Effect of synchronization of fermentation processes in body of young cattle

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Abstract. Indicators of rumen digestion of young cattle has been studied when fed with concentrates with high level of degradable protein and non-structural carbohydrates subjected to barothermal treatment. Extrusion of concentrated feed decreases degradability of concentrates protein by 26-28%. Correlation of indicators of rumen digestion in steers with the method of preparation for feeding with concentrates with high level of degradable protein and non-structural carbohydrates has been determined. So, in animals receiving feed subjected to barothermal treatment, the number of ciliates in rumen fluid increases by 5.4%, total nitrogen – by 2.9%, and concentration of ammonia and volatile fatty acids decreases by 8.1 and 3.4% Thus, processing of concentrates stimulates development of microflora of proventriculus and reduces the rumen protein loss. Barothermal treatment of concentrates with a high protein degradability and high level of non-structural carbohydrates increases productivity of animals and efficiency of feed. The average daily weight gain in animals of experimental group increases by 4.8-6.0%. As a result, the feed cost is reduced by 2.7-6.9%, and protein – by 2.6-5.7%.

1. Introduction

Protein is the most valuable component of feed, the level and quality of which largely determines the productivity of animals. A complete protein nutrition of ruminants provides for the needs of the animal's body for amino acids available for metabolism. However, deficiency of dietary protein and its irrational use in the body of animals leads to the fact that protein becomes one of the most important limiting factors in the systems of intensive milk and meat production [1-5].

It is difficult and unprofitable to raise productivity of animals by simply increasing the proportion of high-protein feed in diets. Such approach leads not only to overconsumption of feed and increase in the cost of the products obtained, but also negatively affects the health of animals, which entails a sharp reduction in the period of their productive use.

A new approach to physiology of nutrition is based on the assumption that the animal's need for protein is satisfied by the amino acids of the microbial protein and the protein that is not degraded in the rumen [6-9].

The main factor for efficient use of protein in the body are favorable conditions in the rumen, providing maximum synthesis of microbial protein with simultaneous increase in the flow of feed...
protein into the intestine. With increase in productivity of animals, the microbial protein is not able to satisfy the increasing needs of the body for amino acids. In such a situation, the role of the "transit" feed protein increases, which avoided degradation in the rumen, as a source of protein available for metabolism. At the same time, the higher the productivity of animals, the greater the contribution of dietary protein not degraded in the rumen to the total pool of amino acids in the body.

Efficiency of nitrogen use is highly dependent on concentration of energy available for energy metabolism, which implies significant fluctuations in degradability of the crude protein of separate feeds. In this regard, it seems relevant to study the dynamics of degradability of crude protein in feeds at a change in the specific energy content [10, 11].

Retention time in the rumen significantly affects the disintegration of rough feed. Protein, which retains in the rumen for a long time, decomposes with a greater intensity than that quickly evacuated from it. The protein of rough feeds is tightly hidden under the cell membrane, rich in cellulose and lignin, therefore, for its degradation, a longer exposure to proteolytic enzymes of microorganisms is required [12-14]. Cereal feeds are evacuated from the proventricles faster, but they are degraded to a large extent, which indicates the specific physicochemical properties of their protein [15, 16].

An important issue in protein nutrition of ruminants is the ability to regulate the degree of protein decomposition in the proventriculus. This can be achieved in two ways: using natural feeds in the diet with protein resistant to degradation in rumen, and by physical or chemical impact on the feed protein. Therefore, the study of dynamics of indicators of protein metabolism and digestion processes in the rumen of young cattle of different ages and the duration of the period between feedings is a sore problem.

The aim of research is to improve the use of protein in the body of young cattle by synchronizing the processes of fermentation of nitrogen-containing substances and carbohydrates in feed.

2. Research methods

Determination of dependence of indices of digestion processes in rumen of young cattle and efficiency of feed when feeding concentrates with a high content of digestible protein and non-structural carbohydrates subjected to barothermal treatment was also carried out in the physiological building of the Republican Unitary Enterprise Research and Practical Center of the National Academy of Sciences of Belarus for Animal Breeding with black-and-white breed of steers aged 6-9 months.

The studies were carried out according to the following scheme (table 1).

| Table 1. Experiment layout. |
|-----------------------------|
| **Group** | **Number of animals, animals.** | **Age of animals, months** | **Duration of experiment, days** | **Feeding peculiarities** |
| I control | 3 | 6-9 | 60 | OP (ground mix of concentrates) |
| II experimental | 3 | 6-9 | 60 | OP (extruded mix of concentrates) |

Physiological experiments on studying indicators of rumen digestion in a compound stomach were carried out on animals with implanted chronic cannulas in rumen (Ø 2.5 cm), through which nylon bags were inserted into the rumen, and the content of the rumen was collected.

The differences in feeding consisted in the fact that animals of the control group received milled mixture of barley and field pea grain, and in the experimental group – extruded one.

Chemical composition of the feed used in experiments was determined according to the scheme of general zootechnical analysis in the laboratory of biochemical analyzes of the Republican Unitary Enterprise “Research and Production Center of the National Academy of Sciences of Belarus for Livestock Breeding”.

Quantitative and qualitative parameters of rumen metabolism processes were determined using the in vivo method.
Intensity of rumen digestion processes in steers was studied by sampling the liquid part of the rumen contents through fistula 2-2.5 hours after morning feeding. Biochemical parameters of blood were determined using a biochemical analyzer "Accent200", hematological parameters were determined using analyzer "URIT-3000VetPlus".

The protein degradability of protein feed was determined according to GOST 28075-89 [17]. In addition to rumen digestion and hematological parameters, the following had been studied during the experiments:

- feed palatability – by ten-day control feedings for two adjacent days according to the difference in the mass of the given feed and uneaten residues;
- the intensity of growth and level of average daily weight gains of animals – by individual weighing at the beginning and at the end of experiment;
- efficiency of feed use – by calculating energy and protein cost for growth.

Statistical processing of the analysis results was carried out taking into account the Student test of validity [18]. When evaluating the values of test of validity, we proceeded depending on the volume of the analyzed material. The likelihood of differences was considered significant at a significance level of $P <0.05$. The following designations of the significance level ($P$) are adopted: *$P<0.05$; **$P<0.01$.

3. Research results

Researches helped to determine that concentrated feeds in diet made 38.4 - 39.5%, grass – 60.5-61.6%. The animals consumed concentrated feeds completely. A 4.9% increase in consumption of corn silage in the second experimental group was recorded.

On average, experimental young animals received 6.21-6.43 kg of dry matter of the diet per animal per day. Metabolizable energy level in dry matter of diet in experimental group made 9.9 Mj/kg, crude protein – 12.6-12.8%, fiber – 27%.

Table 2. Diet for experimental animals.

| Feed and nutrients          | Group |     |
|-----------------------------|-------|-----|
|                             | I     | II  |
| Corn silage, kg             | 14.20 | 14.90 |
| Compound feed KR-3, kg      | 1.4   | 1.4  |
| Ground grain mixture, kg    | 0.6   |      |
| Extruded grain mixture, kg  |       | 0.6  |
| The diet contains:          |       |     |
| Feed units                  | 5.89  | 6.09 |
| Metabolizable energy, MJ    | 61.4  | 63.6 |
| Dry matter, kg              | 6.21  | 6.43 |
| Crude protein, g            | 795   | 816  |
| DP, g                       | 618   | 588  |
| NDP, g                      | 177   | 228  |
| Crude fat, g                | 230   | 240  |
| Crude fiber, g              | 1687  | 1764 |
| NFES, g                     | 3113  | 3225 |
| Calcium, g                  | 41.0  | 42.6 |
| Phosphorus, g               | 26.4  | 27.3 |
| Magnesium, g                | 15.4  | 16.0 |
| Potassium, g                | 84.1  | 87.6 |
| Sulfur, g                   | 12.9  | 13.5 |
| Iron, mg                    | 1781  | 1865 |
| Copper, mg                  | 98.4  | 99.6 |
Study of feed protein decomposition in rumen showed that degradability of corn silage protein was 75.6%, compound feed – 81, mixture of ground barley and pellet – 82.1, extruded mixture of barley and pellet – 53.8%. Thus, extrusion contributed to a 28.3 p.p. decrease in degradability of the grain mixture.

Studies have shown that rumen digestion in animals differed slightly between groups (table 3).

| Parameter                  | Group  |
|----------------------------|--------|
|                            | I      | II     |
| pH                         | 6.46±0.18 | 6.61±0.18 |
| VFA, mmol/100 ml           | 10.73±0.28 | 10.36±0.21 |
| Total nitrogen, mg/100 ml  | 100.3±1.95 | 103.0±1.05 |
| Ammonia, mg/100 ml         | 13.35±0.65 | 12.27±0.74 |
| Ciliates, thousand/ml      | 648±23.5 | 683±14.75 |

Acidity of the rumen fluid medium (pH) did not vary significantly in all groups. A lower pH level 6.46 was recorded in the control group. The indicator was at the level of 6.61 for animals in the experimental group.

The higher pH level in rumen fluid of experimental group steers is probably due to 3.4% decrease in the level of volatile fatty acids. Also, animals of the second group showed 8.1% decrease in concentration of ammonia in comparison with the control group.

Decrease in ammonia level and increase in total protein may indicate that the intensity of microbial protein synthesis has increased due to a more uniform supply of nutrients to the rumen and creation of more favorable conditions for the vital activity of microflora, as evidenced by 5.4% increase in the ciliates count. However, all indicators were within the normal range.

Feeding animals with extruded mixture had a significant effect on animals’ blood composition (table 4).

| Parameter                  | Group  |
|----------------------------|--------|
|                            | I      | II     |
| Red blood cells, 10^{12}/l | 6.74±0.13 | 6.99±0.120 |
| White blood cells, 10^9/l  | 10.55±0.25 | 10.33±0.230 |
| Hemoglobin, g/l            | 108.55±5.95 | 109.17±6.060 |
| Total protein, g/l         | 77.8±2.3 | 81.87±1.620 |
| Glucose, mmol/l            | 2.82±0.26 | 2.81±0.050 |
| Urea, mmol/l               | 4.72±0.16 | 4.33±0.150 |
| Calcium, mmol/l            | 2.93±0.125 | 2.74±0.0670 |
| Phosphorus, mmol/l         | 1.54±0.1 | 1.66±0.050 |
| Hematocrit, %              | 32.4±0.8 | 33.83±0.6740 |

In steers of experimental group, increase in the erythrocytes level by 3.7%, total protein – by 5.2, phosphorus – by 7.8 and hematocrit – by 4.4% has been recorded. At the same time, the level of urea decreased by 8.3% and calcium – by 6.5%. However, the differences above were unreliable.

To control the body weight, the animals were weighed and the effect of the extruded grain mixture on productivity of the animals has been determined (table 5).
Table 5. Dynamics of body weight and efficiency of feed uses by experimental young animals.

| Parameter                                      | Group   |
|------------------------------------------------|---------|
|                                                | I       | II      |
| Body weight, kg                                | 205.2±1.6 | 204.5±1.70 |
| at the beginning of the experiment             |         |         |
| at the end of the experiment                   | 252.2±0.8 | 254.3±1.80 |
| Gross weight gain, kg                          | 47±2.4  | 49.8±2.80 |
| Average daily weight gain, g                   | 783±40  | 830±46.80 |
| % to control                                   | 100     | 106.0   |
| Feed costs per 1 kg of weight gain, feed units | 7.52    | 7.34    |
| % to control                                   | 100     | 97.3    |
| Protein costs per 1 kg of weight gain, kg      | 0.98    | 0.95    |
| % to control                                   | 100     | 97.4    |

Analysis of the data obtained showed that feeding animals with extruded mixture of pellet and barley grain instead of ground grain contributed to increase in growth energy and efficiency of using nutrients in the diet. Higher weight gains were recorded in the II experimental group – 830 g per day, which is 6.0% higher than in the control group. Feed costs in this group were lower than in the first one by 2.7% and made 7.3 feed units. Feed protein utilization efficiency increased by 2.6%.

4. Conclusion

Indicators of rumen digestion of young cattle has been studied when fed with concentrates with high level of degradable protein and non-structural carbohydrates subjected to barothermal treatment. Correlation of indicators of rumen digestion in steers with the method of preparation for feeding with concentrates with high level of degradable protein and non-structural carbohydrates has been determined. Thus, extrusion of concentrated feed helps to reduce degradability of protein in concentrates themselves. In animals receiving feed subjected to barothermal treatment, the number of ciliates in rumen fluid increases by 5.4%, total nitrogen – by 2.9%, and concentration of ammonia and volatile fatty acids decreases by 8.1 and 3.4%, respectively. Thus, processing of concentrates stimulates development of microflora of proventriculus and reduces protein loss in the rumen. Barothermal treatment of concentrates with a high protein degradability and high level of non-structural carbohydrates increases productivity of animals and efficiency of feed. The average daily weight gain in animals of experimental group increases by 4.8-6.0%. As a result, the feed cost is reduced by 2.7-6.9%, and protein – by 2.6-5.7%.

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