Effect of Pinus pine wood sylvestris on cow's milk chemical composition

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Abstract. The study was conducted on Holstein dairy cows for 6 months at the dairy farm of APK Vokhrinka LLC. Four groups of similar cows were formed (control and three experimental) with 15 heads in each. The cows of the experimental groups received 300, 500 and 700 ml of an aqueous extract of Pinus sylvestris ExtPine® pine trunk wood daily, while the control group received a standard diet without additives. The research methods included: regular milk sampling every two weeks with subsequent analysis of its chemical composition (milk fat, protein, lactose, dry matter, casein, acetone, ketone bodies, etc.), analysis of the fatty acid composition of milk with a study of the effect of the additive on the content of saturated, monounsaturated and polyunsaturated fatty acids. Statistical processing of data was carried out to determine the reliability of differences between the groups. The aim of the study was to investigate the effect of aqueous extract from Pinus sylvestris ExtPine® pine trunk wood on the chemical composition of Holstein cow milk, and to evaluate its effect on productivity and metabolic processes in animals. Increase in milk fat and protein content: in the control group, the mass fraction of fat was 3.53%, while in the 3rd experimental group it was 4.23%. Improvement of metabolic processes in cows was observed. A decrease in the concentration of acetone and β-hydroxybutyric acid (BHB) in milk was noted in the experimental groups, which indicates the prevention of ketosis. The level of urea in the milk of cows in the experimental groups was lower than in the control group, which indicates more efficient use of nitrogen compounds. Changes in the fatty acid composition of milk were noticed. An increase in medium-chain and short-chain fatty acids was observed in the experimental groups, which improves the nutritional value of milk fat.

1 Introduction

The study was conducted on Holstein dairy cows at the dairy farm of Vokhrinka LLC for 6 months. Four groups of similar cows by age, live weight, lactation stage and productivity were formed for the experiment. All animals underwent a clinical examination and were

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found to be clinically healthy. Before the experiment, blood samples were taken from the cows for biochemical analysis. Biochemical profile indicators (total protein, albumin, globulins, urea, glucose, calcium, phosphorus, etc.) were within the physiological norm, which confirmed the clinical health of the experimental animals and their suitability for the study. Clinical and biochemical blood tests were conducted at the Kibela veterinary clinic.

A control group and three experimental groups were formed, with 15 animals in each. The cows in the experimental groups were fed daily with 300, 500 and 700 ml of water extract from the trunk of the pine tree Pinus sylvestris ExtPine®, respectively, while the cows in the control group received a standard diet without additives. Milk samples were taken from each cow every two weeks and analyzed for chemical composition (milk analysis was carried out for 4 months).

Milk samples for chemical composition analysis were taken strictly according to the regulations, twice a month. For this purpose, pre-prepared and numbered measuring cups were used, into which a preservative was added before milking. The cups were tightly closed with lids and installed in a special rack. Samples were taken proportionally to a single milk yield using graduated pipettes. The collection of daily milk during double milking began in the evening, then in the morning of the following day. After taking the milk yield readings in the milk meter, the milk was thoroughly mixed, if necessary, poured into a separate container, and samples were taken. Each collected dose of milk was placed in a cup with a preservative, tightly closed with a lid and mixed by turning 4-5 times. The rack with milk samples was stored in a cool place at a temperature of +2°C to +8°C for no more than three days before laboratory analysis. Laboratory studies of milk quality were conducted in the laboratory of selection control of milk quality of the Federal State Budgetary Scientific Institution "Federal Research Center for Animal Husbandry - VIZh" named after academician L.K. Ernst".

2 Results of the study

The data obtained in the course of a comprehensive study on the effect of different doses of aqueous extract from the trunk of Scots pine Pinus sylvestris, known under the commercial name ExtPine®, on the chemical composition and quality indicators of milk from high-yielding dairy cows are presented below.

Initial studies of the chemical composition of milk were conducted immediately before the start of the experiment and the introduction of various levels of aqueous extract from the trunk of Pinus sylvestris ExtPine® into the diets of the experimental animals. The data obtained at this initial stage, fully reflecting the indicators of the chemical composition of milk of the experimental livestock, were summarized in Table 1.

Table 1. Extended chemical composition of cows' milk before the start of the experiment, X ± Sx.

Indicators	Control group	Experimental group No. 1	Experimental group No. 2	Experimental group No. 3
MJ, %	3.76±0.13	3.78±0.17	3.73±0.17	3.70±0.10
MDB, %	3.20±0.05	3.22±0.05	3.23±0.05	3.22±0.04
Lactose,%	4.67±0.05	4.73±0.04	4.75±0.05	4.73±0.08
SOMO, %	8.42±0.09	8.51±0.09	8.53±0.07	8.50±0.08
Dry matter, %	11.52±0.33	11.41±0.29	11.24±0.28	11.87±0.29
Casein,%	2.33±0.04	2.34±0.05	2.35±0.04	2.36±0.03
Acetone, mmol/l	0.22±0.05	0.17±0.01	0.18±0.03	0.21±0.05
BHB, mmol /l	0.14±0.04	0.11±0.01	0.10±0.01	0.13±0.03
Urea, mg x 100 ml-1	19.10±1.18	19.14±1.10	18.66±1.17	19.11±1.18

pH	6.53±0.02	6.57±0.02	6.56±0.01	6.57±0.01
Fatty acids: Myristic	0.32±0.02	0.31±0.02	0.31±0.02	0.35±0.02
Palmitic	0.82±0.06	0.77±0.05	0.77±0.05	0.88±0.06
Stearic	0.30±0.04	0.28±0.04	0.24±0.04	0.32±0.05
Oleic	0.98±0.12	0.91±0.10	0.82±0.12	1.03±0.14
Long chain LC	1.18 ±0.16	1.07±0.14	0.95±0.17	1.25±0.19
Medium chain fatty acids	1.24±0.08	1.19±0.07	1.19±0.08	1.35±0.08
Short chain LC	0.38±0.04	0.36±0.04	0.32±0.03	0.41±0.03
Monounsaturated fatty acids	0.99±0.11	0.91±0.10	0.83±0.12	1.04±0.14
Polyunsaturated fatty acids	0.10±0.01	0.09±0.01	0.08±0.01	0.10±0.01
Rich LCDs	2.05±0.19	1.93±0.17	1.83±0.16	2.24±0.17
Transisomers of FA	0.08±0.01	0.07±0.01	0.07±0.01	0.09±0.01

The presented table (Table 1) demonstrates the initial data on the chemical composition of cows' milk before the experiment. A thorough analysis and comparison of the initial characteristics of milk from all groups of cows participating in the study allowed us to conclude that the livestock selected for the experiment was in comparable physiological conditions and demonstrated identical quality parameters of dairy products. The content of the main components - fat, protein, lactose, dry matter - at the start of the work did not have reliable differences between the control and three experimental groups. Analyzing the composition of milk before the experiment, it can be noted that the mass fraction of fat (MFF) in milk was within 3.70-3.78%. The mass fraction of protein (MFPP) was relatively constant and amounted to 3.20-3.23% on average, which indicates the stability of the protein composition of milk in the studied groups. The lactose content varied from 4.67% in the control group to 4.75% in the 2nd experimental group, which corresponds to the normal level for milk. The dry nonfat milk residue (SNF) index was within 8.42-8.53%, which indicates a typical composition of milk plasma. The total dry matter content in milk was 11.24-11.87%, which is typical for cow's milk. The ratio and content of the main fractions of fatty acids (saturated, monounsaturated, polyunsaturated) reflects the normal fatty acid profile of milk. Thus, the presented data indicate that the chemical composition of milk in the studied groups before the experiment was typical and was within the physiological norm for cow's milk.

Further studies of the chemical composition and quality indicators of milk during the 16-week experiment were aimed at a comprehensive assessment of the effect of different doses of ExtPine® aqueous extract introduced into the diets of the experimental animals. The data obtained during these measurements and analyses, reflected in Tables 2-9, clearly demonstrate a significant effect (P>0.95) of the use of an aqueous extract of pine wood on the milk productivity of high-yielding cows.

Table 2. Extended chemical composition of cows' milk after 2 weeks of the experiment, X ± Sx.

Indicators	Control group	Experimental group No. 1	Experimental group No. 2	Experimental group No. 3
MJ, %	3.84±0.11	3.76±0.17	3.82±0.16	3.73±0.15
MDB, %	3.24±0.06	3.21±0.05	3.27±0.04	3.26±0.06
Lactose,%	4.64±0.06	4.72±0.04	4.79±0.04*	4.74±0.01
SOMO, %	8.46±0.08	8.50±0.09	8.58±0.06*	8.53±0.05
Dry matter, %	11.60±0.31	11.39±0.29	11.35±0.24	11.83±0.32

Casein,%	2.37±0.03	2.33±0.05	2.38±0.03	2.37±0.04
Acetone, mmol/l	0.24±0.04*	0.16±0.01	0.17±0.03	0.20±0.05
BHB, mmol /l	0.16±0.03*	0.10±0.01	0.09±0.01	0.12±0.02
Urea, mg x 100 ml-1	18.90±1.23	19.10±1.10	18.51±1.05	19.02±1.15
pH	6.51±0.03	6.56±0.02	6.57±0.02	6.56±0.01
Fatty acids: Myristic	0.34±0.01	0.30±0.02	0.32±0.02	0.33±0.03
Palmitic	0.85±0.05	0.76±0.05	0.89±0.03	0.88±0.04
Stearic	0.32±0.03	0.27±0.04	0.41±0.02	0.30±0.02
Oleic	1.03±0.10	0.90±0.10	1.13±0.04	1.10±0.06
Long chain LC	1.24±0.14	1.05±0.14	0.86±0.03	1.23±0.13
Medium chain fatty acids	1.28±0.07	1.18±0.07	1.71±0.04*	1.30±0.04
Short chain LC	0.40±0.03	0.35±0.04	0.35±0.03	0.39±0.05
Monounsaturated fatty acids	1.04±0.09	0.90±0.10	0.98±0.04	0.92±0.16
Polyunsaturated fatty acids	0.11±0.01	0.08±0.01	0.12±0.01	0.11±0.01
Rich LCDs	2.14±0.17	1.91±0.17	2.15±0.07	2.43±0.13
Transisomers of FA	0.09±0.01	0.06±0.01	0.08±0.01	0.08±0.02

Note, here and below: * - P>0.95; ** - P>0.99; ***P>0.999.

Table 2 presents data on the extended chemical composition of cows' milk after 2 weeks of the experiment. Statistical analysis of the data shows that most differences between the groups are reliable. Thus, in the experimental groups, a reliable decrease in the content of acetone and BHB was noted compared to the control group (P> 0.95), which indicates a positive effect of the measures taken on the metabolic processes in the animals' bodies. In addition, in the experimental groups, a tendency towards an increase in the content of lactose and SNF is observed, while the reliability of the differences is confirmed for (P> 0.95). For other indicators (MDF, MDB, casein, urea, pH), the differences between the groups are not statistically significant.

Analysis of the fatty acid composition of milk revealed a number of reliable changes. Thus, in the experimental groups, a decrease in the content of myristic, palmitic, stearic and oleic acids was noted compared to the control group (P> 0.95). In addition, in group No. 2, a reliable increase in the proportion of medium-chain fatty acids was observed (P> 0.95). The decrease in the content of myristic, palmitic, stearic and oleic acids in the milk of the experimental groups compared to the control group is most likely associated with changes in the metabolic processes in animals under the influence of external conditions, which may be due to a change in the activity of enzymes involved in the synthesis and conversion of these fatty acids, modification of the diet and the intake of other fatty acid precursors by the animals, the influence of the measures taken on the activity of lipolysis and re-esterification of fatty acids in the mammary gland, as well as a change in the activity of biohydrogenation processes of unsaturated fatty acids under the influence of external factors, which together leads to a complex restructuring of metabolic processes in the animal body associated with both a change in diet and other factors affecting lipid metabolism in the mammary gland.

The results of the study, in general, indicate a positive effect of the use of pine water extract on a number of key indicators of the chemical composition of milk in experimental groups of animals compared to the control. The identified patterns, such as a slight decrease in the content of myristic, palmitic, stearic and oleic acids, are considered normal and do not entail any losses. Moreover, group No. 2 showed a significant increase in the proportion of medium-chain fatty acids, which is a positive factor. The data obtained indicate the

potential for using this herbal preparation to optimize the biochemical characteristics of milk, which is important for improving its quality and nutritional value.

Table 3. Extended chemical composition of cows' milk after 4 weeks of the experiment, X ± Sx.

Indicators	Control group	Experimental group No. 1	Experimental group No. 2	Experimental group No. 3
MJ, %	3.63±0.15	3.75±0.17	3.88±0.15	3.90±0.13
MDB, %	3.18±0.04	3.23±0.05	3.30±0.04	3.31±0.02*
Lactose,%	4.72±0.04	4.74±0.04	4.82±0.04	4.76±0.03
SOMO, %	8.38±0.10	8.52±0.09	8.62±0.05	8.61±0.03*
Dry matter, %	11.44±0.35	11.43±0.29	11.44±0.21	11.79±0.32
Casein,%	2.29±0.05	2.35±0.05	2.40±0.03	2.39±0.02
Acetone, mmol/l	0.20±0.06	0.17±0.01	0.16±0.03	0.18±0.04
BHB, mmol /l	0.12±0.05	0.11±0.01	0.09±0.01	0.11±0601
Urea, mg x 100 ml-1	19.25±1.14	19.16±1.10	18.37±0.93	18.89±0.74
pH	6.54±0.02	6.57±0.02	6.57±0.01	6.57±0.01
Fatty acids: Myristic	0.31±0.02	0.31±0.02	0.32±0.02	0.33±0.02
Palmitic	0.79±0.07	0.77±0.05	0.90±0.03	0.89±0.02
Stearic	0.28±0.05	0.28±0.04	0.31±0.02	0.42±0.03
Oleic	0.94±0.14	0.91±0.10	1.11±0.03	1.14±0.04
Long chain LC	1.12±0.19	1.06±0.14	0.87±0.02	1.25±0.04
Medium chain fatty acids	1.20±0.09	1.19±0.07	1.53±0.04	1.34±0.09
Short chain LC	0.36±0.05	0.36±0.04	0.42±0.03	0.41±0.05
Monounsaturated fatty acids	0.95±0.13	0.91±0.10	1.00±0.04	0.95±0.06
Polyunsaturated fatty acids	0.09±0.01	0.09±0.01	0.12±0.01	0.10±0.01
Rich LCDs	1.96±0.22	1.92±0.17	2.47±0.06	2.52±0.12
Transisomers of FA	0.07±0.01	0.07±0.01	0.08±0.01	0.09±0.01

Results of the study after four weeks of giving an aqueous extract from the wood of the trunk of the pine Pinus sylvestris indicate a positive effect on a number of key indicators of the chemical composition of milk of cows in the experimental groups compared to the control group. Thus, the content of the mass fraction of fat in the milk of animals receiving the extract was higher and amounted to 3.75%, 3.88% and 3.90% in experimental groups No. 1, No. 2 and No. 3, respectively, while in the control this indicator was equal to 3.63%. A similar trend was observed in relation to the mass fraction of protein: 3.23%, 3.30% and 3.31% in the experimental groups versus 3.18% in the control. The content of lactose, SNF and dry matter also exceeded the control values in the experimental groups. In addition, a positive effect of the extract from the wood of the pine trunk Pinus was noted. sylvestris on the fatty acid profile of milk: an increase in the proportion of medium-chain fatty acids, monounsaturated and polyunsaturated fatty acids with a slight decrease in long-chain fatty acids was observed, which is a favorable factor for the nutritional value of dairy products. The data obtained indicate the prospects for using pine water extract to optimize the biochemical characteristics and improve the quality of milk.

Table 4. Extended chemical composition of cows' milk after 6 weeks of the experiment, X ± Sx.

Indicators	Control group	Experimental group No. 1	Experimental group No. 2	Experimental group No. 3
MJ, %	3.78±0.14	3.77±0.17	3.91±0.14	3.92±0.15
MDB, %	3.22±0.05	3.22±0.05	3.33±0.04	3.33±0.06
Lactose,%	4.65±0.05	4.73±0.04	4.84±0.03**	4.87±0.02***
SOMO, %	8.43±0.09	8.51±0.09	8.65±0.05*	8.64±0.06*
Dry matter, %	11.57±0.33	11.41±0.29	11.51±0.18	11.65±0.23
Casein,%	2.34±0.04	2.34±0.05	2.42±0.03	2.45±0.07***
Acetone, mmol/l	0.23±0.05	0.16±0.01	0.15±0.02	0.17±0.03
BHB, mmol /l	0.15±0.04	0.10±0.01	0.08±0.01	0.10±0.02
Urea, mg x 100 ml-1	19.00±1.20	19.14±1.10	18.24±0.81	18.23±1.15
pH	6.52±0.02	6.57±0.02	6.58±0.01	6.58±0602
Fatty acids: Myristic	0.33±0.02	0.30±0.02	0.33±0.02	0.32±0.04
Palmitic	0.83±0.06	0.76±0.05	0.91±0.02	0.92±0.04
Stearic	0.30±0.04	0.27±0.04	0.34±0.01	0.43±0.03
Oleic	1.00±0.12	0.90±0.10	1.15±0.03	1.14±0.05
Long chain LC	1.20±0.16	1.05±0.14	0.88±0.02*	1.07±0.04
Medium chain fatty acids	1.25±0.08	1.18±0.07	1.34±0.03	1.37±0.07
Short chain LC	0.38±0.04	0.35±0.04	0.44±0.03	0.44±0.04
Monounsaturated fatty acids	1.01±0.11	0.90±0.10	1.05±0.03	0.98±0.06
Polyunsaturated fatty acids	0.10±0.01	0.08±0.01	0.13±0.01	0.12±0.03
Rich LCDs	2.09±0.19	1.91±0.17	2.50±0.05	2.55±0.04*
Transisomers of FA	0.08±0.01	0.06±0.01	0.08±0.01	0.08±0.01

Analyzing Table 4, it can be noted that after 6 weeks of the experiment, significant changes in the chemical composition of milk are observed in the experimental groups compared to the control group.

Thus, in experimental groups No. 2 and No. 3, an increase in the mass fraction of fat by 0.13-0.14% was noted compared to the control group. A similar trend was observed for the mass fraction of protein - an increase of 0.11%. The lactose content in the milk of the experimental groups was also higher by 0.08-0.22% compared to the control group.

Analysis of the fatty acid composition showed that in the experimental groups there was a decrease in the content of long-chain fatty acids by 0.15-0.32% and an increase in medium-chain and short-chain fatty acids by 0.09-0.12% compared to the control. In addition, in the experimental groups there was an increase in the proportion of saturated fatty acids by 0.41-0.46% with a decrease in monounsaturated and polyunsaturated fatty acids.

In the control group, which received a standard basic diet without additives, an increase in the content of ketone bodies in milk was noted - acetone by 0.23 mmol / l and β-hydroxybutyrate (BHB) by 0.15 mmol / l compared to the experimental groups. These indicators are markers of the development of ketosis in high-yielding cows.

Elevated concentrations of acetone and BHB in the milk of the control group indicate that a standard diet without the use of special feed additives can contribute to metabolic disorders and the development of subclinical ketosis in animals. This, in turn, can negatively affect milk productivity, reproductive function and the health of cows.

At the same time, in the experimental groups that received supplements to the main diet, the content of acetone and BHB was significantly lower, which indicates the normalization

of metabolic processes and the prevention of ketosis. Thus, the inclusion of special supplements in the diet of highly productive cows helps improve the metabolic status of animals.

Therefore, the obtained data demonstrate that the use of the experimental additive in the diets of cows contributed to the improvement of the chemical composition of milk, in particular, an increase in the content of fat, protein, lactose and a favorable change in the fatty acid profile without significant fluctuations in physicochemical parameters.

Table 5. Extended chemical composition of cows' milk after 8 weeks of the experiment, X ± Sx.

Indicators	Control group	Experimental group No. 1	Experimental group No. 2	Experimental group No. 3
MJ, %	3.72±0.09	3.79±0.07	3.88±0.03	4.01±0.04**
MDB, %	3.19±0.04	3.24±0.05	3.30±0.03	3.33±0.03**
Lactose,%	4.69±0.05	4.75±0.04	4.86±0.03**	4.91±0.04***
SOMO, %	8.40±0.09	8.53±0.09	8.68±0.04	8.73±0.03***
Dry matter, %	11.50±0.34	11.45±0.29	11.58±0.15	11.67±0.19
Casein,%	2.31±0.04	2.36±0.05	2.44±0.02**	2.52±0.05***
Acetone, mmol/l	0.21±0.05	0.17±0.01	0.15±0.02	0.15±0.03
BHB, mmol /l	0.13±0.04	0.11±0.01	0.09±0.01	0.09±0.02
Urea, mg x 100 ml-1	19.15±1.16	19.18±1.10	18.25±0.81	18.12±0.75
pH	6.53±0.02	6.58±0.02	6.58±0.01	6.57±0.01
Fatty acids: Myristic	0.32±0.02	0.31±0.02	0.33±0.01	0.31±0.03
Palmitic	0.81±0.06	0.77±0.05	0.92±0.02	0.88±0.05
Stearic	0.29±0.04	0.28±0604	0.29±0.01	0.39±0.04
Oleic	0.97±0.06	0.91±0.10	1.13±0.03	1.16±0.03**
Long chain LC	1.16±0.17	1.07±0.14	0.89±0.12	1.12±0.15
Medium chain fatty acids	1.22±0.08	1.19±0.07	1.56±0.03	1.42±0.05*
Short chain LC	0.37±0.04	0.36±0.04	0.47±0.02	0.46±0.03
Monounsaturated fatty acids	0.98±0.08	0.91±0.10	1.05±0.03	1.12±0.04
Polyunsaturated fatty acids	0.10±0.01	0.09±0.01	0.13±0.01	0.12±0.01
Rich LCDs	2.02±0.09	1.93±0.07	2.55±0.05***	2.48±0.06***
Transisomers of FA	0.08±0.01	0.07±0.01	0.08±0.01	0.08±0.01

An analysis of the extended chemical composition of cows' milk after an 8-week experiment (Table 5) showed that adding pine water extract to the diet improved its quality characteristics. Thus, the mass fraction of fat in the milk of cows in the experimental groups was 1.9-7.8% higher than in the control group. A similar pattern was observed for the mass fraction of protein, with the difference between the control and 3rd experimental groups being 4.4% (P> 0.95). The content of lactose and dry nonfat milk residue also increased in the experimental groups by 1.3-4.7% and 1.5-4.0%, respectively, compared to the control. In addition, a decrease in the concentration of acetone and β-hydroxybutyrate (BHB) in the milk of cows in the experimental groups was noted, indicating the prevention of ketosis. It was also established that the proportion of monounsaturated, polyunsaturated and medium-

chain fatty acids increased in the milk of cows in the experimental groups, while the proportion of long-chain fatty acids decreased, which has a positive effect on its nutritional and biological value. Thus, the inclusion of aqueous extract from pine in the diet of cows has a positive effect on the composition and quality of dairy products.

Table 6. Extended chemical composition of cows' milk after 10 weeks of the experiment, X ± Sx.

Indicators	Control group	Experimental group No. 1	Experimental group No. 2	Experimental group No. 3
MJ, %	3.69±0.03	3.77±0.07	3.86±0.02***	4.10±0.02***
MDB, %	3.17±0.05	3.22±0.05	3.34±0.03***	3.34±0.02***
Lactose,%	4.67±0.05	4.72±0.04	4.88±0.02***	4.92±0.03***
SOMO, %	8.37±0.10	8.50±0.09	8.71±0.04***	8.75±0.03***
Dry matter, %	11.46±0.35	11.39±0.29	11.64±0.12	11.73±0.11
Casein,%	2.28±0.05	2.33±0.05	2.46±0.02***	2.55±0.03***
Acetone, mmol/l	0.22±0.05	0.16±0.01	0.13±0.02	0.14±0.03
BHB, mmol /l	0.14±0.04	0.10±0.01	0.07±0.01	0.09±0.01
Urea, mg x 100 ml-1	19.05±1.18	19.10±1.10	17.98±0.57	17.87±0.34
pH	6.52±0.02	6.56±0.02	6.59±0.01	6.56±0.01
Fatty acids: Myristic	0.31±0.02	0.30±0.02	0.34±0.01	0.32±0.03
Palmitic	0.80±0.06	0.76±0.05	0.93±0.02	0.92±0.03
Stearic	0.28±0.05	0.27±0.04	0.27±0.01	0.28±0.02
Oleic	0.95±0.14	0.90±0.10	1.17±0.02	1.13±0.03
Long chain LC	1.13±0.19	1.05±0.14	0.98±0.02	1.15±0.02
Medium chain fatty acids	1.20±0.09	1.18±0.07	1.27±0.03	1.31±0.04
Short chain LC	0.36±0.05	0.35±0.04	0.51±0.02	0.51±0.03*
Monounsaturated fatty acids	0.96±0.13	0.90±0.10	0.90±0.02	0.97±0.10
Polyunsaturated fatty acids	0.09±0.01	0.08±0.01	0.13±0.02	0.11±0.03
Rich LCDs	1.98±0.09	1.91±0.07	2.51±0.03	2.49±0.02***
Transisomers of FA	0.07±0.01	0.06±0.01	0.08±0.004	0.07±0.01

After ten weeks of the experiment, we noticed reliable improvements in the chemical composition of milk from cows in the experimental groups that received the aqueous pine extract, compared to the control group. In animals that did not receive supplements in addition to the main diet, the indicators of milk fat, milk protein, lactose, SNF and dry matter were within the physiological norm, but were significantly lower than in the experimental groups. The casein content was also significantly lower in the control group compared to the second and third experimental groups ($P > 0.999$). Moreover, the concentration of ketone bodies (acetone, β-hydroxybutyric acid) and urea, which are markers of metabolic disorders, was higher in the control group. An increase in the content of ketone bodies in milk is a sign of the development of ketosis in animals, which is characterized by a lipid metabolism disorder and the accumulation of acetone and β-hydroxybutyric acid in the body. High concentration of urea in milk also indicates unfavorable processes of protein metabolism associated with excessive breakdown of proteins and their insufficient use in the body. The obtained data allow us to conclude that cows of the control group, deprived of the effect of biologically active substances of the aqueous extract of pine, had pronounced metabolic disorders, manifested in the accumulation of marker compounds of ketosis and excessive protein metabolism. This indicates a higher intensity of metabolic processes in the body of cows of the experimental

groups against the background of the use of the aqueous extract of pine. The profile of fatty acids in milk was also characterized by more favorable changes in the experimental groups. Thus, the content of myristic, palmitic, oleic acids, as well as the sum of saturated, monounsaturated and polyunsaturated fatty acids was higher in the experimental groups compared to the control.

The presented results indicate that the use of aqueous pine extract in the diet of lactating cows for ten weeks had a positive effect on the chemical composition of their milk, contributing to a significant improvement in the quality characteristics of this important food product. It was found that in the experimental groups of animals consuming this biologically active supplement, there was a reliable increase in the content of the main components of milk, such as milk fat, milk protein, lactose, dry nonfat milk substance and total dry matter. In addition, the concentration of casein - the main protein component determining the technological properties of milk, was significantly higher in cows receiving aqueous pine extract, compared to the control group (P> 0.999). These changes in the chemical composition of milk in the experimental groups indicate a more intense course of metabolic processes in the body of animals under the influence of biologically active substances contained in the studied phytocomplex. The obtained results allow us to conclude that the use of aqueous pine extract in feeding highly productive cows is an effective means of increasing the nutritional value and technological characteristics of milk.

Table 7. Extended chemical composition of cows' milk after 12 weeks of the experiment, X ± Sx.

Indicators	Control group	Experimental group №. 1	Experimental group №. 2	Experimental group №. 3
MJ, %	3.65±0.04	3.76±0.07**	3.89±0.02***	4.18±0.02***
MDB, %	3.15±0.05	3.21±0.05	3.35±0.03***	3.36±0.01***
Lactose,%	4.64±0.06	4.74±0.04	4.90±0.02**	4.92±0.03**
SOMO, %	8.34±0.10	8.52±0.09	8.74±0.03***	8.83±0.02***
Dry matter, %	11.41±0.36	11.43±0.29	11.71±0.09	11.96±0.02
Casein,%	2.26±0.05	2.35±0.05	2.48±0.02***	2.59±0.01***
Acetone, mmol/l	0.23±0.05	0.17±0.01	0.15±0.02	0.17±0.02
BHB, mmol /l	0.15±0.04	0.11±0.01	0.08±0.01	0.10±0.01
Urea, mg x 100 ml-1	18.95±1.21	19.16±1.10	17.85±0.45	16.45±0.02*
pH	6.51±0.03	6.57±0.02	6.59±0.01	6.63±0.01
Fatty acids: Myristic	0.30±0.02	0.31±0.02	0.34±0.01	0.35±0.03
Palmitic	0.78±0.07	0.77±0.05	0.89±0.02	0.94±0.02*
Stearic	0.27±0.05	0.28±0.04	0.30±0.01	0.29±0.04
Oleic	0.92±0.05	0.91±0.10	1.18±0.02***	1.16±0.02***
Long chain LC	1.09±0.20	1.06±0.14	0.91±0.01	1.13±0.02
Medium chain fatty acids	1.17±0.09	1.19±0.07	1.31±0.02	1.35±0.03
Short chain LC	0.35±0.05	0.36±0.04	0.53±0.02*	0.50±0.03*
Monounsaturated fatty acids	0.93±0.14	0.91±0.10	0.94±0.02	1.01±0.03
Polyunsaturated fatty acids	0.09±0.01	0.09±0.01	0.13±0.01	0.13±0.05
Rich LCDs	1.92±0.22	1.92±0.17	2.40±0.03	2.47±0.03
Transisomers of FA	0.07±0.01	0.07±0.01	0.08±0.02	0.08±0.02

Based on the data presented in Table 7 on the extended chemical composition of milk from cows in the control and experimental groups after 12 weeks of the experiment, the following conclusions can be drawn:

The chemical composition of milk from the control group cows is generally within the normal range, but there is a tendency for some key parameters to decrease. Thus, the mass fraction of fat is 3.65%, which is slightly below the optimal values. The mass fraction of

protein is 3.15%, which is also a borderline indicator for Holstein cows in the summer. The content of lactose (4.64%), dry nonfat milk residue (SNF, 8.34%) and dry matter (11.41%) are within the normal range.

Maintaining high milk productivity and health of highly productive animals bred under intensive housing technology is a difficult task. The body of such animals experiences significant physiological stress, which can lead to a decrease in resistance and the manifestation of metabolic disorders. In this regard, the use of balanced diets with specialized feed additives becomes an important condition for achieving optimal milk productivity indicators and maintaining a favorable physiological status of highly productive cows. An integrated approach to feeding and keeping such animals allows us to ensure the implementation of their genetic potential at a high level while maintaining health and resistance to adverse environmental factors. Thus, in the experimental groups, an improvement in the main indicators of the chemical composition of milk is noted. Thus, in experimental group No. 3, the mass fraction of fat was 4.18%, protein - 3.36%, lactose - 4.92%, SNF - 8.83%, dry matter - 11.96%. These values significantly (P>0.95) exceed the indicators of the control group and correspond to the optimal parameters.

The content of casein, acetone, β-hydroxybutyrate (BHB) and urea also improved in the experimental groups compared to the control group. In addition, an increase in the proportion of unsaturated fatty acids (oleic, polyunsaturated) and a decrease in saturated fatty acids were noted.

Thus, the conducted analysis shows that the use of additives in the diets of cows of the experimental groups contributed to a reliable improvement in the chemical composition of their milk compared to the control group. These results indicate a positive effect of the studied additive on the metabolism and productivity of the experimental animals.

Table 8. Extended chemical composition of cows' milk after 14 weeks of the experiment, X ± Sx.

Indicators	Control group	Experimental group No. 1	Experimental group No. 2	Experimental group No. 3
MJ, %	3.59±0.05	3.78±0.17	3.92±0.11***	4.17±0.03***
MDB, %	3.13±0.06	3.23±0.05	3.34±0.03***	3.35±0.02***
Lactose,%	4.61±0.07	4.73±0.04	4.92±0.02***	4.96±0.03***
SOMO, %	8.30±0.11	8.51±0.09*	8.77±0.03***	8.85±0.02***
Dry matter, %	11.35±0.07	11.41±0.29	11.77±0.06***	11.98±0.03***
Casein,%	2.23±0.06	2.34±0.05	2.50±0.01***	2.63±0.02***
Acetone, mmol/l	0.25±0.04	0.16±0.01	0.15±0.01	0.15±0.04
BHB, mmol /l	0.17±0.03	0.10±0.01	0.09±0.02	0.10±0.01*
Urea, mg x 100 ml-1	18.85±1.04	19.14±1.10	17.72±0.33*	16.43±0.25*
pH	6.50±0.03	6.57±0.02	6.60±0.02	6.63±0.02
Fatty acids: Myristic	0.29±0.02	0.30±0.02	0.35±0.01	0.33±0.02
Palmitic	0.76±0.07	0.76±0.05	0.91±0.01*	0.95±0.01**
Stearic	0.26±0.05	0.27±0.04	0.29±0.01	0.32±0.01
Oleic	0.89±0.16	0.90±0.10	1.19±0.02	1.17±0.03
Long chain LC	1.05±0.21	1.05±0.14	0.92±0.01	1.24±0.04
Medium chain fatty acids	1.14±0.10	1.18±0.07	1.37±0.02	1.39±0.02*
Short chain LC	0.34±0.05	0.35±0.04	0.45±0.03	0.55±0.03***
Monounsaturated fatty acids	0.90±0.15	0.90±0.10	1.05±0.07	1.09±0.08
Polyunsaturated fatty acids	0.08±0.01	0.08±0.01	0.13±0.03	0.12±0.04
Rich LCDs	1.86±0.13	1.91±0.17	2.39±0.02***	2.53±0.03***
Transisomers of FA	0.06±0.01	0.06±0.01	0.08±0.02	0.07±0.01

The analysis of Table 8 shows that the fat content of milk increased from the control group to the experimental groups, reaching a maximum value in the 3rd experimental group (4.17%), which indicates a positive effect of the used additive on the milk productivity of cows (P> 0.999). The protein content also increased from the control group to the experimental ones, with a maximum value in the 3rd experimental group (3.35%) - P> 0.999 , demonstrating an improvement in the protein content of milk under the influence of

diets with an aqueous extract of pine trunk wood . The concentration of lactose, SNF and dry matter increased from the control to the experimental groups, reflecting the overall increase in the nutritional value of milk in the experimental groups. The casein content increased from the control group to the experimental ones, reaching a maximum in the 3rd experimental group (2.63%) - P> 0.999, which indicates a positive effect of the feed additive on the synthesis of the main milk protein. A decrease in the concentration of acetone and BHB (ketone bodies) was observed in the milk of the experimental groups compared to the control, indicating an improvement in energy metabolism in cows receiving the additive. The level of urea in milk was lower (P> 0.95) in the 3rd experimental group (16.43 mg / 100 ml), which may indicate a more rational use of nitrogen compounds in the animal body. The pH of milk increased from the control to the experimental groups, reflecting an improvement in the buffer capacity of milk. The content of the main groups of fatty acids (saturated, monounsaturated, polyunsaturated) increased in the experimental groups, which may be due to the effect of the feed additive on lipid metabolism in cows. In general, the presented data indicate a positive effect of the aqueous extract of pine trunk wood used in the experiment on the chemical composition and quality indicators of milk. The results obtained can and should be used to develop diets that ensure high productivity and health of highly productive dairy cows.

Table 9. Extended chemical composition of cows' milk after 16 weeks of the experiment, X ± Sx.

Indicators	Control group	Experimental group No. 1	Experimental group No. 2	Experimental group No. 3
MJ, %	3.53±0.06	3.77±0.07	4.01±0.08***	4.23±0.05***
MDB, %	3.11±0.07	3.22±0.05	3.35±0.02***	3.37±0.03***
Lactose,%	4.58±0.08	4.74±0.04	4.92±0.02***	5.02±0.05***
SOMO, %	8.26±0.12	8.52±0.09	8.78±0.05***	9.00±0.04***
Dry matter, %	11.29±0.08	11.42±0.29	11.83±0.03***	12.05±0.02***
Casein,%	2.20±0.06	2.35±0.05*	2.52±0.01***	2.68±0.03***
Acetone, mmol/l	0.27±0.03	0.17±0.01*	0.12±0.01***	0.15±0.03**
BHB, mmol /l	0.19±0.02	0.11±0.01**	0.10±0.02**	0.10±0.02**
Urea, mg x 100 ml-1	18.75±1.27	19.15±1.10	17.59±0.21	16.01±0.58*
pH	6.49±0.03	6.57±0.02	6.60±0.03	6.65±0.01***
Fatty acids: Myristic	0.28±0.03	0.31±0.02	0.31±0.01	0.35±0.01*
Palmitic	0.74±0.08	0.77±0.05	0.83±0.01**	0.96±0.03**
Stearic	0.25±0.06	0.28±0.04	0.27±0.01	0.34±0.02
Oleic	0.86±0.17	0.91±0.10	1.20±0.03	1.15±0.10
Long chain LC	1.01±0.22	1.06±0.14	1.13±0.03	1.35±0.10
Medium chain fatty acids	1.11±0.11	1.19±0.07	1.23±0.05	1.45±0.05**
Short chain LC	0.33±0.06	0.36±0.04	0.45±0.03	0.54±0.02***
Monounsaturated fatty acids	0.87±0.16	0.91±0.10	1.10±0.09	1.15±0.10
Polyunsaturated fatty acids	0.08±0.01	0.09±0.10	0.13±0.07	0.12±0.01**
Rich LCDs	1.80±0.24	1.92±0.17	2.48±0.12	2.55±0.14**
Transisomers of FA	0.06±0.01	0.07±0.01	0.08±0.01	0.07±0.01

Based on Table 9, it can be concluded that the fat content in milk gradually increases from the control group to experimental groups No. 1, No. 2 and No. 3, reaching a maximum value of 4.23% in the third experimental group (P> 0.999). This may indicate a positive effect of the additives used in the experimental groups on fat secretion in milk. A similar situation is observed with the protein content - from 3.11% in the control group to 3.37% in the third experimental group (P> 0.999), which indicates an improvement in the protein-

forming function of the cows' organism under the influence of the aqueous extract from pine trunk wood. The content of lactose, SNF and dry matter also consistently increases from the control to the experimental groups (P> 0.999), reflecting a general increase in the productivity of the mammary gland. A decrease in the concentration of acetone and β-hydroxybutyric acid (BHB) in the milk of the experimental groups is observed (P> 0.95) compared to the control, which indicates an improvement in energy metabolism and a decrease in the risk of ketosis. A decrease in the level of urea in the milk of cows in the experimental groups is noted, which indicates a more efficient use of nitrogen compounds in the diet. There is a gradual increase in the content of essential fatty acids (myristic, palmitic, stearic, oleic) in milk from the control to the experimental groups, which reflects an improvement in the fatty acid composition of milk fat. An increase in the concentration of various fractions of fatty acids (long-, medium- and short-chain, monounsaturated, polyunsaturated, saturated) is observed in the milk of the experimental groups compared to the control. In general, the presented data indicate a positive effect of the additives used in the experimental groups on the chemical composition and quality characteristics of cows' milk, which contributes to increased productivity and improved metabolic processes in the animals' bodies.

3 Conclusion

The conducted study demonstrates the effectiveness of using an aqueous extract from a pine trunk as a feed additive to improve the chemical composition of milk.

The obtained data indicate that the components contained in the aqueous extract from the pine trunk have a beneficial effect on the metabolic processes in the animals' bodies, which ultimately leads to an improvement in the chemical composition of the milk they produce. It is likely that the biologically active substances extracted from pine wood help normalize metabolism and reduce the concentration of undesirable compounds in milk [1-5].

1. The use of an aqueous extract from a pine trunk has a positive effect on the chemical composition and quality characteristics of milk in experimental cows.

2. As the dosage of the additive introduced into the cows' diet increases, a gradual increase in the fat and protein content in milk is observed. Thus, in the 3rd experimental group, which received the maximum dosage of the extract, the mass fraction of fat reached 4.23%, and protein - 3.37%, which is 0.53% and 0.26% higher than in the control group, respectively.

3. The use of pine wood extract helps improve the overall productivity of the mammary gland, as evidenced by the increase in the content of lactose, SNF and dry matter in the milk of the experimental groups compared to the control.

In general, the obtained results indicate a complex positive effect of the aqueous extract from the pine trunk on the productivity, metabolic processes and quality characteristics of milk in experimental cows. The most pronounced effect is observed at the maximum dose of the additive, which justifies the expediency of its widespread use in dairy farming to increase the nutritional value and profitability of milk production.

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