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Determination of milk quality indicators and first streams depending on the stage of lactation and daily milk yield

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Abstract. The relevance of the study is to solve the problem of cow's milk quality and the influence of factors of lactation stage and daily milk yield on milk parameters, and to establish links between the content of somatic cells in milk and other milk parameters. The purpose of the study was to determine the influence of the lactation stage and daily milk yield on the quality indicators of milk and its first streams, and to establish links between the content of somatic cells and other indicators of the

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quality of milk and its first streams. Research methods – zootechnical (selection of groups, organisation of the experiment, determination of milk productivity, assessment of the stage of lactation, the level of milk yields, control milking), biochemical (determination of the main indicators of milk quality), statistical, mathematical. A significant difference between milk quality indicators in the daily milk yield and in the first three streams of milk ($p \geqslant 0.95$) was established, therefore, the need to separate the first streams of milk from the main milk yield was experimentally proved. It was found that the indicators of the quantity and quality of milk and its first streams in various degrees correlate with the stage of lactation, the highest daily milk yield was established in cows that were in the first trimester of lactation. Fluctuations in the quality indicators of milk and its first streams depending on the level of daily milk yield were established. It was found that the content of somatic cells in milk is quite significantly negatively associated with the indicators of lactose content and freezing point of milk, to a lesser extent – with daily milk yield, and positively – with the duration of lactation, protein and whey+casein content. In the first streams of milk, the correlation coefficients for milk productivity and quality did not exceed 0.250. The highest somatic cell content was positively correlated with the MSNF index, protein and whey+casein content, freezing point, urea content, and negatively correlated with daily milk yield and fat content. The findings can be used in milk production farms and when planning breeding work to improve the quality characteristics of milk by selection

Keywords: dairy cows; milk quality parameters; lactation stage; daily milk yield; somatic cell content

INTRODUCTION

Food safety is the foundation of the health of any nation in the world, and the population of developed countries is paying more and more attention to healthy nutrition. In most countries, laws set minimum requirements for milk components and standards that provide value added if they are satisfactory. Therefore, producers need to implement strategies that ensure the best quality of milk in the production process and, thus, receive economic benefits. High standards of quality and safety of dairy raw materials, which are the norm for the world's leading producers, should be integrated into domestic production as soon as possible. The issue of milk quality is of particular relevance in connection with the signing of the EU-Ukraine Association Agreement in 2014, under which Ukraine had to harmonise its legislation with EU provisions, in particular, Regulation (EC) No. 853/2004 (2004) laying down specific hygiene rules for food, including milk and milk products.

The need to approach European standards has contributed to the introduction of new requirements for raw materials for the production of dairy products, so the task of Ukraine, which seeks the fastest accession to the EU, is to introduce these standards. For this purpose, on March 12, 2019, the Order of the Ministry of Agrarian Policy and Food of Ukraine No. 118 (2019) was issued. This order has been repeatedly amended to improve the requirements for milk quality in the conditions of Ukraine. The new requirements set criteria for exceeding which milk cannot be sold.

In addition to food safety, milk quality is an important factor with significant weight in the marketing and industrial sectors. In most countries, laws set minimum requirements for milk components and standards that provide value added if they are satisfactory. Therefore, producers need to implement strategies that ensure the best quality of milk in the production process and, thus, receive economic benefits. High standards of quality and safety of dairy raw materials, which are the norm for the world's leading producers, should be integrated into domestic production as soon as possible. On the other hand, consumers are becoming more aware of food safety issues as the population's income increases.

Much attention is paid to milk quality research all over the world, and high quality requirements are set for milk and dairy products. Thus, one of the important tasks is to search for factors influencing milk quality indicators. P.L. Ruegg (2022), M. Cassandro (2020), L.M. Piddubna *et al.* (2021) highlight genetic factors as the main impact factors, whereas R. Feliciano *et al.* (2020), E. Jeon *et al.* (2023) distinguish climatic factors.

S. Quiédeville *et al.* (2022), J. Nzeyimana *et al.* (2023) prove a significant impact on cow productivity and milk quality of weather conditions and the heat stress caused by them. However, many researchers focus on technological factors. Thus, A. Correa-Calderón *et al.* (2022), E. Hayes *et al.* (2023) prove the importance of feeding rations in obtaining high milk yields and high-quality milk. M. Lutsenko *et al.* (2021), R. Vieira *et al.* (2022) note the special importance of keeping livestock conditions for obtaining high-quality milk. Among the main factors influencing the quality of milk, V. Tančin *et al.* (2020) distinguish the indicator of the number and stage of lactation. In the context of international standards for milk quality, T. Chernyavska (2023) and D. Giannuzzi *et al.* (2023) identify the particular importance of studying the somatic cell content in milk as a key indicator of milk and dairy product safety. Thus, the study of factors affecting the quality of milk requires testing in various conditions.

Given the relevance of the issue, the purpose of the study was to determine the factors that affect the quality indicators of milk and its first streams: the timing and stages of lactation, the level of daily milk yield, and the relationship between milk quality indicators. Special attention is paid to the study of the indicator of

the content of somatic cells in milk and the establishment of relationships of this trait with other indicators of milk quality.

MATERIALS AND METHODS

The scientific and economic experiment was conducted in June 2023 on high-yielding cows of the Ukrainian Black-and-White dairy breed, taking into account productivity and lactation stage, at Gagarin Agrofirm LLC in Kharkiv Oblast. Control (n = 160) and experimental (n = 56) groups of analogue cows were established in terms of productivity and lactation stages under the conditions of one typical four-row cowshed with a tethered keeping. The conditions of keeping, feeding and drinking regimes, and microclimate parameters during studies between groups of experimental animals were the same. Cows were fed with complete feed mixtures twice a day. Control milking was performed twice a day – in the morning and in the evening using portable buckets. Sanitary and hygienic treatment of udders and teats in cows of all groups was carried out in the same way. In the experimental group, the first three streams of milk from each quarter of the udder were taken in a separate container, in the control group – an average sample from a bucket. Milk samples from each cow were taken using a probe in proportion to morning and evening milk yields in accordance with the requirements of the instructions for sampling milk and dairy products (DSTU ISO 707:2002, 2003). Samples were delivered to the laboratory with a preservative (MicroTabs broad-spectrum tablets, USA).

Biochemical parameters of milk were determined in a certified laboratory for assessing the quality of livestock products. Determination of the mass fraction of fat, protein, casein+whey proteins, lactose, dry matter was carried out by express infrared spectrometry (DSTU 8396:2015, 2017). The freezing point of milk was determined by the conductometric express method (DSTU 7671:2014, 2015), the content of somatic cells – by express flow cytometry (DSTU 7672:2014, 2015).

The influence of lactation on milk quality indicators was determined by dividing cows of the control and experimental groups into gradations: ⩽ 100; 101-200; 201-300; 300 ⩾ differences between groups by gradation were determined, and correlation coefficients between lactation duration and milk quality indicators were established. Accordingly, the influence of lactation duration on the quality indicators of the first streams of milk in cows of the experimental group was determined. The influence of daily milk yield on milk quality indicators was determined by dividing cows of the control and experimental groups into gradations: ⩽ 25, 26-30, 31-35, 36 ⩾ kg and determined differences between groups by gradation, and established correlation coefficients between daily milk yield and milk quality indicators. Accordingly, the influence of daily milk yield on the quality indicators of the first streams of milk in cows of the experimental group was determined.

All experimental studies were conducted in accordance with modern methodological approaches, requirements and standards (DSTU ISO/IEC 17025:2019, 2021), Directive 2010/63/EC (2010) and the Procedure for conducting animal testing in research institutions (Law of Ukraine No. 249, 2012). The experiments were performed in accordance with the provisions of the European Convention for the Protection of Vertebrate Animals used for Experimental and other Scientific Purposes (1986).

RESULTS AND DISCUSSION

At the first stage of the experiment, a comparative analysis of milk quality indicators of cows of the control and experimental groups was carried out (Table 1). Milk quality indicators of cows in the control group corresponded to the state of mature milk in accordance with Table 1.

***Table 1**. Milk quality indicators of experimental cows*

Milk quality indicators	Control (n = 160)	Experimental (n = 56)
Fat,%	3.913 ± 0.041	1.404 ± 0.063
Protein,%	3.287 ± 0.029	3.351 ± 0.030
Whey+casein,%	3.481 ± 0.026	3.580 ± 0.030
Ratio (fat/protein)	1.197 ± 0.012	0.418 ± 0.017
Lactose,%	4.958 ± 0.013	4.839 ± 0.044
Dry matter,%	12.430 ± 0.055	10.212 ± 0.077
MSNF,%	8.516 ± 0.027	8.808 ± 0.059
Urea,%	23.031 ± 0.138	22.929 ± 0.225
Freezing point, °C	0.559 ± 0.001	0.529 ± 0.003
Somatic cell content (thous/ cm^3)	469.09 ± 64.286	1,223.643 ± 37.114

***Source:** compiled by the authors*

Analysis of the obtained data proved the probable difference between the milk quality indicators of the control and experimental groups of cows (p ⩾ 0.95). Thus, the fat content in the first streams of milk was almost three times lower than in the average samples – by an average of 2.509%. The protein content in the

control and experimental groups did not significantly differ, and therefore, the fat/protein ratio significantly differed in favour of the experimental group – by 0.779. The dry matter content was higher in the milk of cows in the control group by 2.218%. The indicator of the content of somatic cells in the first streams of milk in cows of the experimental group exceeded the control by more than 2.5 times – by 754,553 thous/cm^3 with a probability ($p \geqslant 0.99$). Other indicators of milk quality did not significantly differ from those of the control group. At the second stage of the experiment, all control animals and experimental cows were divided into groups on gradations according to lactation terms to determine the effect of the lactation stage on milk quality indicators. The results are shown in Tables 2-3.

***Table 4**. The Contribution of agroforestry practice to pesanggem household income*

Milk quality indicators	Lactation periods, days			
	⩽ 100 (n = 28)	101-200 (n = 56)	201-300 (n = 46)	300 ⩾ (n = 30)
Daily milk yield, kg	33.107 ± 0.916	28.107 ± 0.849	25.804 ± 0.983	28.700 ± 1.361
Fat,%	3.692 ± 0.064	3.889 ± 0.070	4.002 ± 0.075	4.030 ± 0.106
Protein,%	2.900 ± 0.040	3.253 ± 0.042	3.495 ± 0.046	3.389 ± 0.063
Whey+casein,%	3.130 ± 0.041	3.450 ± 0.038	3.659 ± 0.041	3.596 ± 0.060
Ratio (fat/protein)	1.276 ± 0.023	1.201 ± 0.022	1.147 ± 0.018	1.193 ± 0.027
Lactose,%	5.039 ± 0.021	4.968 ± 0.019	4.933 ± 0.025	4.900 ± 0.038
Dry matter,%	11.889 ± 0.091	12.391 ± 0.088	12.705 ± 0.096	12.587 ± 0.127
MSNF,%	8.197 ± 0.050	8.501 ± 0.038	8.702 ± 0.044	8.557v0.065
Urea,%	22.964 ± 0.315	22.804 ± 0,224	23.152 ± 0.262	23.333 ± 0.350
Freezing point, °C	-0.560 ± 0.002	-0.560 ± 0.002	-0.560 ± 0.002	-0.557 ± 0.003
Somatic cell content (thous/cm^3)	157,750 ± 15,600	524,482 ± 109,051	488,913 ± 118,921	625,900 ± 197,748

***Source:** compiled by the authors*

It was found that the milk quality indicators of cows of the control group fluctuated according to the lactation period. The influence of lactation duration on milk quality indicators is confirmed by indicators of the correlation coefficient. The highest daily milk yield was found in cows that were in the first trimester of lactation (33.107 ± 0.916 kg), the lowest – from 201 to 300 days (25.804 ± 0.983). This fact is confirmed by a fairly high negative association between the duration of lactation and daily milk yield (r = -0.622). The fat content of milk, on the contrary, increased with every 100 days of lactation, and a low positive correlation coefficient was observed between the lactation period and the fat content in milk (r = 0.293).

The lowest protein content in milk was observed in cows in the first trimester of lactation (2,900 ± 0.040%), the highest – from 201 to 300 days (3,495 ± 0.046%), the protein content in milk significantly correlated with the duration of lactation (r = 0.747). The correlation coefficient between fat and protein content in the milk of cows in the control group was quite significant (r = 0.497). The ratio of fat and protein content in the milk of cows in the control group was the lowest from 101 to 200 days of lactation, and the highest – at the end of lactation. Similarly to protein, the whey+-casein content index varied, and the protein content in milk significantly correlated with the duration of lactation (r =v0.687). Lactose levels, on the contrary, were higher in cows in the first trimester of lactation (5.039 ± 0.021%), however, there was no significant difference in this indicator in cows at different lactation periods. A negative correlation coefficient of average strength was found between the day of lactation and the lactose content (r = -0.403). The dry matter content, MSNF index, and urea content in the milk of control cows increased with the duration of lactation. However, the correlation coefficient was quite significant between the day of lactation and MSNF (r = 0.601) and between the day of lactation and the dry matter content (r = 0.514), and the urea content in milk did not actually correlate with the day of lactation (r = 0.075).

The freezing point of milk of cows in the control group exceeded the minimum requirements (-0.520°C) and was on average the same throughout lactation with limits of-0.494-0.585°C and negatively and slightly correlated with the duration of lactation (r = -0.108). The content of somatic cells was significantly lower in the first trimester of lactation (157,750 ± 15,600 thous/cm^3), and the highest – at the end of lactation. The content of somatic cells was slightly positively associated with the day of lactation (r = 0.130).

Indicators of the quality of the first streams of milk of cows of the experimental group also fluctuated according to the lactation time (Table 3). The highest daily milk yield was found in cows that were in the first trimester of lactation (33,500 ± 4,252 kg), the lowest – at the end of lactation (28,000 ± 3,000). A negative relationship was established between the duration of lactation and the daily milk yield of cows of the experimental group (r = -0.356).

***Table 3**. Indicators of the quality of the first streams of cow's milk at different stages of lactation*

Milk quality indicators	Lactation periods, days			
	⩽ 100 (n = 4)	101-200 (n = 37)	201-300 (n = 13)	300 ⩾ (n = 2)
Daily milk yield, kg	33,500 ± 4,252	32,784 ± 0,703	30,000 ± 1,160	28,000 ± 3,000
Fat,%	1.213 ± 0.145	1.341 ± 0.079	1.575 ± 0.122	1.830 ± 0.210
Protein,%	3.233 ± 0.107	3.294 ± 0.034	3.523 ± 0.057	3.505 ± 0.145
Whey+casein,%	3.458 ± 0.110	3.525 ± 0.034	3.753 ± 0.057	3.720 ± 0.150
Ratio (fat/protein)	0.379 ± 0.056	0.406 ± 0.022	0.449 ± 0.035	0.521 ± 0.038
Lactose,%	4.828 ± 0.281	4.886 ± 0.043	4.756 ± 0.115	4.525 ± 0.175
Dry matter,%	9.910 ± 0.212	10.151 ± 0.086	10.450 ± 0.194	10.390 ± 0.540
MSNF,%	8.698 ± 0.297	8.809 ± 0.057	8.875 ± 0.173	8.555 ± 0.325
Urea,%	22.500 ± 0.289	23.027 ± 0.304	23.000 ± 0.408	21.500 ± 0.500
Freezing point, °C	-0.525 ± 0.021	-0.532 ± 0.003	-0.523 ± 0.009	-0.509 ± 0.017
Somatic cell content (thous/ cm^3)	1,055,500 ± 81,974	1,227,270 ± 51,182	1,283,385 ± 54,164	1,104,500 ± 115,500

***Source:** compiled by the authors*

The indicator of fat content in the first streams of milk increased with the duration of lactation, these indicators positively correlate with each other to an average degree (r = 0.403). The correlation coefficient between fat and protein content in the first streams of milk of cows of the experimental group was at the level of r = 0.306. The lowest protein content in the first streams of milk was observed in cows in the first trimester of lactation (3,233 ± 0.107%), the highest – from 201 to 300 days (3,523 ± 0.057%). Similarly to the protein content, the whey+casein content index varied, it was the highest from 201 to 300 days (3.753 ± 0.057%). The effect of lactation duration on protein and whey+casein content in the first streams of milk is confirmed by positive indicators of the correlation coefficient (r = 0.517 and r = 0.509, respectively). The ratio of fat and protein content in the milk of cows in the control group was lowest at the beginning of lactation and increased with the duration of lactation. The lactose level was higher in cows lactating for 101-200 days (4.828 ± 0.281%), and the lowest at the end of lactation. According to the indicator of lactose content, a negative association was observed with the day of lactation (r = -0.334).

The content of dry matter and urea in the first streams of milk of cows of the experimental group increased unexpectedly with the duration of lactation, the correlation coefficients were insignificant, respectively r = 0.284 and r = -0.137. The freezing point of milk of cows in the control group exceeded the minimum requirements (-0.520°C) and was on average the same throughout lactation with limits of 0.494-0.585°C. The freezing point index was negatively correlated with the duration of lactation (r = -0.269). The somatic cell content was significantly lower in the first trimester of lactation (157,750 ± 15,600 thous/cm^3), and the highest – at the end of lactation. The MSNF index and the content of somatic cells in the first streams of milk practically did not depend on the day of lactation (r = -0.058 and r = 0.080, respectively).

At the next stage, milk quality indicators were studied depending on the level of milk productivity. 160 milk samples from cows of the control group were examined, the average daily productivity of which was 28.431 ± 0.540 kg of milk with limits lim = 12-41 kg. The largest proportion of cows had a daily milk yield of 31-35 kg (30.6%). The results of the experiment are shown in Table 4.

***Table 4**. Milk quality indicators of cows of the control group with different levels of daily milk yield*

Milk quality indicators	Daily milk yield, kg			
	⩽ 25 (n = 54)	26-30 (n = 32)	31-35 (n = 49)	36⩾ (n = 25)
Fat,%	4.002 ± 0.077	3.988 ± 0.068	3.818 ± 0.060	3.786 ± 0.116
Protein,%	3.551 ± 0.041	3.365 ± 0.053	3.088 ± 0.037	2.978 ± 0.050
Whey+casein,%	3.699 ± 0.041	3.605 ± 0.052	3.317 ± 0.038	3.207 ± 0.051
Ratio (fat/protein)	1.126 ± 0.016	1.192 ± 0.023	1.240 ± 0.018	1.274 ± 0.037
Lactose,%	4.904 ± 0.025	4.994 ± 0.017	5.015 ± 0.018	4.987 ± 0.024
Dry matter,%	12.734 ± 0.100	12.610 ± 0.095	12.188 ± 0.080	12.045 ± 0.134
MSNF,%	8.734 ± 0.043	8.621 ± 0.053	8.368 ± 0.041	8.258 ± 0.052
Urea,%	23.149 ± 0.295	23.063 ± 0.284	22.878±0.210	22.880 ± 0.367
Freezing point, °C	0.558 ± 0.002	0.564 ± 0.001	0.561 ± 0.002	0.557 ± 0.002
Somatic cell content (thous/cm^3)	570,128 ± 141,494	338,563 ± 108,565	337,592 ± 84,863	419,600 ± 127,863

***Source:** compiled by the authors*

Fluctuations in milk quality indicators of cows of the control group depending on the level of daily milk yield were established. Thus, the fat content in milk was highest in cows with the lowest daily milk yield, and the lowest in cows with the highest daily milk yield ($p \geqslant 0.95$). The correlation coefficient between these indicators was respectively negative and amounted to r=-0.240. The protein and whey+casein content in the milk of cows in the control group varied with a similar trend, but with a significantly higher negative correlation coefficient (r = -0.673 and r = -0.573, respectively). The ratio of fat to protein was highest in cows with a daily milk yield of 26-30 kg of milk, and the lowest in cows with the lowest daily milk yield (⩽ 25 kg).

The lactose content in milk increased with an increase in daily milk yields, it was highest in cows with a milk yield of 31-35 kg per day. Calculation of the correlation coefficient established a positive level of association between daily milk yield and lactose content (r = 0.435). The dry matter content in milk was unexpectedly higher in cows with the lowest daily milk yield, although signs with average bond strength were negatively correlated with each other (r = -0.423). It is logical that the MSNF index also varied with a similar trend, it was highest in cows with the lowest daily milk yield and negatively correlated with it at the level of r = -0.496.

The urea content was not significantly different in cows with different levels of daily milk yield, the correlation coefficient was negative and insignificant (r = -0.112). The freezing point index did not change much in cows with different levels of daily milk yield and positively slightly correlated with this trait (r = 0.174). The highest content of somatic cells was observed in cows with a minimum daily milk yield (852.087 ± 232.773 thous/cm^3), the lowest – in cows with a daily milk yield of 26-35 kg. The correlation coefficient was correspondingly negative, although low (r = -0.195). Indicators of the quality of the first streams of milk were studied in cows of the experimental group with different levels of milk productivity (Table 5).

***Table 5**. Quality indicators of the first streams of milk from cows of the experimental group with different levels of daily milk yield*

Milk quality indicators	Daily milk yield, kg			
	⩽ 25 (n = 5)	26-30 (n = 9)	31-35 (n = 28)	36 ⩾ (n = 14)
Fat,%	1.554 ± 0.134	1.561 ± 0.172	1.368 ± 0.072	1.322 ± 0.168
Protein,%	3.446 ± 0.077	3.434 ± 0.078	3.399 ± 0.038	3.166 ± 0.054
Whey+casein,%	3.666 ± 0.075	3.668 ± 0.076	3.625 ± 0.039	3.401 ± 0.055
Ratio (fat/protein)	0.449 ± 0.030	0.454 ± 0.048	0.402 ± 0.021	0.416 ± 0.048
Lactose,%	4.488 ± 0.178	4.834 ± 0.102	4.851 ± 0.065	4.943 ± 0.055
Dry matter,%	10.042 ± 0.310	10.433 ± 0.202	10.246 ± 0.096	10.060 ± 0.171
MSNF,%	8.790 ± 0.230	8.872 ± 0.148	8.879 ± 0.088	8.738 ± 0.087
Urea,%	22.000 ± 0.447	23.333 ± 0.601	22.679 ± 0.313	23.500 ± 0.466
Freezing point, °C	0.503 ± 0.015	0.531 ± 0.008	0.530 ± 0.005	0.534 ± 0.004
Somatic cell content (thous/cm^3)	1,345,600 ± 103,982	1,289,667 ± 98,660	1,219,179 ± 49,270	1,146,571 ± 84,289

***Source:** compiled by the authors*

It was found that in the first streams of milk there are also fluctuations in quality indicators, depending on the daily milk yield. Thus, the fat content in the first streams of milk is highest in cows with a milk yield of ⩾ 30 kg. The correlation coefficient between daily milk yield and fat content in the first streams of milk was negative and low (r = -0.117). The protein and whey+casein content in the first streams of milk were highest in cows with a daily productivity of up to 30 kg inclusive. Accordingly, these indicators were negatively correlated with daily milk yield with the same correlation coefficient (r = -0.385). The ratio (fat/protein) was highest in the first streams of milk of cows with a daily milk yield of up to 30 kg inclusive.

The lactose content in the first streams of milk increased with an increase in daily milk yields, it was highest in cows with a daily milk yield of 36 kg or more. Calculation of the correlation coefficient established a positive level of association between daily milk yield and lactose content in the first streams of milk (r = 0.260). The dry matter content in the first streams of milk was incredibly high in cows with a daily milk yield of 26-30 kg, the signs did not actually correlate with each other (r = -0.078). The MSNF index in the first streams of milk was almost the same in cows of all gradations, these indicators did not actually correlate with each other (r = -0.023).

The urea content in the first streams of milk of experimental cows did not significantly differ in cows with different levels of daily milk yield, the signs are not actually related (r = 0.016). The freezing point of the first streams of milk did not change much in cows with different levels of daily milk yield and positively slightly correlated with this feature (r = 0.205). The highest content of somatic cells in the first streams of milk was observed in cows with a minimum daily milk yield (1345,600 ± 103,982 thous/cm^3), the lowest – in cows with the highest daily milk yield. The

correlation coefficient was respectively negative and low, although higher than that of cows in the control group (r = -0.238). The indicator of somatic cell content requires special attention when assessing milk quality, so the correlation coefficients of this feature with other indicators of milk quality of the control and experimental groups of cows were calculated to establish the patterns of influence (Table 6).

***Table 6**. Correlation coefficients (r) between the content of somatic cells (thous/cm³) with milk productivity and quality traits*

Relationship of the somatic cell content indicator with signs of milk productivity and quality	Correlation coefficient (r)	
	cow groups	
	control (n = 160)	experimental (n = 56)
Duration of lactation, days	0.130	0.080
Daily milk yield, kg	-0.195	-0.238
Fat,%	-0.044	-0.141
Protein,%	0.155	0.188
Whey+casein,%	0.145	0.200
Lactose,%	-0.481	0.137
Dry matter,%	-0.068	0.071
MSNF,%	-0.072	0.244
Urea,%	-0.063	0.153
Freezing point, °C	-0.489	0.158

***Source:** compiled by the authors*

It was found that the content of somatic cells in milk is quite significantly negatively associated with the indicators of lactose content and freezing point of milk, to a lesser extent – with daily milk yield, and positively – with the duration of lactation, protein and whey+casein content. In the first streams of milk, the correlation coefficients for milk productivity and quality did not exceed 0.250. The highest somatic cell content was positively correlated with the MSNF index, protein and whey+-casein content, freezing point, urea content, and negatively correlated with daily milk yield and fat content.

Thus, it can be argued that the latest data on the quality of milk and its first streams have been obtained, depending on the duration of lactation and the amount of daily milk yield. Positive and negative relationships between traits were established, including correlations of somatic cell content with other indicators of milk productivity and quality. The need to separate the first streams of milk from the main milk yield has been experimentally proved, which helps to reduce the content of somatic cells in milk by three times and improve some quality indicators.

The study of milk quality is a topic of interest to many researchers and consumers of dairy products. The main criteria for milk quality that the EU pays attention to are total bacterial count, somatic cell count, freezing point, fat and protein content. Thus, using the multi-platform approach, C. Connolly *et al.* (2023) found that the metabolomic profile of cow milk at the beginning of lactation is markedly different from that in the middle and end of lactation. R. Feliciano *et al.* (2023) established seasonal patterns of milk quality indicators (fat and protein content) in different weather conditions throughout the year. However, A. Palii *et al.* (2020), J. Magan *et al.* (2021) link seasonal changes in milk quality primarily to the cow's diet. J. Cole *et al.* (2023) investigated the effect of the season and stage of lactation on milk quality parameters and found that fat, protein, and lactose content vary depending on the development of lactation. G. Huculak (2019) proved that lactation affects the fat content of milk. P. Lacková *et al.* (2023) proved the seasonality of milk quality indicators. C. Hurtaud *et al.* (2020) proved changes in milk quality during milking – from the beginning to the end, lactose and protein content decreased, while fat content increased. This fact is confirmed by studies of the first streams of milk, in which the fat content is lower, and the protein content is higher.

The probable difference between the indicators of milk quality and the quality of milk of the first streams is proved. Thus, the fat content in the first streams of milk was almost three times lower than in the average samples, and the dry matter content was 2.218% higher in the milk of cows in the control group. The indicator of the content of somatic cells in the first streams of milk in cows of the experimental group exceeded the control almost three times – by 754,553 thous/cm³ with probability. A significant effect of the lactation day on the content of protein, lactose, dry matter, MSNF was experimentally proven, and the fat content of milk increased with every 100 days of lactation. The freezing point index was negatively correlated with the duration of lactation. The somatic cell content was significantly lower in the first trimester of lactation and highest at the end of lactation. The duration of lactation was negatively correlated with the indicator of daily milk yield. The freezing point indicator was slightly negative, and the content of somatic cells is slightly positively associated with the day of lactation. The data obtained were consistent with research (Connolly *et al.,* 2023) on

the influence of the lactation stage on the level of milk yield and milk quality indicators.

In studies of the parameters of the first streams of milk, the indicator of fat, protein, and whey+casein content increased with the duration of lactation, and the lactose content decreased with the development of lactation. The MSNF index and the content of somatic cells in the first streams of milk practically did not depend on the day of lactation. Fluctuations in milk quality indicators of cows of the control group depending on the level of daily milk yield were established. Thus, the content of fat, protein, whey+casein, dry matter, MSNF, urea, somatic cells in milk was highest in cows with the lowest daily milk yield. The lactose content, on the contrary, was higher in cows with a high level of daily milk yield. The freezing point indicator did not change much in cows with different levels of daily milk yield. In the first streams of milk, fluctuations in quality indicators are also established, depending on the daily milk yield.

Somatic milk cells are a mixture of milk-producing cells and immune cells. Somatic cells enter milk during the milking process, and their number is used all over the world to determine the quality of milk and the health of cows. It is known that the content of somatic cells in milk depends on many factors: environmental conditions, content, productivity level, duration and stage of lactation, etc. (Gerun *et al.,* 2020; Toghdory *et al.,* 2022). Regular monitoring of the content of somatic cells in milk is especially important in the subclinical course of mastitis. The lower the content of somatic cells in milk, the higher its quality and shelf life. In EU member states, the average actual somatic cell count has not exceeded 200,000/ml for more than twenty years. The level of dependence of the indicator of the content of somatic cells in milk and the first streams of milk on the indicators of productivity and quality of milk is established. A negative relationship was determined between the content of somatic cells in milk with the lactose content, freezing point and daily milk yield, and a positive relationship with the duration of lactation, protein and whey+casein content. In the first streams of milk, the content of somatic cells to a low degree positively correlated with the MSNF index, protein, whey+casein, freezing point, urea content, and negatively – with daily milk yield and fat content.

Thus, it has been experimentally proven that milk quality and first milk streams depend to varying degrees on the stage of lactation and daily milk yield. Positive and negative relationships between traits were established, including correlations of somatic cell content with other indicators of milk productivity and quality. The necessity of separating the first streams of milk from the main milk yield has been proved, which allows reducing the content of somatic cells in milk by three times and improving some quality indicators.

CONCLUSIONS

The probable difference between the milk quality indicators of the control and experimental group of cows is proved ($p \geq 0.95$). The fat content in the first streams of milk was 2.509% lower than in the average samples. The fat/protein ratio varied significantly in favour of the experimental group – by 0.779. The dry matter content was higher in the milk of cows in the control group by 2.218%. The indicator of the content of somatic cells in the first streams of milk in cows of the experimental group exceeded the control by more than 2.5 times – by 754,553 thous/cm^3 with a probability ($p \geq 0.99$).

It was found that the indicators of the quantity and quality of milk and its first streams in different degrees correlate with the stage of lactation: daily milk yield ($r = -0.622$), fat content ($r = 0.293$), protein ($r = 0.747$), lactose ($r = -0.403$), dry matter ($r = 0.514$), MSNF ($r = 0.601$). The correlation coefficient between fat and protein content in the milk of cows in the control group was quite significant ($r = 0.497$), the ratio of fat and protein content was the lowest from 101 to 200 days of lactation, and the highest – at the end of lactation. The freezing point index exceeded the minimum requirements (-0.520°C) throughout lactation, negatively and slightly correlated with the duration of lactation ($r = -0.108$). The content of somatic cells was significantly lower in the first trimester of lactation (157,750 ± 15,600 thous/cm^3), and the highest – at the end of lactation.

The relationship between the duration of lactation and milk quality indicators in the first milk flows was proved: fat content ($r = 0.403$), protein ($r = 0.517$), whey+casein ($r = 0.509$), lactose ($r = -0.334$) freezing point ($r = -0.269$). The somatic cell content was significantly lower in the first trimester of lactation (157,750 ± 15,600 thous/cm^3), and the highest – at the end of lactation. The relationship of milk quality indicators depending on the level of daily milk yield was established: fat content ($r = -0.240$), protein ($r = -0.673$), whey+casein ($r = -0.573$), lactose ($r = 0.435$), dry matter ($r = -0.423$), MSNF ($r = -0.496$), freezing point ($r = 0.174$), somatic cells ($r = -0.195$). The level of association with the level of daily milk yield with the quality of milk of the first streams was slightly different: with the content of fat ($r = -0.117$), protein ($r = -0.385$), whey+casein ($r = -0.385$), lactose ($r = 0.260$), dry matter ($r = -0.078$), MSNF ($r = -0.023$), freezing point ($r = 0.205$), somatic cell content ($r = -0.238$).

It was found that the content of somatic cells in milk is quite significantly negatively associated with the indicators of lactose content and freezing point of milk, to a lesser extent – with daily milk yield, and positively – with the duration of lactation, protein and whey+casein content. In the first streams of milk, the correlation coefficients for milk productivity and quality did not exceed 0.250. The highest somatic cell content was positively

correlated with the MSNF index, protein and whey+casein content, freezing point, urea content, and negatively correlated with daily milk yield and fat content. The prospect of further studies is to identify a wider range of factors affecting milk quality, especially genetic, technological, and environmental factors that affect the content of somatic cells in milk of different conditions.

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CONFLICT OF INTEREST

None.

REFERENCES

[1] Cassandro, M. (2020). Animal breeding and climate change, mitigation and adaptation. *Journal of Animal Breeding and Genetics,* 137(2), 121-259. doi: 10.1111/jbg.12469.

[2] Chernyavska, T.O. (2023). Study of the influence of factors on the content of somatic cells in milk. *Bulletin of Sumy National Agrarian University. The Series: Livestock*, 4, 72-76. doi: 10.32782/bsnau.lvst.2023.4.8.

[3] Cole, J.B., Makanjuola, B.O., Rochus, C.M., van Staaveren, N., & Baes, Ch. (2023). The effects of breeding and selection on lactation in dairy cattle. *Animal Frontiers*, 13(3), 62-70. doi: 10.1093/af/vfad044.

[4] Connolly, C., Yin, X., & Brennan, L. (2023). Impact of lactation stage on the metabolite composition of bovine milk. *Molecules*, 28(18), article number 6608. doi: 10.3390/molecules28186608.

[5] Correa-Calderón, A., Avendaño-Reyes, L., López-Baca, Á.M., & Macías-Cruz, U. (2022). Heat stress in dairy cattle with emphasis on milk production and feed and water intake habits. Review. *Revista Mechisapa de Ciencias Pecuarias*, 13(2), 488-509. doi: 10.22319/rmcp.v13i2.5832.

[6] Directive 2010/63/EU of the European Parliament and of the Council "On the Protection of Animals Used for Scientific". (2010, September). Retrieved from https://www.fao.org/faolex/results/details/ru/c/LEXFAOC098296/.

[7] DSTU 7671:2014. (2015). *Cow's milk. Determining the freezing point by the conductometric method (express method)*. Retrieved from https://online.budstandart.com/ua/catalog/doc-page.html?id_doc=85545.

[8] DSTU 7672:2014. (2015). *Cow's milk. Determination of the number of somatic cells by flow cytometry (express method)*. Retrieved from https://online.budstandart.com/ua/catalog/doc-page?id_doc=82402.

[9] DSTU 8396:2015. (2017). *Cow's milk. Determination of the mass fraction of fat, protein, lactose, dry substances by infrared spectrometry (express method)*. Retrieved from https://online.budstandart.com/ua/catalog/doc-page.html?id_doc=75412.

[10] DSTU ISO 707:2002. (2003). *Milk and dairy products. Guidelines for sampling*. Retrieved from https://online.budstandart.com/ua/catalog/doc-page?id_doc=67272.

[11] DSTU ISO/IEC 17025:2019. (2019). *General requirements for the competence of testing and calibration laboratories*. Retrieved from https://online.budstandart.com/ua/catalog/doc-page.html?id_doc=88724.

[12] DSTU ISO/IEC 17025:2019. (2021). *General requirements for the competence of testing and calibration laboratories*. Retrieved from https://online.budstandart.com/ua/catalog/doc-page.html?id_doc=88724.

[13] European convention for the protection of vertebrate animals used for experimental and other scientific purposes. (1986). Retrieved from https://rm.coe.int/168007a67b.

[14] Feliciano, R.J., Bou´e, G., Mohssin, F., Hussaini, M.M., & Membr´e, J.-M. (2023). Raw milk quality in large-scale farms under hot weather conditions: Learnings from one-year quality control data. *Journal of Food Composition and Analysis,* 117, article number 105127. doi: 10.1016/j.jfca.2023.105127.

[15] Feliciano, R.J., Boué, G., & Membré, J-M. (2020). Overview of the potential impacts of climate change on the microbial safety of the dairy industry. *Foods,* 9(12), article number 1794. doi: 10.3390/foods9121794.

[16] Gerun, I.W., Sklyar, O.I., & Musiienko, O.V. (2020). The influence of milk production technology on its quality and safety. *Bulletin of the Sumy National Agrarian University, Series "Veterinary Medicine",* 4(51), 17-22. doi: 10.32845/bsnau.vet.2020.4.3.

[17] Giannuzzi, D., Capra, E., Bisutti, V., Vanzin, A., Marsan, P.A., Cecchinato, A., & Pegolo, S. (2023). Methylome-wide analysis of milk somatic cells upon subclinical mastitis in dairy cattle. *Journal of Dairy Science*, 107(3), 1805-1820. doi: 10.3168/jds.2023-23821.

[18] Hayes, E., Wallace, D., O'Donnell, C., Greene, D., Hennessy, D. , O'Shea, N., Tobin, J.T., & Fenelon, M.A. (2023). Trend analysis and prediction of seasonal changes in milk composition from a pasture based dairy research herd. *Journal of Dairy Science,* 106(4), 2326-2337. doi: 10.3168/jds.2021-21483.

[19] Huculak, G. (2019). Dependence of milk productivity Holstein cows on the duration of lactation period and organism's physiological activity. *Bulletin of Sumy National Agrarian University. The Series: Livestock*, 1-2(36-37), 54-57. doi: 10.32845/bsnau.lvst.2019.1-2.8.

[20] Hurtaud, C., Dutreuil, M., Vanbergue, E., Guinard-Flament, J., Herve, L., & Boutinaud, M. (2020). Evolution of milk composition, milk fat globule size, and free fatty acids during milking of dairy cows. *JDS Communications*, 1(2), 50-54. doi: 10.3168/jdsc.2020-18473.
[21] Jeon, E., Jang, S., Yeo, J-M., Kim, D-W., & Cho, K. (2023). Impact of climate change and heat stress on milk production in Korean Holstein cows: A large-scale data analysis. *Animals*, 13(18), article number 2946. doi: 10.3390/ani13182946.
[22] Lacková, P.T., Maskaľová, I., Vajda, V., & Bujňák, L. (2023). Evaluation of nutrition according to milk metabolites and components in seasonal dependence in dairy cows. *Folia Veterinaria*, 67(3), 11-17. doi: 10.2478/fv-2023-0022.
[23] Law of Ukraine No. 249 "On the Procedure for Carrying out Experiments and Experiments on Animals by Scientific Institutions". (2012, March). Retrieved from https://zakon.rada.gov.ua/laws/show/z0416-12#Text.
[24] Lutsenko, M., Halai, O., Legkoduh, V., Lastovska, I., Borshch, O., & Nadtochii, V. (2021). Milk production process, quality and technological properties of milk for the use of various types of milking machines. *Acta Scientiarum. Animal Sciences*, 43(1), article number e51336. doi: 10.4025/actascianimsci.v43i1.51336.
[25] Magan, J.B., O'Callaghan, T.F., Kelly, A.L., & McCarthy, N.A. (2021). Compositional and functional properties of milk and dairy products derived from cows fed pasture or concentrate-based diets. *Comprehensive Reviews in Food Science and Food Safety,* 20(3), 2769-2800. doi: 10.1111/1541-4337.12751.
[26] Nzeyimana, J.B., Fan, C., Zhuo, Z., Butore, J., & Cheng, J. (2023). Heat stress effects on the lactation performance, reproduction, and alleviating nutritional strategies in dairy cattle, a review. *Journal of Animal Behaviour and Biometeorology,* 11(3), article number e2023018, doi: 10.31893/jabb.23018.
[27] Order of the Ministry of Agrarian Policy and Food of Ukraine No. 118 "On Approval of Requirements for Safety and Quality of Milk and Dairy Products". (2019, March). Retrieved form https://zakon.rada.gov.ua/laws/show/z0593-19#Text.
[28] Palii, A.P., Paliy, A.P., Rodionova, K.O., Zolotaryova, S.A., Kushch, L.L., Borovkova, V.M., Kazakov, M.V., Pavlenko, I.S., Kovalchuk, Y.O., Kalabska, V.S., Kovalenko, O.V., Pobirchenko, O.M., & Umrihina, O.S. (2020). Microbial contamination of cow's milk and operator hygiene. *Ukrainian Journal of Ecology*, 10(2), 392-397. doi: 10.15421/2020_113.
[29] Piddubna, L.M., Zakharchuk, L.V., & Korniichuk, D.O. (2021). Assessment of the influence of a complex of factors on milk productivity of cows. *Bulletin of the Sumy National Agrarian University*, *Series "Livestock",* 2(45), 113-120. doi: 10.32845/bsnau.lvst.2021.2.17.
[30] Quiédeville, S., Grovermann, C., Leiber, F., Cozzi, G., Lora, I., Eory, V., & Moakes, S. (2022). Influence of climate stress on technical efficiency and economic downside risk exposure of EU dairy farms. *The Journal of Agricultural Science,* 160, 289-301. doi: 10.1017/S0021859622000375.
[31] Regulation (EU) of the European Parliament and of the Council No. 853/2004 "On the Establishment of Special Hygiene Rules for Food Products of Animal Origin". (2004, June). Retrieved from https://zakon.rada.gov.ua/laws/show/994_a99#Text.
[32] Ruegg, P.L. (2022). The bovine milk microbiome – an evolving science. *Domestic Animal Endocrinology,* 79, article number 106708. doi: 10.1016/j.domaniend.2021.106708.
[33] Tančin, V., Mikláš, Š., Uhrinčať, M., & Mačuhová, L. (2020). Factors affecting raw milk quality of dairy cows under practical conditions. *Potravinarstvo Slovak Journal of Food Sciences,* 14, 744-749. doi: 10.5219/1336.
[34] Toghdory, A., Ghoorchi, T., Asadi, M., Bokharaeian, M., Najaf, M., & Nejad, J.G. (2022). Effects of environmental temperature and humidity on milk composition, microbial load, and somatic cells in milk of holstein dairy cows in the northeast regions of Iran. *Animals*, 12(18), article number 2484. doi: 10.3390/ani12182484.
[35] Vieira, R.K.R., Rodrigues, M., Silva Santos, P.K., Medeiros, N.B.C., Cândido, E.P., & Rodrigues, M.D.N. (2022). Risk factors associated with the bovine subclinical mastitis in an Amazon micro-region. *Tropical Animal Health and Production*, 54, article number 356. doi: 10.1007/s11250-022-03354-w.

Визначення показників якості молока і його перших цівок залежно від стадії лактації та добового надою

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Анотація. Актуальність досліджень полягає у вирішенні проблеми якості молока корів і впливу на параметри молока факторів стадії лактації і добового надою, а також встановлення зв'язків між вмістом соматичних клітин у молоці та іншими параметрами молока. Мета роботи – визначення впливу стадії лактації і добового надою на показники якості молока і його перших цівок, а також встановлення зв'язків вмісту соматичних клітин з іншими показниками якості молока і його перших цівок. Методи дослідження – зоотехнічні (підбір груп, організація досліду, визначення молочної продуктивності, оцінювання стадії лактації, рівня надоїв, контрольні доїння), біохімічні (визначення основних показників якості молока), статистичні, математичні. Встановлено вірогідну різницю між показниками якості молока у добовому надої молока та у перших трьох цівках молока (p≥0,95), отже експериментально доведено необхідність відокремлення перших цівок молока від основного надою. Встановлено, що показники кількості і якості молока і його перших цівок у різних ступенях корелюють із стадією лактації, найбільший добовий надій молока встановлено у корів, що перебували на першому триместрі лактації. Встановлено коливання показників якості молока і його перших цівок залежно від рівня добового надою. Встановлено, що вміст соматичних клітин у молоці досить значно негативно пов'язаний з показниками вмісту лактози і точки замерзання молока, у меншій мірі – з добовим надоєм, і позитивно – із тривалістю лактації, вмістом білку і протеїну. У перших цівках молока коефіцієнти кореляції із продуктивності та якості молока не перевищував 0,250. Найбільше вміст соматичних клітин позитивно корелював з показником COMO, вмістом протеїну, білка, точкою замерзання, вмістом сечовини, негативно – із добовим надоєм і вмістом жиру. Результати роботи можна використовувати у господарствах з виробництва молока та при плануванні племінної роботи з метою поліпшення якісних характеристик молока селекційним шляхом

Ключові слова: молочні корови; параметри якості молока; стадія лактації; добовий надій; вміст соматичних клітин