal biota in ruminants on the background of the vitamin-mineral supplemen use indicates the intensification of the processes of division and reproduction of bacterial cells, their growth, and therefore, the active accumulation of raw biomass in the forestomach. This ruminal metabolite increases in the experimental group of animals compared to the control by 13.3%, and the probability criterion is P<0.05. The largest share in the biomass is represented by the amylolytic population, the number of which in the rumen is the highest, relative to cellulolytic, proteolytic, etc. At the same time, in the raw bacterial mass of the II group, the content of absolutely dry matter increases by 1.4 times compared to the control.

Table 1. Indicators of ruminal metabolism of dairy cows (M ± m, n = 3)

The investigated indicator and unit of measurement	Groups of animals	
	I (control)	II (experimental)
pH	6.93±0.04	6.81±0.03
Raw biomass of bacteria, mg/100 ml	1057.0±33.8	1197.0±12.0*
Dry biomass of microflora, mg/100 ml	175.0±12.2	243.0±11.1*
Number of microorganisms, million/ml:		
amylolytic	10.20±0.22	11.90±0.37*
cellulolytic	6.00±0.33	7.23±0.21*
proteolytic	3.60±0.12	4.13±0.12*
Enzyme activity:	9.73±0.29	11.10±0.25*
amylolytic, conditional amylolite unit	1.27±0.04	1.65±0.05**
cellulolytic, %	15.94±0.90	21.10±0.92*
proteolytic, Mekv. tyrosine in 100 ml/min	0.281±0.012	0.293±0.01
VFA, mmol/100 ml	9.73±0.29	11.10±0.25*
Nitrogen, mmol/l		
total	80.79±0.44	86.29±0.44***
residual	22.73±0.14	24.15±0.44*
protein	58.06±0.55	62.14±0.83*
ammonia	13.36±0.20	11.79±0.21**
Phosphorus, mmol/l		
total acid-soluble	10.02±0.16	10.99±0.18*
inorganic	7.39±0.07	7.06±0.05*
organic	2.63±0.13	3.93±0.23**
RNA	617.2±20.0	701.9±6.7*
DNA	396.1±21.5	438.3±6.3

Note. The difference is probable regarding control: *P<0.05; **P<0.01; ***P<0.001.

Thus, the listed ruminal metabolites are a confirmation of the synthesis of an easily digestible, biologically valuable microbial protein, which is nutritionally equivalent to chicken egg protein. At the same time, the microbial protein is enriched with sulfur-containing amino acids (methionine, cystine, cysteine) in the rations of the research group's ruminants at an optimal level of sulfur. Microorganisms' protein assimilation is on average 70-80%, digestibility - 80-86%.

In the content of the rumen of cows of the II group after feeding vitamin-mineral supplemen, compared to the premix P 60-5M, simultaneously with the change in the number of the listed species of bacterial populations in the forestomachs, a similar pattern occurs with their enzymatic activity. In the rumen fluid of animals of the experimental group, relative to the similar indicator of the control group, amylase activity is higher by 29.9%, and it is probable (P<0.01). In this experiment, the activity of cellulolytic microflora also increases in the rumen of cows of the II group, in particular, by 5.2%, and according to statistical data, the difference is probable (P<0.05). The advantage of the enzymatic activity of proteolytic bacteria in the rumen fluid of animals of the research group is 4.3%. The increase in the activity of microorganisms in the contents of the rumen of cows of the II group contributes to the intensive splitting of structural (cellulose, hemicellulose, pectin, etc.) and non-structural (starch, sugar) carbohydrates of feed, which causes the formation of a large amount of the final product - volatile fatty acids (acetic, propionic, butyric and a small amount of formic, isobutyric, valeric and caproic acid) - by 14.1% (P<0.05). Volatile fatty acids, on the one hand, serve as the main source of metabolic energy (glycolysis) and after absorption in the rumen are used in the body for energetic (Krebs cycle) and synthetic processes, as well as precursors of milk components - fat and protein, and on the other hand - valeric, caproic, isobutyric and isovaleric acids stimulate the breakdown of fiber and assimilation of ammonia by bacteria. At the same time, the listed acids are carriers of the carbon skeleton involved in protein synthesis by the microbial cell (Obertiukh, 2005).

Nitrogen and Phosphorus fractions are actively included in the process of intensive ruminal metabolism in the body of animals of the experimental group. In particular, in the content of the rumen of cows of the II group, there is an

increase in the concentration of total nitrogen, relative to I group by 6.8% (P<0.001). Residual Nitrogen in the rumen fluid of animals of the experimental group exceeds the similar indicator of the control group by 6.2% and is within the limits of probability (P<0.05). On the background of feeding improved vitamin-mineral supplement in the rumen content of cows, compared to premix P 60-5M, the concentration of protein nitrogen increases by 7.0% (P<0.05). Ammonia is an important indicator of fermentation in ruminant forestomachs, which for most microorganisms (about 90%) is one of the main sources of Nitrogen in the processes of microbial protein synthesis, and for 25% it is an indispensable factor for bacterial growth. The concentration of this fraction in the rumen content of cows of group II is lower by 11.8%, and according to statistics, the difference is probable (P<0.01). The indicated level of ammonia nitrogen in the rumen fluid of animals is a consequence of its effective use by the microorganisms of the forestomachs for the synthesis of the main components of their body. The most active "consumers" of ammonia are amylo- and cellulolytic microflora, which is consistent with their high concentration in the rumen environment of cows in the study. It is known that an acidic environment helps reduce the intensity of ammonia absorption by the rumen wall, i.e. prolongs the period of the latter's stay in the forestomach, which thereby enables bacteria to absorb it as efficiently as possible (Antypin et al., 2014).

Phosphorus is an indispensable element in the processes of glycolysis and the Krebs cycle, due to which macroergic compounds (ADP, ATP, ATP + ADP, etc.) are formed. These compounds are universal accumulators and energy donors, which ensures the normal functioning of the bacteria of the forestomach and the macroorganism as a whole. The structure of nucleic acids, which are carriers of genetic information, includes orthophosphate, which is involved in the regulation of protein biosynthesis. The level of rumen phosphorus, in turn, is closely related to vitamin D. The latter increases the activity of microbial phytases, which enhance the hydrolysis of inositol phosphates with the release of inorganic phosphorus (Demydiuk et al., 2011). In this experiment, the amount of total acid-soluble Phosphorus in the rumen content of animals of the II group exceeds this indicator of I group by 9.7% (P<0.05). The level of inorganic Phosphorus in the rumen fluid of cows of the experimental variant is probably lower (by 4.5%; P<0.05), due to its active use by bacteria in the processes of glycolysis and anabolism. On the background of improved vitamin-mineral supplement in the rumen content of ruminants there is a probable increase in organic phosphorus by 1.5 times. In the rumen fluid of cows of the II group the content of phosphorus RNA is higher - by 13.7% (P<0.05), compared to I group. The concentration of phosphorus DNA in the rumen content of the animals of the experimental group exceeds the similar indicator of the control group by 10.7%.

The data obtained in the experiment are to some extent agree by the results of a similar research (Snitynskyi et al., 2009; Kafliovska and Bihun, 2012; Sosnovska, 2017; Sachuk et al., 2019). Thus, the use of the complex mineral preparation "Kalfomin" prevents the occurrence of cow diseases associated with metabolic disorders, in particular postpartum paresis, and in young animals - rickets (Sachuk et al., 2019). Research by Sosnovska (2017) found that feeding premix to dairy cows contributes to a more complete assimilation of nutrients in the ration and thus leads to an increase in milk yield, depending on its amount - 1% and 1.5%, respectively by 0.2 and 0.4 kg. Other scientists also found a positive effect of premixes on the viability of calves and their higher resistance to dyspeptic diseases, and in the blood serum of cows during the dry period, there was an increase in the content of vitamin A (Kafliovska and Bihun, 2012).

The analysis of the conducted studies shows that feeding dairy cows with improved vitamin-mineral supplement in a complex with improved compound feed provides an optimal level of vitamin and mineral nutrition, which contributes to an increase in the intensity of the metabolic processes in the rumen, and as a result of this - an increase of the milk productivity by 10.8%. At the same time - improvement of the chemical composition of milk, in particular, an increase in fat and protein, respectively by 0.1% and 0.12%.

CONCLUSIONS

It is theoretically substantiated and experimentally proven, taking into account the level of metabolism in the body of cattle and their milk productivity, that for the purpose of profitable dairy farming in the soil and climate zone of Pre-Carpathia, it is recommended to feed dairy cows with improved by phosphorus and sulfur compound feed. the use of vitamin-mineral supplement in livestock feeding contributes to the increase in the nutritional value of feed, the activation of metabolic processes in the body and as a final result obtaining of high-quality products at a low cost.

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