AGRICULTURAL SCIENCES

EFFECTIVENESS OF CARBOHYDRATE NUTRITION SYSTEM FOR HIGH PRODUCTIVE COWS FEEDING

Kartashova A.
Candidate of agricultural sciences, director
Murmansk SARS – branch VIR
Russia, Murmansk
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Abstract

It was necessary to develop a carbohydrate nutrition system for full realization of the genetic potential of high productive cows and optimization of feed intake. Balance experiments were conducted in 2017-2023 on cows at different stages of the physiological cycle. Based on the research results, a carbohydrate nutrition system for high productive cows was developed, taking into account neutral and acid-detergent fiber (NDF and ADF). The use of this system will increase the milk productivity of animals by 7.13% per year, reduce the cost of feeding by 3.6-11.5% and receive an additional 10,279,200 rubles of net profit for a herd of 499 heads.

Keywords: cattle, carbohydrate nutrition system, NDF, ADF

Bulk feed forms the basis of the cattle diet. They determine the type of feeding, the quantity and quality of concentrates and feed additives, premixes included in the diet, and determine the level of productivity and profitability of production. At the same time bulk feeds have the most variable chemical composition and nutritional value.

The production of roughage is the most important branch of agricultural production. The economic efficiency of dairy cattle breeding and the agricultural enterprise depends on the level of its development. High productive cattle breeding can develop successfully when the quality of feed, and primarily roughage, is significantly improved. World experience confirms that when the qualitative composition of roughage decreases, the achievements of breeding progress are not used [1].

Fiber is of great importance in providing energy needs of ruminants. Numerous studies have established that 40 to 75% of crude fiber of feed is digested in the gastrointestinal tract of cattle. Many studies have been devoted to studying the patterns of conversion of feed carbohydrates in ruminants [2, 3].

The level of carbohydrate conversion in the digestive tract of ruminants depends on the consumption of carbohydrate fractions, their chemical and physical structure, and the adaptability of the microflora to environmental conditions. The carbohydrate nutritional value of feed can vary significantly depending on the presence and ratio of carbohydrate fractions, as well as on the content of other nutrients.

The existence of symbiotic microflora in the forestomachs of ruminants makes it possible to break down fiber and use as energy. Monosaccharides received with feed and formed after the break down of polysaccharides are mostly fermented under anaerobic conditions to volatile fatty acids, methane, and carbon dioxide. Volatile fatty acids, after resorption into the blood, are the main source of energy for the ruminant organism and used in various biosynthetic processes [4, 5].

Along with nutritional value, roughage is of great importance as a voluminous and slowly digestible substrate necessary to ensure normal motility.

The level and quality of roughage in the ration have a significant impact on the digestibility of nutrients. Thus, according to Nehring, with a fiber level of 15-20%, its digestibility is about 73% and decreases to 61% with a fiber content of 30-35% [6]. Similar data were obtained by A. D. Dmitrochenko and T. D. Pshenichny [3].

Van Soest at al. [7] proposed an analysis scheme that most clearly presents the nutritional characteristics of the feed. According to this scheme (Table 1), the feed is divided into cellular contents and cell walls, and the latter - by other constituent elements. When the feed is treated with a neutral detergent, the cell contents dissolve in this detergent. The remaining fibrous fraction, which contains cell walls, is neutral detergent fiber (NDF). Then, when the sediment undissolved in the neutral detergent is treated with an acid detergent, the hemicelluloses are dissolved. The resulting sediment is acid detergent fiber (ADF).

Table 1.

Fractions of plant carbohydrates and their characteristics

Fraction	Components
Cell contents – soluble in neutral detergent	Starch, sugar, lipids, organic acids, soluble protein, non-protein nitrogen, pectin
Cell wall components – insoluble in neutral detergent – NDF	Cellulose, hemicelluloses, lignin
Soluble in acid detergent	Hemicelluloses
Insoluble in acid detergent – ADF	Cellulose, lignin

The level of neutral detergent and acid detergent fiber (NDF and ADF) affects the palatability and digestibility of feed. Neutral detergent fiber plays an important role in regulating the amount of feed that an animal can consume. Each feed has its own degree of NDF break down in the rumen. Difficult to break down NDF remains in the rumen longer, which maintains a high level of rumen filling after feed intake, thus reducing overall feed intake with a simultaneous decrease in animal productivity. Based on this, the lower the NDF level (but not less than 28%), the higher the dry matter intake. The NDF indicator can be used to predict the dry matter intake of feed by ruminants. Easy broken down fiber quickly passes through the gastrointestinal tract, the amount of volatile fatty acids is reduced, the energy level decreases, and the feed does not have time to fully undergo microbial fermentation.

The aim of the research is to develop a system of complete carbohydrate nutrition for high productive cows taking into account the NDF and ADF.

To obtain data balance experiments were conducted in 2017-2022 on Holstein cows at different stages of the physiological cycle (I, II, III lactation phases, dry period) at the farm “Polar Star” in the Murmansk Region.

The diets of the experimental cows included: mixed grass hay, perennial grass silage, alfalfa haylage, sunflower cake, beet pulp, standard mixed fodder, a mixture of ground corn and barley, and a premix. Different levels of NDF and ADF in the rations were created by selecting feeds taking into account their digestibility.

All feeds were tested for a complete zootechnical analysis: dry matter, crude protein, sugar, Ca, P, crude fiber, neutral detergent fiber (NDF) and acid detergent fiber (ADF).

Monitoring of the clinical condition of animals was determined by taking blood for biochemical analysis, as well as by examining urine. In the blood were determined pH, sugar, acid capacity, total protein, calcium, phosphorus, carotene. In urine - pH, total nitrogen.

In milk were determined protein and fat.

Cellulolytic activity of forestomach microflora was determined using the method of Henderson, Horvath and Block as modified by Churlisa.

NDF and ADF were determined using the method of Van Soest and Southgate as modified by N.N. Semina.

The research results were processed using the method of variation statistics.

The study showed that during the first phase of lactation (1-100 days of lactation) and the second phase of lactation (100-201 days), animals with the recommended level of NDF and ADF (experimental group) had a higher microbiological activity in the rumen. The digestibility of dry matter and crude fiber increased significantly. There was also a tendency for other nutrients to increase in digestibility. Animals used feed nitrogen better. The average daily milk yield of cows in the experimental group in the first phase of lactation was 10.1% higher than in the control, and 7.0% higher in the second phase of lactation. Feed costs per 1 kg of 4% milk were lower in the experimental group (Table 2).

In cows in the period of the third phase of lactation (201-300 days), which were on the recommended diet, the digestibility of crude fiber was significantly higher. The cows' diet turned out to be more balanced, which made it possible to increase the overall level of energy nutrition of animals. Better utilization of the diet nutrients by the animals of the experimental group was reflected in both live weight gain and milk productivity. The diet with the recommended level of NDF and ADF contributed to a slower decline in cow productivity. The experimental group additionally received 0.5 kg per 1 head per day. The cost of 1 kg of 4% milk was 0.96 feed units in the experimental group, in the control - 1.0.

In the cows of the experimental group, the digestibility of dry matter, NDF, and crude fiber was higher during the dry period. The diet of the cows of the experimental group turned out to be more balanced. Enzymatic processes in the rumen were more intense. A higher content of protozoa and protein nitrogen was observed. The animals used feed nitrogen better. With the same amount of nitrogen consumed, the animals of the experimental group lost less of it with urine and feces, more was used for deposition in the body and fetal development.

The biochemical blood parameters of the studied animals were within the physiological norm.

As a result of the obtained data [8, 9] during research conducted in 2017-2022 in the chemical-analytical laboratory of the experimental station and “Polar Star” on Holstein cows with a productivity of 7.0-9.0 thousand kg of milk during the first, second, third phase of lactation and dry period, a system of complete carbohydrate nutrition for high productive Holstein cows was developed ensuring the maximum manifestation of the genetic potential of animal productivity during the periods of the physiological cycle in the conditions of the European North.

Table 2

Productivity of experimental cows

Indicators	Control group (farm ration)	Experimental group (recommended ration)
I phase of lactation		
Milk yield, kg	46,80 ± 0,78	49,70 ± 0,96*
% fat	3,37 ± 0,05	3,49 ± 0,04
4% milk	39,40 ± 0,75	43,40 ± 0,81**
Feed units per 1 kg 4% milk	0,73	0,67
II phase of lactation		
Milk yield, kg	36,80 ± 0,78	38,90 ± 0,96
% fat	3,59 ± 0,05	3,67 ± 0,04
4% milk	34,53 ± 0,41	36,97 ± 0,59*
Feed units per 1 kg 4% milk	0,71	0,66
III phase of lactation		
Milk yield, kg	12,30±0,31	12,71±0,29
% fat	3,57±0,06	3,63±0,05
4% milk	11,50±0,21	12,00±0,14
Feed units per 1 kg 4% milk	1,00	0,96

*- P < 0,05 **- P < 0,01

Based on the established cost of feed over the past three years in the "Polar Star", it was determined the economic efficiency of the carbohydrate nutrition system for high productive cows for its implementation in production.

Table 3 shows that the feed costs of the experimental group cows for the production of 1 kg of milk are less than in the control group for all lactation phases.

The average selling price of milk on the farm is 30 rubles (Table 4). Productivity per 1 forage cow in 2019 was 10 024 kg of milk. The farm produced 13 709.6 kg of milk per day. Annual milk production is 50 040 c.

Table 3

Cost of feed for production of 1 kg of milk

Lactation phase	Cost of feed per 1 kg of milk in the control group, rubles	Cost of feed per 1 kg of milk in the experimental group, rubles	Experiment ± control	Reduction in cost of feeding, %
I	13,22	12,74	– 0,48	3,6
II	12,54	12,11	– 0,43	3,6
III	14,21	12,59	– 1,62	11,5

Table 4

Economic efficiency from implementation of carbohydrate feeding system

Indicators	Production indicators at the "Polar Star"	Indicators with the condition of implementation of carbohydrate feeding system
Dairy herd, head	499	499
Average selling price of 1 kg of milk, RUB	30	30
Milk productivity per 1 forage cow, kg	10024	10714,7
Milk received per day, kg	13709,6	14686,9
Milk received per year, centners	50040	53466,4
Received from milk sales, RUB	150 120 000	160 399 200
Profit (per year) from implementation of carbohydrate feeding system, RUB		+ 10 279 200

With the introduction of the carbohydrate feeding system for cows, milk productivity per forage cow will increase by 7.13% and will amount to 10,714.7 kg. Annual milk production will reach 53,466.4 centners. Consequently, the farm will additionally receive 10,279,200 rubles of net profit.

The conducted studies have shown that the recommended diet for cows, depending on their physiological state, is optimal, providing better digestibility of nutrients, more efficient use of nitrogen, greater use of protein for deposition in the body and development of the fetus. This contributes to an increase in milk productivity of animals by 7.13% per year, a decrease in the cost of feeding animals by 3.6-11.5% and an additional 10,279,200 rubles of net profit.

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