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Original article

FEED ALLOWANCE FOR HOLSTEIN COWS DURING LACTATION AND DRY PERIODS (SAKHALIN ISLAND)

I.O. Rozhkova-Timina

The study presents the results of a survey of agricultural enterprises and peasant farms in the Sakhalin Oblast. The authors conducted the visual estimation of the feed consumption and cows' overall health, revealed the chemical analysis of primary zootechnical parameters of the feed, compared the results with the rates and previous data, and gave recommendations. Moreover, the authors assessed the fodder, feed allowance and compared it with the nutritional rates using the software "Feeding rations" developed by the "Plinor limited liability company". Furthermore, one can identify that the daily milk yield of Holstein cows doubled in the period 2001–2010, but the feed allowance of the Holstein cows during lactation and dry periods still did not meet nutritional requirements. The low nutritional value of green forage is caused by the small amount of legumes in the herbage. One should prepare winter forage earlier to improve the quality of ration (hay, haylage, silage). Mowing grasses ten days later than the optimal time leads to a protein decrease in forage by 30%–35%. It is crucial to balance the feed allowance with biological and mineral supplements, adding grain mixture or sunflower cake.

Keywords: *feed allowance; Holstein breed; dairy efficiency; lactating cow; dry period; Sakhalin*

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Научная статья

РАЦИОНЫ КОРОВ ГОЛШТИНСКОЙ ПОРОДЫ ВО ВРЕМЯ ЛАКТАЦИОННОГО И СУХОСТОЙНОГО ПЕРИОДОВ (О. САХАЛИН)

И.О. Рожкова-Тимина

В исследовании представлены результаты обследования сельскохозяйственных предприятий и крестьянских (фермерских) хозяйств Сахалинской области. Авторами проведена визуальная оценка потребления корма и общего состояния здоровья коров, был проведен химический анализ основных зоотехнических показателей кормов, сравнение полученных результатов с нормами и предыдущими данными, даны рекомендации. Кроме того, авторы оценили корма, кормовую норму и сравнили ее с нормами питания с помощью программы «Кормовые рационы», разработанной обществом с ограниченной ответственностью «Плинор». Кроме того, можно установить, что суточный удой коров голштинской породы за период 2001–2010 гг. удвоился, но рацион коров голштинской породы в лактационный и сухостойный периоды по-прежнему не соответствовал потребности в питании. Низкая питательность зеленых кормов обусловлена малым количеством бобовых в травостое. Для улучшения качества рационов следует раньше начинать заготавливать зимние корма (сенаж, силос). Скашивание травы на десять дней позже оптимального срока может привести к снижению содержания белка в кормах на 30–35%. Крайне важно сбалансировать норму корма биологическими и минеральными добавками, добавляя зерновую смесь или подсолнечный жмых.

Ключевые слова: *рационы кормления; голштинская порода; молочная продуктивность; лактирующие коровы; сухой период; Сахалин*

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Introduction

Since the beginning of the 20th century, one can observe fast world population growth. Today, the Earth's population has reached 8 billion people [19].

Thus, the food demand is also growing. One of the priority goals of all countries is food security. This aspect requires an increase in agricultural products such as meat, eggs, and dairy production [13].

One of the leading breeds of cattle on the island of Sakhalin (Russia) is the Holstein breed [2, 7, 14, 16, 27]. The peculiarity of this breed is its high milk production. Also, the Holstein breed is well adapted to industrial maintenance. In Russia, the Holstein cattle breed was first bred in the Sakhalin Oblast at the beginning of the 20th century. The reason was that the agricultural enterprises faced difficulties in importing dairy products from the mainland due to their short shelf life and began to make their production [7].

Due to the growing needs of the population, it became necessary to increase milk production [18]. In connection with this necessity, the goal of dairy production is to increase the productivity of dairy cows, which depends on the quality of the fodder [2, 10, 11, 25, 29, 32]. Lactating cows of Holstein breed are expected to give the maximum amount of high quality dairy products. It is logical that these cows need high quality feed both for lactation, and for the entire life processes. But for the expectation come true, the cow should be accurately prepared for the complicated and physiologically stressful period of milk formation [16]. A healthy animal receiving a nutritious diet has normal reproductive functions, high milk production and good product quality. For the optimization of feed allowances, one should take into account the energy, protein, fat, mineral composition and the content of trace elements, amino acids and vitamins [3, 9, 20, 21, 24, 28]. Feed restriction or nutrients deficiency instantly result in a negative energy balance, which causes a decrease of milk production [22].

At the finish of a lactation cycle high-producing dairy cows need a dry period, when milk production is ceased, to prepare the organism (the mammary gland and rumen) for the next lactation. Attention to detail in non-milking cow feed allowances has the same importance as during lactation period. Preparations for a successful lactation starts during, or even before, the preceding dry period. The proper balance of protein and energy must be filled up for the cow to rebuild any lost muscle and restore its fat reserves, as well as to reset the rumen to first a low intake and within a few weeks to a rapidly increasing intake [23, 26].

But the problem of having a balanced feed allowance and getting a good milk product is quite widespread all over the world [10, 11, 17, 21, 28].

The study aims to analyze and optimize feed allowance for Holstein cows in Sakhalin Oblast by taking into account the lactation and dry periods.

We solved the following tasks to achieve the goal:

1. Reveal the peculiarities of management and feeding the lactating and dry cows of the Holstein breed in agricultural enterprises and peasant farms in Sakhalin;
2. Analyze the cows' feed allowances and check their compliance with nutritional rates of Russian Federation;
3. Compare the feed allowances of different years;
4. Give recommendations for feeding and optimization of feed allowances.

The object of research is the fodder and feed allowance of lactating and non-milking Holstein cows.

Materials and methods

Study site. The area of the Sakhalin Oblast (Sakhalin Island and the Kuril Islands) is 87.1 thousand km^2, where Sakhalin occupies 76 thousand km^2. Most of the island (70%) is mountainous, and the rest is covered with river valleys. Sakhalin has a monsoon climate, which varies in different parts of the island. The average January temperature in the south is -6 °C, in the north -24 °C. In August, the average temperature ranges from + 20 °C (in the south) to + 15 °C (in the north). A characteristic feature of Sakhalin is high humidity, which leads to the impossibility of long-term fodder storage and seasonable provision [4]. In addition, only three types of Sakhalin soils from fifteen are suitable for use: meadow-soddy, brown forest and marsh soils. They have a thin humus horizon and high acidity, which hinders fertility [5]. The nutritional characteristics of plants depend on soils' composition and nutritional regime [31].

The course of work. From August 25 to September 1, 2020, the researchers of the Sakhalin Research Institute of Agriculture conducted an expeditionary survey of agricultural enterprises and peasant farms where they breed dairy cattle. In total, ten farms from different zones of the region were surveyed.

The researchers used the following methods:

- Visual: feed consumption, overall health and behavior of cows. At the same time, we received data of feed allowance and milk productivity;
- Chemical analysis: moisture, total nitrogen, protein, fat, fiber, ash, carbohydrates (sugars), macronutrients (Ca, K, P, Mg, S), carotene were determined in the agrochemical center "Sakhalinskiy;"
- Calculation: for processing the received information and compiling balanced feed allowances, we used the software "Feeding rations" developed by the Plinor limited liability company;
- Comparison: the results of the research were compared with previous results (the 2001; 2010).

Results

The peculiarities of management and feeding the cows in agricultural enterprises and peasant farms. According to Federal State Statistics Service [13], the number of cattle, including lactating and dry cows, gradually increased in Sakhalin Oblast (see Table 1). The average annual milk yield per cow in agricultural enterprises of Sakhalin (excluding small businesses) was 6300 kg on January 1, 2019.

Table 1.

Dynamics of the cattle number in agricultural enterprises of the Sakhalin Oblast in 2016–2020

Categories of agricultural enterprises	Years of observation				
	2016	2017	2018	2019	2020
Agricultural organizations Cattle	9141	10830	11792	13557	16306
cows	3804	4583	4932	5629	6858
Peasant (farming) households and individual entrepreneurs Cattle	3765	4187	5122	5669	6083
cows	1516	1716	2145	2317	2550
Farms of all categories					
Cattle	18183	20270	21678	23724	26725
cows	7505	8451	9072	9879	11299

When examining agricultural enterprises and peasant farms, we found cattle is maintained in a pasture-stall way. The annual milk yield is about 5500-6000 kg from a cow (18-20 kg/day during lactating period).

The Sakhalin grazing season begins in June; later, when the fodder grass begins to coarse and its food quality deteriorates, the cows are fed with green-cut fodder. Summer is the most favorable period for the use of pastures and green feed. During the summer, one should provide cattle with the necessary nutrients to obtain strong, viable offspring, restore reproductive function, and increase milk productivity. Thus, green-cut fodder has to have a high energy value: usually it contains protein (unchanged in comparison with canned fodder), energy components (monosaccharides, disaccharides, and polysaccharides), carotene, and other essential compounds [15].

But in the Sakhalin's climatic conditions, the pasture period has its peculiarities. The average June temperature in the south of Sakhalin is 12.1°C

above zero. With a northerly wind direction, sharp cold snaps are possible due to the brought ice masses. Therefore, the growth rate of the herbage changes significantly, and the change in the phase of the growing season is irregular. The nutritional value of herbaceous plants and their chemical composition can change. We determined the insufficient biological characteristics of the green feed produced mainly from annual grasses to satisfy the nutritional needs of Holstein cows. In this regard, it is necessary to monitor the structure of the feed allowance and change the number of dietary supplements.

At the end of summer, the cows eat only green feed. The herbage of pastures is heterogeneous and consists of perennial cereals and legumes. Bulk food consists mainly of cereal grasses (timothy grass, fescue grass, orchard grass, canary grass, Kentucky blue-grass) and leguminous herbs, such as clover varieties. The examples of such feed allowances are presented in the tables 2 and 3.

In August, there is a shortage of green feed. Natural pastures by this time are depleted: the grasses have already been eaten or used to prepare forage or lose their yield at the end of the ripening period. Therefore, in autumn, it is necessary to change feed. This aspect leads to significant changes in the digestion of the cow. Optimization of feed allowance during this period is based on a balance of dry matter and protein.

The end of summer is time to prepare winter fodder such as hay, haylage, and silage. During the hay production, the harvesting crews face some climatic features: due to humidity and possibly cold weather, it is challenging to keep up with the schedule for the receipt and drying of the green mass. The total nutritional value of harvested hay ranges from 0.49 to 0.51 fodder units per 1 kg with a high fiber level (more than 33% in 1 kg of dry matter). Therefore, the digestibility of organic matter in feed is below 65%. Also, the harvested hay has a low content of protein, available carbohydrates, major and trace elements, and vitamins.

The cows' feed allowance and its compliance with nutritional rates. In table 2 and 3 there are the examples of feed allowance for dry and lactating cows at the end of summer. The common nutrients and major elements are compared with rates.

From Table 2, we can note that the composition of some elements differs from rates. Crude fat and crude fiber exceed the rate, starch and sugar are in deficiency. Several zootechnical indexes and the content of macroelements and vitamins also do not meet the standards.

Table 2.

The summer ration of cows during dry period according to taking (per 1 head / 1 day; milk yield 5500-6000 kg/year)

Composition		
Combined fodder	kg	2
Grass-gramineous pasture	kg	33
Dicalcium phosphate	g	150
Salt	g	150
Common nutrition elements		
	Fact	Rate
Fodder unit, f.u.	11.09	11.58
Metabolic energy, MJ	124.64	134.28
Dry matter, kg	13.44	13.00
Crude protein, g	1,915.00	1,969.64
Soluble protein, g	1,303.50	-
Insoluble protein, g	247.50	-
Digested protein, g	1,220.52	1,274.24
Crude fat, g	539.00	410.00
Crude fiber, g	3,479.00	2,844.36
Neutral detergent fiber, g	6,567.00	-
Starch, g	642.30	1,377.60
Sugar, g	887.00	1,148.00
Nitrogen-free extractives, g	5,313.00	-
Major elements, g		
Na	75.45	28.31
Ca	103.50	114.60
P	70.50	67.00
Mg	20.00	22.92
K	155.10	82.00
S	27.20	27.20
Vitamins		
Carotene, mg	1,167.00	615.00
Vitamin D, тМЕ	5.53	12.74
Vitamin E, mg	1,920.00	462.84
Zootechnical indexes		
Dry matter per 100 kg of live weight, kg	2.30	2.20
Content of metabolic energy in the regime, MJ	124.64	134.28
Concentration of metabolic energy in 1 kg of dry matter, MJ	9.27	10.33
Concentration of fodder units in 1 kg of dry matter	0.83	0.89
Content of crude fiber in dry matter, %	26.00	22.00
Content of crude protein in dry matter, %	14.00	15.00
Sugar-protein ratio	0.73	0.90
Digestibility of dry matter of the diet, %	62.00	67.00

Table 3.

The summer ration of cows during lactating period

Composition		
Combined fodder for lactating cows	kg	6.00
Grass-gramineous pasture	kg	43.00
Dicalcium phosphate	g	150.00
Salt	g	150.00
Common nutrition elements		
	Fact	Rate
Fodder unit, f.u.	18.15	17.58
Metabolic energy, MJ	201.44	204.95
Dry matter, kg	20.50	16.90
Crude protein, g	3,113.00	2,500.75
Soluble protein, g	1,698.50	-
Insoluble protein, g	322,50	-
Digested protein, g	2,119.83	1,625.49
Crude fat, g	889.00	553.35
Crude fiber, g	4,781.00	3,713.15
Neutral detergent fiber, g	8,557.00	
Starch, g	1,529.30	2,144.02
Sugar, g	1,373.00	1,421.27
Nitrogen-free extractives, g	6,923.00	
Major elements, g		
Na	80.45	51.00
Ca	148.50	168.50
P	115.70	92.26
Mg	37.60	61.18
K	235.70	199.25
S	52.82	52.82
Vitamins		
Carotene, mg	1,541.00	1,109.63
Vitamin D, тМЕ	16.37	22.92
Vitamin E, mg	2,624.00	729.96
Zootechnical indexes		
Dry matter per 100 kg of live weight, kg	3.50	2.90
Content of metabolic energy in the regime, MJ	201.44	204.95
Concentration of metabolic energy in 1 kg of dry matter, MJ	9.83	12.13
Concentration of fodder units in 1 kg of dry matter	0.89	1.04
Content of crude fiber in dry matter, %	23.00	22.00
Content of crude protein in dry matter, %	15.00	15.00
Sugar-protein ratio	0.65	0.87
Digestibility of dry matter of the diet, %	66.00	67.00

In the feed allowances of lactating cows, there is an excess of crude protein, digestible protein, crude fat, crude fiber. The value of starch is below the standard. There is also a discrepancy in almost all macronutrients and vitamins. Such zootechnical indexes as dry matter per 100 kg of live weight and concentration of metabolic energy in 1 kg of dry matter also do not meet the standards.

Discussion

We compared the obtained results with the results of similar studies conducted by the scientists of the Sakhalin Research Institute of Agriculture in previous years [1, 6].

In the winter period, stable livestock management is used, which causes changes in the feed allowance. Tables 4 and 5 show a comparison of the winter rations of Sakhalin Holstein cows on a peasant farm in 2019-2020 and similar data for previous decades. The amount of fodder required to obtain a balanced diet is also given.

Table 4.

The winter ration of the cows during the dry period at the Sakhalin peasant farm

Fodder (per 1 head / 1 day), kg	2001 [1] (annual milk yield 3000 kg)	2020 (annual milk yield 5500–6000 kg)	Recommendations (annual milk yield 6000 kg)
Silage	19.0	25.0	7.0
Hay	2.66	2.0	3.0
Haylage	0.0	6.0	8.0
Root crop	2.0	0.00	1.0
Combined feed	1.3	2.5	2.0
Salt	0.06	0.00	-
Chalk	0.07	0.00	-
Premix	0.005	0.2	-
Protein and vitamin supplement	0.0	0.0	0.2
Grain mixture	0.0	0.0	2.0
Sunflower cake	0.0	0.0	1.0

Table 4 shows that to increase the annual milk yield by two times, one should increase the amount of silage and combined feed in the non-milking cows' ration. Thus, we added haylage and removed root crops. However, one should emphasize that the composition of the combined feed could have changed over almost 20 years. Silage, hay, and haylage are produced from the common Sakhalin fodder grasses (timothy, fescue, cocksfoot, canary grass, clover varieties).

Table 5.

The winter ration of the cows during lactation at the Sakhalin peasant farm

Fodder (per 1 head / 1 day), kg	2001 [1] (milk yield 10 kg/day)	2010 [6] (milk yield 18–20 kg/day)	2020 (milk yield 18.3 kg/day)	Recommendations (milk yield 20 kg/ day)
Silage	20.0	0.0	25.0	15.0
Hay	4.0	1.0	2.0	1.0
Haylage	0.0	18.0	6.0	14.0
Root crop*	5.0	8.0	17.0	6.0
Combined feed	3.0	6.0	6.8	5.0
Salt	0.08	0.1	0.0	0.06
Chalk	0.05	0.0	0.0	0.04
Premix	0.005	0.0	0.2	0.0
Protein and vitamin supplement	0.0	0.0	0.0	0.2

*Note**: Data on the types of root crops used in the diet for 2001 are not available. In other years and the recommendations, the line "root crops" includes potatoes and carrots in a ratio of 4:1.

Table 5 shows that in the period from 2001 to 2010, the work to increase the milk productivity of Holstein cows in the Sakhalin region was carried out. An almost twofold increase of daily milk yield was achieved by adding gramineous herbs to the haylage ration, increasing the amount of compound feed, and at the same time eliminating the silage. In 2020, with a similar milk yield, the ratio of the components of the feed allowance was different. When developing the recommended balanced feed allowance, we suggested the optimal amount of dietary components. At the same time, farms are recommended to use clover and timothy hay, haylage from mixed herbs, and silage from a gramineous mixture.

Tables 4 and 5 show that to increase milk yield, one should increase the quantity of used fodders and balance them. Indeed, for more effective feeding of cows, balanced feed allowances that contain the required amount of nutrients, major and trace elements, amino acids, and vitamins must be used [8, 25, 29, 32]. It is known that with a yield of 5000–7000 kg of milk per year, a lactating cow consumes 10056–15085 MJ of energy, 145–230 kg of protein, 150–300 kg of fat, 200–300 kg of glucose, up to 10 kg of calcium and 7 kg of phosphorus. The optimization of feed allowance considering energy and the number of nutrients has a positive impact on the energy, protein, carbohydrate, mineral metabolism, biochemical parameters of blood in cows' bodies, and their general physiological state. The balance of feed allowance will contribute to the nor-

malization of the ketone bodies and glucose level and the improvement of other biochemical blood parameters that characterize the state of carbohydrate-fat metabolism [6, 8]. Moreover, it is crucial to control the concentration of micronutrients in fodder [15]. The regulation of the number of dietary supplements also contributes to an increase in milk yield and milk quality of lactating cows.

The feed allowance should be developed due to the lactation phase. The nutrition of cows during the dry period largely determines the growth and development of the fetus, the immunity of the newborn calf, its resistance to diseases during the dairy period of life, and the subsequent growth and development of young animals. Consequently, a completely balanced feed allowance is essential for a high level of metabolism, which affects the productivity of non-milking cows, the fetus's formation and development [8, 22, 23].

When developing the recommendations, we took into account that for a high-quality balanced feed allowance, the hay should contain clover and timothy, silage should be from vetch and oat, and haylage should consist of a mixture of different forage grasses. One should also recommend adding a grain mixture, sunflower cake, and protein, vitamin and mineral supplements to cows' diet during the dry period. This aspect contributes to the normalization of the sugar-protein ratio, the content of major and trace elements, vitamins, and amino acids.

The recommendations on the optimal composition of pasture and hay meadows for Sakhalin cattle were developed many years ago. Additionally, we noted the best ratio of nutrients in plants for a mixture of clover, cocksfoot grasses, bromegrass, and gramineous herbs (cocksfoot grasses, timothy, fescue grass, bromegrass). When using the grass stand for hay, one can observe a favorable ratio of nutrients for alfalfa, cocksfoot grasses, and timothy grass mixture. Such pasture feeds fully met the cows' significant nutrient demands [30]. However, nowadays, work on the optimization of pastures and hayfields is not being carried out. Therefore, the herbage is heterogeneous and contains a large number of weeds, especially the tall buttercup. This aspect caused a decrease in the quality of the cows' feed allowances. To increase the milk productivity of cows and the quality of products, agricultural enterprises need to increase the proportion of legumes in the feed allowances.

Conclusion. As a result of a study of Sakhalin agricultural enterprises and peasant farms, we found that cows are on pasture in the summer. This aspect is vital for their consumption of green fodder. However, due to the lack of work for pastures improvement, the species composition of plants in forage meadows is constantly deteriorating. The low nutritional value of feed allowance is caused by the small number of legumes in the herbage. During the winter stable management, the low-quality hay used for feeding does not compensate for the lack of nutrients and elements.

The feed allowances in agricultural enterprises and peasant farms are based on voluminous feed, including combined fodder and green feed. The analysis showed that at the end of summer, they are well-balanced in terms of feed units and metabolic energy. However, feed allowances have an excess of dry matter, crude fibre content in dry matter, and crude fat compared to nutritional rates. This aspect contributes to a decrease in the coefficient of dry matter digestibility of the feed allowance and leads to the final overconsumption of feed.

When comparing contemporary situation with the data of previous years, we found that the daily milk yield of Holstein cows in the period from 2001 to 2010 doubled, nevertheless, the feed allowance of 2010 also did not meet the rates and recommendations.

The optimization of feed allowances with the adequate introduction of biological supplements into the cows' diet increases milk productivity. One should carry out a timely collection of winter fodder to improve the quality. Thus, mowing grasses ten days later the optimal time can lead to a decrease in protein in the forage by 30%–35%. One should also balance the amount of hay, haylage, silage and root crops in the feed allowance. The systematic improvement of pastures by adding the legumes is also recommended.

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DATA ABOUT THE AUTHOR

Inna O. Rozhkova-Timina, PhD in Biology, Senior Researcher of Animal Breeding group
Sakhalin Research Institute of Agriculture
22, Gorkogo Alley, Yuzhno-Sakhalinsk, 693022, Russian Federation
inna.timina@mail.ru
SPIN-code: 5129-0447
ORCID: https://orcid.org/0000-0002-8995-6062
ResearcherID: U-6033-2018
Scopus Author ID: 57202906791

ДАННЫЕ ОБ АВТОРАХ

Инна О. Рожкова-Тимина, к. б. н., старший научный сотрудник группы животноводства
Федеральное государственное бюджетное научное учреждение «Сахалинский научно-исследовательский институт сельского хозяйства»
пер. Горького 22, г. Южно-Сахалинск, 693022, Российская Федерация
inna.timina@mail.ru

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