KAPITEL 7 / CHAPTER 7 [7]
MILK COMPOSITION AND BUTTER QUALITY WHEN MICROELEMENTS ARE ADMINISTERED IN THE COWS' DIET ON CULTIVATED PASTURES OF BUKOVINA WITH DIFFERENT BACKGROUND OF MINERAL FERTILIZERS

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Introduction.

Ensuring high quality and safety of dairy raw materials for the manufacture of dairy products is a fundamental component of protecting the health of the population and, of course, one of the priority challenges facing the agro-industrial complex of Ukraine. It is worth noting that assessing the quality and safety of dairy raw materials depending on the technologies of its production, substantiating scientific approaches to the regulatory provision of measurement accuracy is a dominant requirement, for which it is necessary to conduct constant monitoring studies. Such an approach generally allows assessing raw milk indicators for compliance with the requirements specified in regulatory documents (DSTU), although it makes it impossible to use this information for operational production management and obtaining dairy products with guaranteed quality indicators. In the context of the specified challenge, the lion's share of the problem is created by the incompleteness in the development and implementation of regulatory and methodological tools from the position of comprehensive provision of the national monitoring system and the small number of studies conducted in this direction [2].

Monitoring tests in the field of improving raw milk production technologies are gaining additional importance at this time, when there is a real need to regulate the composition and properties of dairy raw materials, which are criteria for evaluating a number of innovative technological processes, the interaction of organizational factors of complex management of the quality and safety of dairy raw materials, its standardization, certification and metrological support. It is also important that the

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process of forming in Ukraine of reliable European measures for strict control, in particular, such as monitoring of periodic inspections of raw milk by testing centers, has not been completed at the legislative level and is still [5].

7.1. Seasonal changes in the chemical composition of cow's milk

It was found that the mass fraction of fat in cow milk in all studied years in winter was on average highly likely to be higher (p<0.001) than in other seasons of the year: by 0.08% compared to spring, by 0.48% compared to summer, and by 0.03% compared to autumn (Table 1).

Table 1 - Seasonal changes in the chemical composition of cow's milk, %, M±m (on average for 2021–2022,)

Indicator	Season of the year			
	winter (n=16188)	spring (n=19107)	summer (n=19561)	autumn (n=19736)
Mass fraction in milk %:				
fat	3,78±0,07***	3,70±0,07	3,30±0,07	3,75±0,06
protein	3,23±0,03***	3,15±0,03	3,07±0,03	3,21±0,03
lactose	4,90±0,04	4,94±0,02	4,85±0,02	4,85±0,03
Dry matter	12,64±0,08	12,57±0,07	11,88±0,07	12,53±0,08
Dry non-fat milk residue	8,86±0,03	8,87±0,04	8,58±0,03	8,78±0,03
Fat/protein ratio	1,17	1,17	1,07	1,17

*Note: ***p<0.001 – the probability of difference was calculated for spring, summer and autumn*

The trend of seasonal changes in the mass fraction of fat in milk in individual years of monitoring was quite close, with the exception of the summer period, in which the largest and highly probable (p<0.001) differences in its absolute indicators were observed, compared with the spring-autumn period of the year. The winter period was also characterized by a probable increase (p<0.001) in the mass fraction of protein in milk by 0.08% compared to spring, by 0.16% compared to summer and by 0.02% compared to autumn. The mass fraction of lactose in cow's milk under the influence of the season of the year during the monitoring was almost at the same level (4.85–4.94%). The maximum calorie content was noted in the winter period (2.6% higher than the average annual value), the minimum - in the summer (5.6% lower). In the winter, spring and autumn periods, the caloric content of milk was higher than the average value of seven years of monitoring studies by 2.6; 1.1 and 1.9%. Arguing the differences between the values of the freezing point of milk, it should be emphasized that the season of the year had a slight effect on this indicator and their fluctuations were in the range from minus 0.532 ° C to minus 0.572 ° C. It is worth noting that a clear seasonal dependence on the content of somatic cells in milk in different years was also not observed.

According to the results of the study of the mineral composition of milk, it was found that the relative maximum concentrations of Cu, Zn, and Fe in cow's milk were recorded in spring, while Mn was recorded in autumn (Table 2).

Table 2 - Mineral composition of milk, mg/kg, M±m (average for 2021–2022)

Season of the year	Name of the mineral element			
	Cu	Mn	Zn	Fe
Winter (n=84)	0,061±0,007	0,143±0,041	3,106±0,325	1,430±0,220
Spring (n=84)	0,085±0,007	0,066±0,007	3,458±0,391	1,906±0,020
Summer (n=84)	0,072±0,007	0,101±0,034	3,039±0,244	1,388±0,291
Autumn (n=84)	0,070±0,008	0,209±0,103	3,040±0,336	1,596±0,263

At the same time, the content of Zn, Mn and Fe in the milk of cows under "organic" farming conditions is slightly lower compared to traditional technology, although a statistically significant difference was found between them in the accumulation of Cu ($p<0.01$).

7.2. The influence of cow husbandry and milking methods on the quality of raw milk

It was found that the mass fractions of fat in all seasons of the year were on

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average 0.19–0.49% (p<0.05–p<0.001), and dry matter – 0.17–0.29% (p<0.05–p<0.001) higher in the milk of cows that were kept tied.

Table 3 - Milk quality under different cow husbandry methods, M±m (average for 2021–2022)

Indicator	Season of the year			
	winter spring	spring	summer	autumn
An unattached way of keeping (n=3987; 4218; 4269; 3310)				
Mass fraction in milk %:				
fat	3,66±0,07	3,36±0,07	2,84±0,03	3,32±0,06
protein	3,26±0,06	3,27±0,05	3,13±0,06	3,26±0,05
lactose	4,81±0,04	4,88±0,03	4,84±0,06	4,84±0,03
Dry matter	12,49±0,05	12,27±0,02	11,57±0,02	12,07±0,09
Dry non-fat milk residue	8,83±0,02	8,91±0,09	8,78±0,12	8,75±0,07
Freezing point, - ºC	0,553±0,001	0,550±0,001	0,544±0,001	0,548±0,002
Somatic cell content, thousand/cm3	734±21	882±27	866±70	664±28
A tethered way of holding (n=3909; 4718; 5108; 4195)				
Mass fraction in milk %:				
fat	3,85±0,06*	3,78±0,05***	3,33±0,07***	3,77±0,02***
protein	3,23±0,05	3,13±0,03	3,04±0,03	3,17±0,04
lactose	4,90±0,02	4,95±0,02	4,84±0,04	4,81±0,06
Dry matter	12,66±0,06*	12,56±0,08***	11,84±0,04***	12,33±0,08*
Dry non-fat milk residue	8,81±0,03	8,78±0,02	8,51±0,08	8,56±0,08
Freezing point, - ºC	0,557±0,002	0,560±0,002	0,550±0,004	0,549±0,002
Somatic cell content, thousand/cm3	691±43	756±68	643±92	638±20

*Note: *p<0.05; ***p<0.001 – the probability of difference was calculated for the non-attached method of detention*

While in the milk of cows kept free of restraint, there was a tendency towards a slightly higher level of mass fractions of protein by 0.03–0.14% and dry non-fat residue by – 0.02–0.27%. The total content of somatic cells in milk was higher by 4.1–34.7% in the free-restraint method of keeping cows. According to the content of somatic cells, the quality of the selected milk samples in general during the research period was 75–73%, of which 59–55% of the samples belonged to the extra and higher classes. The quality of milk in the free-restraint method was higher in the stall period, decreasing in the spring-summer season, while in the tied method it increased from the winter to the autumn season.

According to the results of variance analysis, it was found that for both methods of keeping, the factor "bull-father" statistically highly significantly ($p<0.001$) influenced the content of mass fractions of fat and protein, the number of somatic cells in the milk of their daughters. This factor most strongly influenced the probability of mastitis diagnosis, respectively - 12.7 and 35.2%.

According to the studied milking methods, the mass fractions of fat, protein, and dry matter corresponded to the basic indicators and quality requirements. The total energy value of 1 kg of milk was at the level of 631.1–703.6 kcal. Indicators more dependent on the method of milking cows were: the freezing point of milk and the content of somatic cells in it [4].

7.3. Research on the chemical composition of commercial milk

In general, during the assessment period, the fat level in the collected milk was 0.27% higher than the basic standard, the mass fraction of protein exceeded the basic indicator by 0.02%, and in terms of dry matter content, the marketable milk met the requirements of the extra grade. It is characteristic that the content of somatic cells in marketable milk ranged from 465 thousand/cm3 to 719 thousand/cm3. In terms of somatic cell content, in general, during the monitoring period, 76.6% of milk samples were of quality, of which 33.3% belonged to the extra and higher grades, while 43.3% belonged to the first. In contrast, the quality of milk was the lowest when it was produced in farms and the population, which is due to the use of technically outdated milking equipment and violation of sanitary and hygienic requirements during milking. The total somatic cell content in this milk was 19.2 and 7.4% higher, respectively, compared to industrially produced products. [6].

7.4. Qualimetric assessment of cow's milk quality and safety

A comprehensive indicator of the quality and safety of cow's milk was obtained by combining its evaluation parameters according to formula 1:

$$K = \sum_{n=1}^{6} (K_{An} \times q_{An}) + (K_{B1} \times q_{B1}) + (K_{C1} \times q_{C1}), \qquad (1)$$

where K is a complex indicator of the quality of cow's milk; KAn is the weight coefficients of single parameters of chemical composition; KV1 is the weight coefficient of physical properties; KS1 is the weight coefficient of sanitary and hygienic features; qAn; qB1; qC1 are dimensionless values of single parameters.

As part of the conducted research, it was found that the experimental samples had better milk quality than the basic ones. In particular, according to the Harrington desirability scale, the values of the complex indicator characterizing their quality were 10.7% higher, and this was due, first of all, to the higher weighting coefficient for the chemical composition of milk, and in particular, the highest weighting coefficient for the mass fraction of fat. Although the values of the complex indicator of quality and safety of both the experimental and basic milk samples were in the range of the assessment "quite high".

7.5. Rational use of grass in cultivated pastures and its impact on productivity, physiological condition of cows and milk quality

In order to increase the production of livestock products, it is necessary to create a strong fodder base, to provide animals with complete nutrition, balanced in terms of all nutrients [16].

A great reserve in feed production in the summer period of animal husbandry is the creation of highly productive pastures, which are based on the intensive use of fertilizers and irrigation. The use of high doses of nitrogen fertilizers on pastures allows you to get 5-10 times higher yields than on natural ones [3, 16]. But fertilizers, increasing the yield of pasture grass, simultaneously change its composition. In pasture grass, the amount of nitrogen, potassium increases and the content of nitrogen-free extractives (BER), trace elements decreases [7]. The lack of trace elements in animal feed rations causes various diseases of them, reduces productivity and worsens the composition of milk.

Domestic and foreign literature contains a fairly large number of studies on the effect of trace element salts on cow productivity, but there is not enough work on feeding deficient trace elements in the conditions of summer keeping of cows on cultivated pasture with different mineral fertilizer backgrounds.

In this regard, it was of particular interest to study the effect of feeding cows with microelements deficient in their diet on their productivity, milk composition and butter quality on a cultivated irrigated pasture with a different background of mineral fertilizers[3].

For several years, we have been conducting comprehensive studies on the rational use of grass from cultivated pastures and its effect on productivity, the physiological state of cows and milk quality. In this general work, we studied:

1. Productivity, composition and technological properties of cow milk.
2. Composition, properties of sweet cream butter and its stability during storage.

The work shows the effect of grass from long-term cultivated irrigated pastures of the 7th-8th year of use and feeding cows with microelements deficient in the diet: cobalt, copper, zinc and manganese on milk productivity, composition, properties of milk and butter quality.

The paper presents material that indicates that feeding deficient microelements to cows grazing on cultivated pasture did not have a negative impact on their milk productivity, composition and properties of milk. Moreover, an increase in cow productivity from feeding microelements, an improvement in the composition of milk and its technological properties when processed into butter was noted.

The experiments were conducted on Simmental cows grazing on cultivated irrigated pasture in Chernivtsi region in 2021 - 2022. For the experiments, 6 groups of cows of 8 heads each were selected using the analogue method (groups 1a, 2a, 3a -

control; groups 1b, 2b, 3b - experimental). The live weight of the cows ranged from 508 to 540 kg, milk yield was 3900-4149 kg, and milk fat content was 3.4-3.50%. The cows were milked in the second month of the fifth lactation.

The duration of the experiment in both 2021 and 2022 was 175-180 days, of which 30 days were the preparatory period and 145-150 were the experimental period.

During the preparatory period of the experiment (the end of stall keeping), all animals were in the same feeding and housing conditions. The cows' diet was composed in accordance with the animals' nutritional needs, which included hay, corn silage, fodder beet, vegetable waste and compound feed. From mineral feeding, the cows received 50 g of monocalcium phosphate and lick salt as needed. The scheme of the zootechnical experiment is presented in Table 4.

Table 4 - Zootechnical experiment scheme

Pasture plots	Fertilizer dose	Group	Number of animals in the group	Preparatory period	Experimental period
I	$N_{120}P_{40}K_{60}$	1a	8	Stall holding period OR	Pasture RR
	$N_{120}P_{40}K_{60}$	1б	8		Pasture RR + microelements
II	$N_{240}P_{80}K_{120}$	2a	8	Stall holding period OR	Pasture RR
	$N_{240}P_{80}K_{120}$	2б	8		Pasture RR + microelements
III	$N_{360}P_{120}K_{180}$	3a	8	Stall holding period OR	Pasture RR
	$N_{360}P_{120}K_{180}$	3б	8		Pasture RR + microelements

During the experimental period, cows were grazed on cultural irrigated cereal and leguminous pasture. The pasture with an area of 120 hectares is divided into three plots, on which different doses of mineral fertilizers are applied annually: on the 1st –

N120P40K60, on the 2nd – N240P80K120, on the 3rd – N360P120K180. 2 groups of cows were grazed on each site, one of which was a control group, the other an experimental one.

Pasture grass is considered complete feed. However, in connection with the intensive use of cultivated pastures (fertilization, irrigation), the chemical composition of the grass changes: an increase in its protein content and a decrease in soluble carbohydrates, fiber, and some trace elements are observed, as a result of which the use of nutrients in the diet decreases. Therefore, in addition to pasture grass, the diet of cows of all groups included barley grit at the rate of 150 g per 1 liter of milk, molasses at 0.5; 0.7; 0.9 kg per head per day in accordance with the doses of fertilizers, thereby compensating for the lack of starch and sugar in the diet. To compensate for fiber, 2 kg of barley straw per head was included in the diet.

The analysis of the feed fed in the summer period showed a low content of trace elements in them. In terms of 1 kg of dry matter, the diet contained 5.9-6.2 mg of copper; 0.11 mg of cobalt; 24-26 mg of manganese and 19-26 mg of zinc, while most researchers believe that to fully satisfy the need of cows for trace elements, the following content is necessary in 1 kg of dry matter of feed: copper not less than 10 mg, cobalt not less than 0.2 mg, manganese should be about 40-60 mg, zinc not less than 50-60 mg [16].

Thus, the need of cows for trace elements due to the feed of the diet was not satisfied. The insufficient amount of trace elements: 25 mg of copper, 5 mg of cobalt, 17 mg of manganese and 28 mg of zinc in the experiment and 25 mg of copper, 5 mg of cobalt, 152 mg of manganese and 170 mg of zinc in the experiment of the year were fed to cows of the experimental groups (1b, 2b and 3b) before lunch milking with barley grits in the form of a 0.03% aqueous solution of their salts. The increase in doses of zinc and manganese supplementation in the experiment to the maximum level was caused by the fact that the content of these elements in the blood of cows continued to remain low and did not reach the values accepted as the norm [5].

Milk productivity from each cow was recorded every decade, and milk was examined once a month for density, acidity, fat, protein and dry matter content. In addition, in the milk of cows of each group, in addition to the listed indicators, the number and size of fat globules, the content of phospholipids and their fractions, vitamin A and carotene, trace elements: copper, cobalt, manganese and zinc were determined.

The fat content and acidity were determined in the cream. Sweet butter was produced, which was subjected to organoleptic evaluation both fresh and after one-year storage and examined for moisture content, fat acidity, peroxide and iodine values, degree of fat spoilage, zinc, manganese, copper and iron content. The content of fatty acids with the number of carbon atoms C4-C20 was determined in milk fat. Methods for research on milk and butter were used [12]. The main digital material was processed biometrically.

7.6. Milk production of cows

The average daily milk yield of cows in the preparatory period was 17.0-17.8 kg with a milk fat content of 3.0-3.1% in 2021 and 18-19 kg with a milk fat content of 3.2% in 2020. Feeding grass from cultivated pastures with supplemental barley straw, straw and molasses during the experimental period allowed to obtain 18-19.8 kg of milk per day from each cow of the control groups in 2021, 15.6-16.8 kg in 2022 and from the experimental ones - 18.6-20.6 kg in 2022, 17.0-17.5 kg in 2023. The fat content of milk during the experimental period in cows of the control groups was 3.39-3.41%, in the experimental ones - 3.50-3.57%. For a more visual idea of the milk yield of cows of all groups, the milk yield was converted to milk with a 4% fat content in it. No differences in milk yield were found between cows of the control groups (1a, 2a, 3a), i.e. different doses of mineral fertilizers applied to pastures when feeding cows with carbohydrate feeds had no effect on milk yield. Feeding cows with microelements contributed to better assimilation of nutrients in the feed, which was expressed in an increase in milk yield of cows of the experimental groups.

In the experimental period, compared to the preparatory period, the content of dry

Table 5

Milk composition (data for two years)*

Indicator	Preparatory period						Experimental period					
	Group of cows											
	1а	1б	2а	2б	3а	3б	1а	1б	2а	2б	3а	3б
Dry matter, %	11,0	11,1	10,9	11,1	11,0	11,3	12,0	12,1	12,1	12,3	12,0	12,18
Fat, %	3,15	3,10	3,15	3,15	3,18	3,19	3,39	3,50	3,40	3,57	3,41	3,57
Protein, %	2,76	2,80	2,68	2,69	2,84	2,86	3,02	3,09	3,05	3,19	3,19	3,32
Casein, %	2,15	2,19	2,06	2,06	2,19	2,24	2,34	2,35	2,33	2,47	2,45	2,58
Total phospholipid content, mg% including: lecithins, % cephalins, %	29,2 14,7 45,3	29,3 14,5 44,9	28,8 14,3 44,8	29,2 14,6 44,9	29,0 14,9 44,2	29,2 15,9 44,3	31,0 26,2 31,1	31,6 30,2 25,3	30,9 34,4 28,9	32,7 32,8 29,8	31,7 31,1 24,0	35,1 33,9 30,7
including:	238	234	257	242	226	242	405	421	388	425	378	427
lecithins, %	91	102	102	110	100	115	276	299	253	304	237	313
cephalins, %	1,0	1,2	1,0	1,1	1,0	1,0	0,8	1,0	0,9	1,0	0,9	1,1
Vitamin A, µg/kg	4,7	4,6	4,1	4,0	4,4	4,3	4,1	4,6	3,9	4,2	3,9	4,5
Carotene, µg/kg	131	137	123	125	134	137	151	180	153	181	160	187
Iron, mg/kg	1,5	1,5	1,5	1,5	1,5	1,5	1,6	2,3	1,6	2,3	1,6	2,5
Zinc, mg/kg	36	33	35	34	36	32	37	43	33	44	36	44

* In the following, all tables show data for 2 years.

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matter, SOMO, protein, phospholipids, vitamin A and carotene increased in the milk of cows of all groups. It is possible that the feeding of pasture grass and carbohydrate supplements to cows contributed to a better formation of the precursors of the constituent components of milk. However, the growth of components in the milk of cows of different groups was not the same. The dry matter content was higher in the milk of the cows of the research groupsby 0.1-0.2%, protein – by 0.13-0.14%, phospholipids – by 0.6-3.4 mg%, vitamin A and carotene – by 22-76 μg/kg compared to the milk of cows of the control groups. The difference in carotene content is significant at $P < 0.05$.

It should also be noted that with increasing doses of mineral fertilizers, the content of vitamin A and carotene in milk decreased from 405 μg/kg in the 1st plot to 388 and 378 μg/kg in the 2nd and 3rd plots and from 276 to 253-237 μg/kg, respectively. This indicates that the introduction of salts of trace elements deficient in the diet contributed to better use of feed nutrients, which is also indicated by a number of authors [4,15]. In the experimental period, compared with the preparatory period, the copper content in the milk of cows of all groups increased from 130 to 150-180 μg/kg, the iron content decreased from 1.1 to 0.8-0.9 mg/kg and zinc from 4.0-4.7 to 3.9-4.5 mg/kg. Such changes in the content of trace elements in milk are explained by the course of lactation of cows. Feeding animals with trace elements contributed to a significant increase in copper in milk by 40-60%; manganese and cobalt - by 35-38% and 40-50% ($P \leq 0.05$).

7.7. Technological properties of milk

The technological properties of milk when processed into butter are concluded from such indicators as the number and size of fat globules, the duration of cream churning, the properties of the oil grain, the fat content in buttermilk and the degree of use of milk fat[11].

The number of fat globules in the milk of cows in the experimental groups was higher by 0.11-0.17 billion/ml and they were somewhat larger in size. Feeding cows with trace elements contributed to an increase in the fat content of milk, as already indicated above, and this increase occurred due to an increase in the number and size of fat globules. In the milk of cows in the experimental groups, fat globules with a diameter of up to 1 micron were 10-15% less. The number of fat globules with a diameter of less than 1 micron is an important indicator in buttermilk production, since when whipping cream they are first of all excreted into buttermilk.

Table 6 - Technological properties of milk

Indicator	Group of cows					
	1a	1б	2a	2б	3a	3б
Number of fat globules, billion/ml	2,14	2,25	2,12	2,26	2,10	2,27
Diameter of fat globules, μ	2,83	2,93	2,80	2,83	2,89	2,98
Fat content in cream, %	34,2	33,7	33,6	34,2	33,9	33,8
Duration of whipping cream, min	52,0	50,5	51,5	51,2	50,5	51,5
Fat content in buttermilk, %	0,85	0,80	0,90	0,86	1,05	0,81
Fat utilization, %	96,0	98,5	97,6	98,7	96,4	98,7
Amount of milk per 1 kg of butter, kg	26,8	26,4	26,6	26,3	27,2	26,1

The changes that occurred in the dispersion of milk fat were reflected in the fat content in buttermilk. It was higher by 6-26% in the buttermilk of the control groups, as a result of which the non-use of milk fat was lower by 1.1-2.5%. The increase in fat in milk, as well as the smaller number of small fat globules in it, contributed to a decrease in milk consumption for the production of 1 kg of butter by 0.6-0.7 kg.

Thus, the use of feeding cows with trace elements deficient in their diet when grazing on cultivated irrigated pasture improved the technological properties of milk when it was processed into butter

7.8. Quality of freshly produced oil

Freshly produced butter in terms of physicochemical parameters met the requirements of "DSTU 4399:2005 Butter. Technical conditions" The moisture content in the butter was 15.6-15.8%, the acidity of milk fat was 0.66-0.79oK. The presence of peroxides in the butter and other highly reactive compounds was the same, as evidenced by the peroxide value and the test with TBA (0.16-0.18 and 0019-0.022). The iodine value of milk fat was 37.0-38.8. The highest iodine value was in groups 2b and 3b, which indicates a higher content of unsaturated acids in it than in other samples.

The physicochemical and organoleptic properties of milk fat are determined mainly by the set of fatty acids that make up it, as well as their ratio. In the formation of the taste and aroma of butter, the main role belongs to volatile fatty acids. Their share in the preparatory period was 10.2-10.8%, and in the experimental period 10.70-11.05% (table 4), while it is necessary to note as a trend - the increase in VFA in the fat of the experimental groups ($P > 0.05$). The total amount of saturated fatty acids in the experimental period compared to the preparatory period decreased from 71.3 to 60.9%. The decrease was mainly due to palmitic acid: if in the preparatory period its amount was 27-28%, then in the experimental period 18-19%. Of the saturated acids, in addition to palmitic acid, the most abundant were myristic acid (11.5-12.6%) and stearic acid (11.1-11.6%).

Analysis of the content of individual saturated acids in milk fat showed that changes in their content in different groups during the study period were insignificant and had an unexpressed character. Unsaturated fatty acids in milk fat of the preparatory period made up an average of 28.3-28.8% of the total amount. During the study period, their amount significantly increased to 38.5-39.0% ($P < 0.01$). The highest content of unsaturated acids was observed in milk fat samples of the study groups - 39.0-39.08%[9,14].

The analysis of the content of individual unsaturated acids showed that the most pronounced changes in the experimental period in comparison with the preparatory period were for oleic, palmitic and decenoic acids. The content of oleic acid increased by 1.5 times, palmitic acid – from 2.8-3.0 to 3.3-3.7%, and decenic acid decreased from 1.1-1.2 to 0.44-0.50% .

The unequal levels of the listed acids in milk fat in the experimental and preparatory periods should be explained by different diets of cows. In the summer period, the animals consumed a larger amount of pasture grass, which is rich in unsaturated compounds.

Table 7 - Content of saturated fatty acids, %

Acids	Preparatory period						Experimental period					
	1a	1б	2a	2б	3a	3б	1a	1б	2a	2б	3a	3б
Butyric	3,47	3,55	3,10	3,37	3,44	3,20	3,63	3,70	3,70	3,65	3,55	3,67
Capric	2,38	2,23	2,22	2,34	2,32	2,25	2,59	2,58	2,55	2,50	2,44	2,45
Caprylic	1,25	1,30	1,10	1,25	1,19	1,15	1,22	1,38	1,15	1,05	1,32	1,08
Capric	3,67	3,60	3,65	3,85	3,57	3,60	3,50	3,38	3,50	3,50	3,65	3,84
Lauric	4,76	5,00	5,00	4,60	4,55	4,50	4,11	4,55	4,00	3,90	3,56	3,55
Tridecyl	0,16	0,08	0,07	0,07	0,13	0,10	0,16	0,15	0,17	0,16	0,23	0,14
Isomyristic	0,21	0,12	0,12	0,10	0,15	0,10	0,22	0,16	0,21	0,16	0,18	0,17
Myristic	12,90	13,00	13,45	13,30	13,42	13,56	11,45	11,46	12,27	12,35	12,65	12,71
Pentadecyl	1,03	1,07	1,20	1,02	1,02	1,20	2,05	1,89	1,94	1,50	1,79	1,73
Isopalmitic	0,40	0,45	0,49	0,50	0,47	0,50	0,49	0,50	0,42	0,31	0,30	0,30
Palmitic	28,44	28,26	28,30	28,31	28,67	28,46	18,50	18,75	18,67	18,90	18,56	18,82
Isomargarine	0,88	0,93	0,90	0,78	0,79	0,97	1,30	1,00	1,01	0,84	1,02	1,01
Isostearic	0,47	0,40	0,39	0,38	0,39	0,36	0,50	0,50	0,55	0,44	0,65	0,64
Stearic	10,97	11,10	11,45	11,35	11,54	11,37	11,50	11,80	11,35	11,56	11,67	11,13
Arachic	0,23	0,24	0,22	0,25	0,25	0,15	0,23	0,22	0,20	0,18	0,20	0,23
Total	71,23	71,11	71,60	71,66	71,50	71,28	61,45	60,92	61,72	61,01	61,77	60,97

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Table 8 - Content of unsaturated fatty acids, %

Acids	Preparatory period						Experimental period					
	1а	1б	2а	2б	3а	3б	1а	1б	2а	2б	3а	3б
Decenoic	1,13	1,25	1,21	1,15	1,13	1,03	0,55	0,56	0,45	0,50	0,44	0,41
Dodecenic	0,07	0,06	0,04	0,03	0,05	0,06	0,08	0,08	0,08	0,10	0,08	0,12
Tetradecenic	2,41	2,44	2,37	2,50	2,25	2,44	2,78	2,78	2,50	2,44	2,54	2,68
Palmitoleic	2,94	3,03	2,95	3,05	2,85	2,79	3,18	3,38	3,20	3,44	3,54	3,70
Oleic	18,78	18,64	18,50	18,35	18,45	18,91	28,33	28,26	28,35	28,68	27,80	27,74
Linoleic	3,38	2,42	2,32	2,16	2,26	2,40	2,10	2,12	2,08	2,30	2,17	2,39
Linolenic	0,91	0,89	0,81	0,99	0,95	0,92	1,33	1,57	1,34	1,38	1,44	1,62
Arachidonic and other polyunsaturated acids	0,16	0,18	0,18	0,16	0,20	0,17	0,22	0,30	0,25	0,26	0,28	0,36
Всього	28,77	28,89	28,40	28,34	28,10	28,72	38,55	39,08	38,28	39,00	38,23	39,03

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Changes in the content of unsaturated acids in the fat of the experimental and control groups during the experimental period were unexpressed, with the exception of conjugated isomers of polyunsaturated acids.

Table 9 - Content of conjugated isomers of polyunsaturated acids, mg%

Group	Preparatory period			Experimental period		
	diene	triene	tetraene	diene	triene	tetraene
1a	335,5	11,5	2,20	450,0	18,2	2,75
1б	345,5	12,3	2,25	550,0	28,9	2,90
2a	359,5	11,0	2,45	473,2	29,5	3,30
2б	354,4	13,1	2,45	508,5	36,5	3,60
3a	340,5	11,0	2,55	438,0	34,6	2,60
3б	337,0	13,0	2,45	528,1	36,0	2,90

Their content during the experimental period significantly increased: diene by 30-60%, triene by 1.5-2 times. Tetraene isomers increased slightly ($P > 0.05$). A higher content of diene and triene isomers of polyunsaturated acids in the fat of the experimental groups was noted, which is probably explained by the action of microelements fed. According to [6, 12, 15], microelements enhance the growth and activity of rumen microflora. Which has a positive effect on the isomerization of unsaturated fatty acids of feed. This phenomenon probably also took place in our experiment.

No significant changes in the content of individual acids depending on the doses of mineral fertilizers applied to pastures were detected in our experiment.

Thus, with the transfer of feed to pasture, the content of volatile fatty acids, unsaturated acids in milk fat increased and the number of high-molecular saturated acids decreased. The application of different doses of mineral fertilizers to pastures did not affect the fatty acid composition of milk fat, and feeding trace elements to cows in the experimental groups contributed to some increase in volatile monoenoic and significant increase in conjugated isomers of polyunsaturated acids.

The quality of the oil and especially its stability during storage are determined not only by the fatty acid composition of milk fat. A large role in this issue is played by the content of trace elements in the oil (initiators and activators of oxidative processes), as well as the content of natural antioxidants (carotene and vitamin A).

The level of trace elements, carotene and vitamin A in the oil of different groups was different. In the oil of the experimental groups, carotene was 6-17% higher, and vitamin A was 4-11%.

Table 10

The content of carotene, vitamin A and trace elements in oil

Indicator	Group of cows					
	1a	1б	2a	2б	3a	3б
Carotene, mg/kg	3,20	3,40	2,80	3,00	2,50	2,90
Vitamin A, mg/kg	4,15	4,40	3,95	4,15	3,45	3,80
Copper, mcg/kg	242	344	240	346	230	370
Iron, mg/kg	1,23	1,53	1,10	1,43	124	1,50
Zinc, mcg/kg	200	280	197	247	186	297
Manganese, mcg/kg	50	59	43	64	44	63

Their absolute content was the highest in oil samples from the first plot, fertilized with a dose of N120P40K60. With increasing fertilizers, the content of the named components in the oil decreased to 2.56 mg/kg of carotene and to 3.50 mg/kg of vitamin A.

Additional feeding of microelements to cows increased their level in the oil. Thus, the content of copper in the oil of the experimental groups was higher by 50-60% ($P < 0.001$) compared to the control ones, and iron - by 16-30% ($P > 0.05$). The higher level in the oil of the experimental groups was also for zinc and manganese ($P < 0.05$).

According to the results of organoleptic evaluation, the oil of all groups was classified as a higher grade, while a more pronounced taste and aroma of the oil of the experimental groups was noted.

7.9. Oil quality after one year of storage

Analysis of the physicochemical parameters of the oil, which was stored for a year, showed that during storage there is an increase in the acidity of milk fat, the formation of peroxides and other decomposition products. The acidity of milk fat increased to 0.8-1.12°C, the peroxide value - to 0.36-0.50, and the sample with TBA - to 0.035-0.044. It must be said that the extinction value of the distillate in the sample with TBA - 0.035-0.044 is significantly below the limit - 0.064, after which the oxidation of the oil becomes noticeable to the taste and the oil is unsuitable for further storage. Despite the increased content of copper and iron in the oil of the experimental groups compared to the control, it resisted oxidative processes well. Apparently, this ability is due to a higher content of natural antioxidants - carotene and vitamin A in the oil. During the storage of oil, their number decreased by 25-30%. The antioxidant role of vitamin A and carotene is indicated [2, 3, 13]. The iodine value during the storage period of oil decreased by 2.3 (from 3.7 to 34.7), which indicates a decrease in the content of unsaturated fatty acids.

During the storage of the oil, no significant changes were observed in the content of volatile fatty acids. Analysis of data on the content of unsaturated and saturated acids in milk fat after storage of the oil for a year shows that the amount of unsaturated fatty acids in the fat decreased to 28-30% and the amount of saturated ones increased to 70-71%. Changes in the fatty acid composition of the oil occurred mainly due to a decrease in oleic (from 27-25 to 20-21%) and linolenic (from 2.6-2.4 to 1.6-1.4%) acids and an increase in lauric and palmitic acids.

Changes observed in the fatty acid composition of milk fat during butter storage did not significantly affect the organoleptic properties of butter. Butter of all groups was classified as top grade according to the results of organoleptic evaluation.

Table 11 - Fatty acid content in milk fat butter after storage for a year, %

Acids	Group of cows					
	1a	1б	2a	2б	3a	3б
Oily	3,56	3,53	3,45	3,50	3,57	3,60
Capronic	2,30	2,24	2,35	2,28	2,22	2,16
Caprylic	1,21	1,11	1,30	1,10	1,05	0,98
Capric	3,40	3,05	3,00	3,41	3,25	3,35
Decenoic	0,90	0,66	0,70	0,62	0,57	0,50
Dodecenoic	0,04	0,04	0,05	0,06	0,05	0,04
Tridecylic	0,30	0,32	0,26	0,25	0,26	0,29
Isomerystic	0,30	0,22	0,20	0,18	0,17	0,17
Myristic	14,00	14,01	13,90	14,52	13,59	13,70
Tetradecenoic	2,50	2,75	2,68	2,66	2,59	2,81
Pentpdecylic	2,71	2,62	2,80	2,65	2,22	2,25
Isopalmitic	0,55	0,52	0,45	0,42	0,45	0,33
Palmitic	26,69	27,03	26,56	26,80	27,11	27,45
Palmitoleic	2,43	2,53	2,47	2,20	2,17	2,27
Isomargarine	0,39	0,44	0,42	0,42	0,50	0,45
Isostearic	0,36	0,38	0,27	0,31	0,42	0,42
Stearic	9,43	9,82	9,53	9,87	10,02	9,78
Oleic	20,55	21,66	21,37	21,24	21,68	21,51
Linoleic	1,48	1,38	1,47	1,31	1,60	1,44
Arachidonic	0,17	0,15	0,18	0,11	0,14	0,16
Linolenic	0,54	0,57	0,53	0,54	0,59	0,58
Arachidonic and other polyenes	0,14	0,15	0,17	0,12	0,12	0,16
Sum of saturated	71,72	71,20	70,90	71,31	70,65	70,69
Sum of unsaturated	28,28	28,80	29,10	28,69	29,35	29,31

Thus, butter produced from milk from cows that grazed on pastures with different

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mineral fertilizer backgrounds and that received micronutrient supplementation had good taste and was stable during storage.

Conclusions

1. The monograph theoretically summarizes and scientifically substantiates a comprehensive system for monitoring the quality and safety of cow's milk, formed in the context of consistently performed expert and analytical actions and the implementation of regulatory and methodological tools for making operational management decisions.

2. It was established that milk of better quality with increased by 0.03–0.48% mass fractions of fat ($p<0.001$), by 0.02–0.16% - protein ($p<0.001$) and by 0.07–0.76% - dry matter was obtained from cows in winter, while in spring it turned out to be more enriched with lactose by 0.04–0.09% and, despite the season of the year, the overwhelming number of milk samples (more than 50%) meets the requirements of extra and higher grades.

3. It is argued that the content of Cu, Mn, Zn and Fe in the milk of cows of the studied farms, despite its compliance with the MPC, depends on the season of the year and land use technology: the maximum concentration of Cu, Zn, Fe in cow's milk was recorded in spring, Mn - in autumn against the background of a trend towards a decrease in the content of Zn, Mn and Fe and a probable decrease in the concentration of Cu ($p<0.01$) under the conditions of "organic" farming, compared to traditional technology.

4. Among the indicators of the chemical composition of milk, the mass fraction of fat was found to be more dependent on the method of keeping, the content of which, regardless of the season of the year, is probably lower ($p<0.05$–$p<0.01$) for keeping cows loosely tied, however, as the content in of somatic cells is mostly determined by the sanitary and hygienic conditions of production and the incidence of mastitis in animals, than by the method of keeping: under unattached keeping non-grade products were obtained from 18% to 32%, tied - from 23% to 33% of cows.

5. It was determined that with an increase in the energy value of milk in cows with tethered housing, there is a parallel increase in the mass fraction of dry matter by 0.17–0.25% ($p<0.05$–$p<0.001$), at the same time as during unattached detention, only a tendency towards a slight increase in the mass fraction of protein by 0.03–0.14% was noted.

6. A highly probable influence ($p<0.001$) of the parent bulls on the quality and safety indicators of the milk of the offspring was revealed, while regardless of the method of keeping, its strength and degree on the probability of mastitis diagnosis in cows are the most significant ($\eta x2$=35.2 and 12.7 %), compared to the effect of the "line" factor.

7. With the transfer of cows from stables to cultural irrigated pastures, their milk productivity increased by 20-22%. At the same time, the content of carotene increased by 3.5-5 times, vitamin A by 2 times, lecithin by 1.5-2 times, and the total amount of phospholipids by 15-20%.

8. Feeding cows balanced in terms of main nutrients grass of cultivated pastures, fertilized with different doses of fertilizers, did not affect the milk productivity and the main indicators of milk composition.However, the content of vitamin A and carotene in milk with increasing doses of fertilizers decreased by 6-10% and 8-20%, respectively.

9. The inclusion of deficient microelements in the diets of cows, balanced in terms of basic nutrients, contributed to an increase in:

a) milk productivity by 6-8%.

b) milk quality by increasing its dry matter content by 0.20%, fat by 0.11-0.17% and protein by 0.13-0.14%;

c) the biological value of milk due to an increase in the content of carotene by 30-50%, vitamin A by 5-15%, lecithin by 4-5%, conjugated isomers of polyunsaturated acids in milk fat by 40-110 mg;

d) the level of trace elements in milk (manganese - by 35-38%, copper and cobalt - by 45-60%).

10. The introduction of trace elements into the diet of cows contributed to the

improvement of the technological properties of milk when it is processed into butter, which led to a decrease in the waste of fat in buttermilk and the consumption of milk for the production of 1 kg of butter.

11. Butter produced from the milk of cows of the experimental groups had a pleasant taste and aroma and was classified as a top grade in organoleptic evaluation. At the same time, butter from the milk of cows of the experimental groups contained more vitamin A (by 4-9%), carotene (by 8-25%), and polyunsaturated fatty acids (by 5-6%) compared to butter from the milk of cows of the control groups.

12. Butter from the milk of cows of all experimental groups had the same stability during storage.

13. The presence of 340 µg/kg of copper and 15 mg/kg of iron in the oil of the experimental groups did not have a negative effect on its stability during storage due to the high content of vitamin A (in the amount of 4.2 mg/kg) and carotene (3.2-3.5 mg/kg), which are an

Proposals for production

1. Introduction into the diet of cows grazing on cultivated pastures with different mineral fertilizer levels, deficient microelements at the rate of 25 mg copper, 170 mg zinc, 152 mg manganese and 5 mg cobalt per head per day contributes to an increase in milk productivity, improvement of milk quality and its technological properties.

2. We suggest that dairy processing enterprises and testing centers use the developed state standards of Ukraine for determining the quality and safety indicators of cow's milk.

3. Testing laboratories apply the developed methods for assessing the monitoring and certification system for the quality and safety of raw milk, which consist in standardized selection of representative samples; use of modern measuring equipment and their certification; production of standard samples; standardization of measurement methods, confirmation of measurement accuracy.

4. We recommend that agro-formation for milk production be guided by the created database of its chemical composition in order to accelerate the formation of the desired structure of competitive herds in terms of quality and safety.