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Effect of Diet on Metabolism and Productivity of Suksun Cows

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doi: [10.33472/AFJBS.6.6.2024.9215-9223](https://doi.org/10.33472/AFJBS.6.6.2024.9215-9223)**ABSTRACT:**

An unbalanced ration and negative energy balance result in metabolic disorders in the body of cows, lead to the development of a number of dysfunctions in organs and systems. The aim of the study was to investigate the influence of feeding on metabolism and productivity of Suksun breed cows in Suksunskoye, Perm Krai. Milk productivity, live weight control, and clinical examination of cows were performed using standardized methods. The fat and protein content in the daily sample was determined using the Lactan 1-4M analyzer, hematological parameters – using the VetScan HM5 analyzer, biochemical parameters – using the StatFax analyzer. Blood insulin levels were determined by immunochemiluminescence analysis. Dry cow diets were in accordance with animal feeding standards. Energy deficiency, mineral and vitamin imbalances have been observed in newly calved cows, resulting in a decrease in monthly milk yield from the third month of lactation. There was a decrease in milk fat content and the protein content was more stable. At the same time, eosinophilia was observed in dry cows with a decrease in the number of monocytes compared to reference values. There was an increase in serum glucose concentration, total bilirubin, creatinine with a decrease in total calcium and inorganic phosphorus levels compared to the statistical average. After calving, hematological parameters normalized, but glucose, total bilirubin, triglycerides, and inorganic phosphorus remained elevated. A decrease in insulin in the blood of newly calved cows was noted. As a result, unbalanced feeding of cows in the fresh period led to a decrease in milk productivity and live weight of animals, violation of lipid and mineral metabolism, and inhibition of functional activity of the insular apparatus of the pancreas.

Keywords: Cows, Suksun breed, feeding, metabolism, milk productivity.

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1. Introduction

A diet that is imbalanced in terms of nutrients and deficient in metabolic energy is a common cause of deep metabolic disorders in cows. These disorders can lead to the development of a range of dysfunctions in the animal's organs and systems. Considering such peculiarities, the maximum attention should be paid to the full provision of rations, their correction and control of energy balance. A targeted approach is the optimal method for ensuring a seamless transition and adaptation of the cow's organism after calving, while also serving as an effective means of preventing metabolic disorders and reproductive system pathologies (Zhelavskiy *et al.*, 2020; Agnew *et al.*, 2003; Drackley and Janovick Guretzky, 2007; Sycheva *et al.*, 2021).

This study aimed to investigate the effect of feeding on metabolism and productivity of Suksun cows.

2. Materials And Methods

Object of Research

The research was conducted at Suksunskoe husbandry farm located Perm region on Suksun breed cows (n=10) with a body weight of 500-550 kg and an average annual milk productivity of 5000 kg of milk with a fat content of 3.96% and a protein content of 3.00%. The study period included the dry period (2 months prior to calving) and the fresh period up to 120 days. The farm used a year-round stall barn system. The cows were fed on the basis of daily rations prepared according to detailed standards based on live weight and physiological condition.

Methods of Research

Milk productivity of cows was measured through individual milking 2 times a month. Fat and protein content in the daily sample was determined on the Lactan 1-4M analyzer at the Department of Zootechnology, Perm State Agro-Technological University. Live weight was controlled by measuring the circumference of the breasts behind the shoulder blades in the morning before feeding during the dry period 1-2 days before expected calving, on the first day after calving, and then monthly until 120 days.

Blood was collected from the tail vein of all animals in the morning before feeding using the vacuum method. Hematological studies were performed on a VetScan HM5 analyzer and biochemical parameters were performed on a StatFax analyzer. Blood insulin levels were determined using the immunochemiluminescent assay method. The obtained data were subjected to mathematical processing using Microsoft Office software.

3. Results

The dry period feeding for the cows was based on the fodder of their own production, comprising 34.1% stover, 41.5% succulent, and 24.4% concentrated nutrients. After calving, the amount of concentrates in the daily ration increased to 50.3%, the amount of stover decreased to 9.9%, and the amount of succulent feed decreased slightly to 39.8%. Cows were fed using mobile feeders twice a day: morning and evening according to daily rations (Table 1).

Table 1: Composition of daily rations for dry cows and newly calved cows

Feed, kg	Dry cows	Newly calved cows
Meadow hay	7.0	3.0

Cereal and legume silage	33.0	45.0
Concentrates	3.0	9.0
Premix	0.1	0.15
Salt	–	0.13

In the diet of newly calved dairy cows, concentrate feeding was tripled, which increased the concentration of metabolizable energy in the diet by 45.9% (Table 2).

Dry cows fed a daily ration consumed 2.3 kg of dry matter per 100 kg of live weight. The EFU content in 1 kg of dry matter was found to be 0.91, with a digestible protein content of 80 g, which corresponds to the standards of animal feeding during the dry period.

Table 2: Nutritional value of daily rations for dry cows and newly calved cows

Indicator	Dry cows	Newly calved cows
EFU	13.5	19.7
Metabolizable energy, MJ	135	197
Dry matter, kg	14.9	21.4
Crude protein, g	1973	3165
Digestible protein, g	1195	1704
Crude fiber, g	3240	4912
Starch, g	1197	3923
Sugars, g	618	987
Crude fat, g	403	732

The newly calved cows were provided with 3.9 kg of dry matter per 100 kg of live weight. In 1 kg of dry matter, the EFU content was 0.92, which is not sufficient for cows to produce milk after calving. The energy standard was 1.0-1.12 EFU. There was 86 g of digestible protein per 1 EFU, with the standard being 80-90 g. The percentage of crude fiber from dry matter was 23%, while the standard is 20-25%. The sugar-protein ratio was 0.6, which was out of the standard range.

Adding 100 g of premix to the daily ration of dry cows and 150 g of premix to the daily ration of calving cows compensated for the mineral and vitamin deficiencies (Table 3).

Table 3: Mineral and vitamin content of daily rations of dry cows and newly calved cows

Indicator	Dry cows	Newly calved cows
Salt, g	–	130
Calcium, g	118	130
Phosphorus, g	67	93
Magnesium, g	25	29
Potassium, g	86	129
Sulphur, g	24	39
Iron, mg	1860	2180
Copper, mg	133	197
Zinc, mg	332	1113
Cobalt, mg	7.3	11.7
Manganese, mg	674	1304
Iodine, mg	7.3	14.6
Carotene, mg	675	733
Vitamin D, KIU	1.5	1.6
Vitamin E, mg	490	751

The calcium-phosphorus ratio in the diets of dry cows was 1.8, that of newly calved cows was 1.4. A 1 kg sample of dry matter from an animal diet during the dry period contained: iron (124.8 mg), copper (8.9 mg), zinc (22.3 mg), cobalt (0.5 mg), manganese (45 mg), and iodine (0.5 mg). The following trace elements were present in slightly higher concentrations in 1 kg of dry matter of the diet of newly calved cows: iron (101.9 mg), copper (9.2 mg), zinc (52.0 mg), cobalt (0.5 mg), manganese (60.9 mg), and iodine (0.7 mg).

In order to achieve the genetic potential for dairy productivity at the onset of lactation, the cow must have an additional reserve of nutrients in its body. With the increase in daily milk yield during the lactation period, animals expend a portion of their own body nutrients for milk production (Butler, 2003; Chabaev *et al.*, 2018).

Data analysis showed that the level of milk productivity is not stable and decreases during the milking period (Table 4).

Table 4: Dynamics of cow productivity indicators, (M±m)

Indicator	Last completed lactation	Ongoing lactation			
		Month 1	Month 2	Month 3	Month 4
Milk yield, kg	5062±259	308.0±75.8	76.03±32.5	710.0±44.8	655.0±25.2
Highest daily milk yield, kg		25.8	24.6	25.3	21.1
Mass fraction of fat, %	3.96±0.03	4.08±0.02	4.03±0.018	4.03±0.038	3.99±0.04
Mass fraction of protein, %	3.00±0.017	3.04±0.01	3.04±0.012	3.03±0.01	3.03±0.018
Live weight, kg					
Before calving	After calving	Month 1	Month 2	Month 3	Month 4
573±4.9	528±6.3	519±6.3	510±6.6	503±6.9	507±7.0
± kg/%	-45/-7.8	-9/-1.7	-9/-1.7	-7/-1.4	+4/+0.8

A reduction in milk yield of 53 kg (7.0%) was observed in lactating cows at the beginning of lactation, starting from the third month, due to an energy deficiency in their diet. The rate of decline increases another 0.8% in the following month. The fat content decreased at a rate of 0.04 % during the analyzed period, while the protein level was more stable.

The change in live weight during lactation had a curvilinear character. In the first month, the decrease was 9 kg or 1.7%. A similar trend was observed in the second and third month of lactation. During the milking period, the mean live weight loss was no greater than 5%. A 0.8% increase in live weight was observed in cows by the fourth month of lactation, relative to the previous month.

The clinical condition of dry cows was evaluated, and it was found that 20% of the animals exhibited an average 15% increase in respiratory and heart rates compared to the expected physiological values. A moderate decrease in appetite, gastrointestinal tract organ dysfunction, decreased fatness, rumen hypotonia, and dull hair cover were also observed. No change in clinical status was observed in the other animals.

When analyzing hematological blood parameters of dry cows, it was found that the number of eosinophils increased on average by 2.2 times, and the number of monocytes decreased on average by 40% compared to reference values (Table 5).

Table 5: Hematological parameters of the blood of Suksun cows, (M±m)

Indicator	Dry cows	Newly calved cows	Reference values
RBC, × 10 ¹² /L	6.1±0.2	7.1±0.3	5.0–10.0
Hb, g/L	109.2±3.1	109.2±2.9	80.0–150.0

Hematocrit, %	32.4±1.1	41.9±1.1	24.0–46.0
MCV, fl	53.3±1.6	58.8±1.6	40.0–60.0
MCH, pg	17.9±0.4	15.4±0.4	11.0–17.0
MCHC, g/L	337.6±2.2	261.4±1.5	290.0–360.0
WBC, × 10 ⁹ /L	6.2±0.4	6.0±0.7	4.0–12.0
BA, %	0.0±0.0	0.4±0.1	0.0–2.0
EO, %	17.3±2.2	3.1±0.7	1.0–8.0
Neutrophils, %	45.2±3.3	47.8±3.4	15.0–45.0
MO, %	1.2±0.3	5.3±1.0	2.0–9.0
LY, %	36.2±0.9	43.3±0.6	45.0–75.0
PLT, × 10 ⁹ /L	157.4±10.3	241.7±5.4	100.0–800.0

At the same time, down-calving cows showed an average increase in serum glucose concentration by 26%, total bilirubin by 93%, and creatinine by 18%, with a simultaneous decrease in total calcium by 16.5% on average and inorganic phosphorus by 19% compared to the statistical average (Table 6). The data obtained indicated that intoxication had occurred in the animals due to alterations in the functioning of the liver and kidneys. Additionally, a disorder of mineral metabolism was also registered.

Table 6: Biochemical parameters of the blood serum of Suksun cows, (M±m)

Indicator	Dry cows	Newly calved cows	Reference values
Total protein, g/L	77.03±1.23	73.17±1.76	72.00–86.00
Albumin, g/L	37.86±0.98	33.41±0.89	29.00–38.00
Globulin, g/L	39.18±1.40	39.76±1.90	25.00–41.00
Glucose, mmol/L	4.19±0.09	4.73±0.07	2.22–3.33
ALT, U/L	19.11±0.80	20.89±0.35	1.30–60.00
AST, U/L	31.78±0.23	17.89±0.23	11.00–160.00
Total bilirubin, µmol/L	9.84±0.48	11.59±0.74	0.20–5.10
Urea, mmol/L	3.69±0.28	5.11±0.33	3.34–6.68
Creatinine, µmol/L	191.39±1.70	155.67±1.62	88.0–162.00
Triglycerides, mmol/L	0.19±0.02	0.74±0.17	0.20–0.60
Alkaline phosphatase, U/L	53.67±1.73	99.22±4.90	20.00–164.00
Total calcium, mmol/L	2.09±0.30	2.34±0.06	2.50–3.12
Inorganic phosphorus, mmol/L	1.18±0.03	2.33±0.04	1.45–1.94

After calving, there was a normalization of the clinical condition of the cows as well as hematological indicators due to a decrease in the number of eosinophils and an increase in the number of monocytes in the blood (Table 5). With regard to the biochemical data, the levels of glucose, total bilirubin, triglycerides, and inorganic phosphorus remained elevated (Table 6). Consequently, the mean concentration of glucose in the blood serum of cows increased by 42%, that of total bilirubin by 2.3 times, that of triglycerides by 23%, and that of inorganic phosphorus by 20% in comparison to the reference values. At the same time, serum total calcium levels decreased by an average of 7% compared to physiologic levels.

Given the elevated serum glucose content observed in the examined animals, we proceeded to determine the serum insulin levels of these cows. According to literature data (Shamberev *et al.*, 1986), the insulin concentration in the blood of cows producing 5000 kg of milk in the first month of lactation is 5.2±1.47 µIU/mL. In our studies, insulin levels were at 1.26±0.16 µIU/mL.

4. Discussion

The feeding of dry cows should ensure a high level of milk production after calving (Kulieva, 2023). However, we found an 8.5% energy deficit in the diet of newly calved cows, which is supported by literature data, as many researchers have found a similar pattern (Shirina *et al.*, 2022; Gamko *et al.*, 2023).

Physiological constants are particularly unstable in the dry period, after calving, and during the formation of lactation – in critical periods when the body is overburdened with metabolic and energetic processes, a whole cascade of hormonal surges, in which the body is in a borderline state on the verge (breakdown) of pathology (Allen and Bradford, 2009; Shahzad *et al.*, 2019).

It is known that following calving, cows undergo substantial alterations in homeostasis, which are attributable to physiological increasing milking capacity, fluctuations in metabolic intensity, and involitional processes within the uterus (Zhelavsky *et al.*, 2020; Allen and Bradford, 2009; Cardoso *et al.*, 2013). As a result, during the first phase of lactation, there is a negative energy balance, which the cow compensates by mobilizing body resources, resulting in live weight loss (Allen and Bradford, 2009; DeGaris *et al.*, 2010; Wu *et al.*, 2020), as confirmed by our research. Decrease in milk production in case of energy deficiency of the diet can be considered as one of the protective reactions of the organism.

The mobilization of the fat pool results in the formation of fatty acids and glycerol. When fatty acids are incompletely oxidized to ketones, feed intake is further suppressed, exacerbating the negative energy balance and increasing the mobilization of fat pool. The potential risk is that the body of a cow may accumulate significant quantities of fat, which the liver is unable to metabolize effectively. This can result in the infiltration of fat into the liver, accompanied by alterations in the biochemical profile of the blood (Euglevsky *et al.*, 2017; Doninotti, 2017).

At the same time, the data on the impact of negative energy balance on biochemical indices in cattle blood are inconclusive. Some authors have observed an increase in the level of total protein, albumin, and phosphorus in the serum of cows following calving, accompanied by a decrease in the concentration of glucose, triglycerides, and calcium when compared to the physiological standard (Slesareva and Omarov, 2017; Larina *et al.*, 2018). Other researchers have demonstrated a reduction in total protein, glucose, and carotene levels, accompanied by an increase in urea, total bilirubin, alkaline phosphatase, AST, and ALT concentrations when compared to the reference values (Poroshina *et al.*, 2011).

At the same time, during the dry period, the phosphorus-calcium balance becomes positive, and deposition of these elements in bone tissue occurs. Therefore, blood phosphorus content increases after calving and decreases during lactation. At the height of lactation, blood calcium content increases, then gradually decreases by the time of drying off, reaching a minimum after calving (Gromyko, 2005; Allen and Bradford, 2009; Cardoso *et al.*, 2013; DeGaris *et al.*, 2010; Wu *et al.*, 2020).

In our study, we observed altered liver function, disturbed lipid and mineral metabolism in newly calved animals. The obtained results indicated the restructuring of metabolic processes in the body after calving. Low insulin levels in the blood of cows in the first months of lactation are explained by some researchers by the suppression of the functional activity of the insular apparatus of the pancreas (Shamberev *et al.*, 1896).

Therefore, the unbalanced feeding of cows during the newly calved period, which was accompanied by a negative energy balance, resulted in a reduction in milk productivity and live weight of the animals, alterations in liver function, disruption of lipid and mineral metabolism, and inhibition of the functional activity of the pancreas.

5. Conclusion

When dry cows were fed according to animal feeding standards (meadow hay, cereal and legume silage, concentrates, premixes), a mineral and vitamin imbalance and energy deficiency were observed, which was accompanied by a decrease in monthly milk yield by 7%, a decrease in live weight and milk fat content. In addition, there was an increase in serum glucose concentration, total bilirubin, creatinine with a decrease in the level of total calcium and inorganic phosphorus compared to the average statistical parameters, indicating the occurrence of intoxication in animals. The normalization of hematological parameters after calving was observed against the background of increased glucose, total bilirubin, triglycerides and inorganic phosphorus levels, and decreased insulin levels.

Thus, the results demonstrate that an unbalanced diet during the neonatal period results in a reduction in milk production and live weight, as well as disturbances in lipid and mineral metabolism and an inhibition of the functional activity of the pancreas.

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