The Influence of Somatic Cell Count in Milk on Its Composition During the Summer Period

Utjecaj broja somatskih stanica na kemijski sastav mlijeka tijekom ljetnog razdoblja

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THE INFLUENCE OF SOMATIC CELL COUNT IN MILK ON ITS COMPOSITION DURING THE SUMMER PERIOD

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SUMMARY

The aim of our paper was to study the relationship between somatic cell count, milk productivity, and specific technological parameters of the milking process in cows during the summer period. The research was conducted on a commercial farm in the central part of Ukraine from June to August 2024 on the Holstein cows with 1 to 5 lactations. Milk analysis was performed in a commercial laboratory using Bentley Instruments equipment. The following was analyzed: fat content (FC, %), protein content (PC, %), lactose content (LC, %), somatic cell count (SCC, thsd./cm^3), and milk urea nitrogen (MUN, mg/100 ml). General linear model (GLM) and correlation analysis were applied. To analyze the influence of the "group of SCC" factor on the milk composition, all studied milk samples were divided into three groups according to the SCC in them: 1) ≤300; 2) 300–500; 3) ≥500. There was an established negative correlation between the LC, somatic cell score (SCS, -0.387, $p < 0.001$) and single milk yield (-0.225, $p < 0.001$). It was found that most traits, such as the FC, F/P, and MUN concentrations, increased in August if compared to the other summer months. The SCS decreased every month during the summer and was lowest in August (3.04±0.048).

Keywords: dairy cows, somatic cells, selection traits, lactose, GLM

INTRODUCTION

Udder diseases are generally the most common cause of cow culling on farms around the world (Rilanto et al., 2020; Thomsen and Houe, 2023). Mastitis is one of the most common udder diseases on dairy farms, leading to significant losses (Zhuk et al., 2022). It is therefore widely monitored on cattle farms (Sharma et al., 2011), as well as on the goat and sheep farms (Molina et al., 2010; Zazharska, 2024). One indicator of the health of a cow's mammary gland is the somatic cell count (SCC) in its milk (Cobirka et al., 2020; Ermetin et al., 2025), as an increase in the number occurs during mastitis (Sharma et al., 2011). It has been proven that an increase in somatic cell score (SCS) in milk leads to a decrease in gross margin from dairy cow breeding (Matvieiev et al., 2023) and causes changes in both the physicochemical and technological properties of milk (Li et al., 2014). All this affects the stability of high-quality milk production and prevents farmers from receiving the expected profit (Ruban et al., 2023a).

From the abovementioned information, it becomes clear why the scientists are conducting various studies aimed at reducing the SCC in milk, and this trait is present in dairy cattle breeding programs in many countries (Cole and VanRaden, 2018). The scientists have investigated a relationship between the SCC and linear type traits of cows (Zink et al., 2014), milk microbiota (Rodrigues et al., 2017), hoof diseases (Rodríguez et al., 2021), bedding type (Alanis et al., 2021), and the like.

It is known that the SCC in milk from the cows in a free-stall housing system is lower than in the cows in a tie-stall system (Neja et al., 2016). A relationship between a somatic cell number and productivity has been found (Ermetin et al., 2025). The high levels of stress associated with milk production in high-producing animals weaken their immunity, leading to an increase in the SCC in their milk (Mukherjee and Dang, 2011). A high

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SCC negatively affects not only the milk yield but also its composition (Cinar et al., 2015).

Among other factors, the stage of lactation also affects the SCC in milk (Sebastino et al., 2020). A correlation coefficient between milk yield and SCC at different stages of cow lactation varied from -0.063 to -0.213 ($p < 0.01$) in early and late lactation, respectively (Ermetin et al., 2024). An increase in the body condition score during calving is associated with a decrease in the SCS in the cows with the first and the second parity and an increase in the SCS in the third parity and older cows (Berry et al., 2007). It is worth noting that the manifestation of the trait is more influenced by the exogenous factors, since the heritability coefficient of SCS is low at 0.09 (Wei et al., 2021). Given the importance of the SCC levels in milk, a special index has been developed to predict a milk loss caused by an increase in the SCC content in milk (Jeretina et al., 2017). Temperature is an important factor. In the countries with a non-seasonal calving, the SCC was highest in spring and summer (Morse et al., 1988). Other researchers also indicate the influence of the season, noting a higher amount of SCC in milk in summer and spring than in winter (Bernabucci et al., 2015).

Milk contains a large number of components necessary for human nutrition (Dudásová, 2021; Ruban et al., 2023b); therefore, the study of their content dynamics during the summer months and the identification of a relationship between the SCC in milk and its quality parameters seems interesting and relevant. Our study investigated the relationship between somatic cell count, milk productivity, and specific technological parameters of the milking process in cows during the summer period.

MATERIAL AND METHODS

General Conditions

The study was conducted on a commercial farm in central Ukraine (48°57′47″N 30°7′57″ E). For the study, the Holstein cows of 1–5 lactations were selected. The animals were kept year-round in a low-cost housing facility barn for 400 head (100×32.1×10.5). The cows were milked in a milking parlor on a "carousel" installation with 80 milking places (Gea Farm Technologies, Germany). The animals were milked three times a day. A total mixed ration (TMR) was used for cows throughout the year.

The distribution of TMR took place twice a day, starting at 9:00 a.m. and 6:00 p.m., respectively. During the period from June to August 2024, 6,094 milk samples were collected.

Recorded traits

By the *DairyPlan C21* herd management software, we received the information about following values: cow's single milk yield (SMY, kg) during the second (middle) milking in the day, time of animal identification prior to milking, milking start time, and milking end time.

Based on the primary data, milking duration (MD, min) and average milk flow (AMF, kg/min) were calculated per milking as the single milk yield divided by MD, as it was performed in the research by Berry et al. (2013).

An average milk sample was taken by the company's employees every month during the control milkings. The analysis of the milk samples was carried out in the laboratory of the Lviv Agricultural Advisory Service using the Bentley Instruments equipment. (DairySpec and SomaCount), UK. Hereby, the content of fat (FC, %), protein (PC, %), lactose (LC, %), somatic cell count (SCC, thousands/cm^3), and milk urea nitrogen (MUN, mg/100 ml) were determined. All indicators were determined according to the methods, as specified in the manual (Bentley Instruments, 2015).

To assess the overall milk yield level according to the energy corrected milk (ECM, kg), the special technique (Sjaunja et al., 1990) was used according to the following formula:

$$ECM = (FC, \% \times 383 + PC, \% \times 242 + LC, \% \times 165.4 + 20.7)/3140) \times \text{milk yield, kg}$$

This avoided a bias of the mean by extremely high raw SCC (Kul et al., 2019). The actual SCC was translated into somatic cell score (SCS) using a log10 transformation (Wiggans and Shook, 1987), as follows:

$$SCS=\log2(SCC/100{,}000)+3$$

To ensure statistical analysis, the milk samples amount (6,094 samples) was divided into three groups according to the SCC in it: Group 1 – < 300 thousand/cm^3 (4552 observation); Group 2 – 300-500 thousand/cm^3 (454 observation); Group 3 – > 500 thousand/cm^3 (1088 observation).

Statistical analysis

The data was analyzed using the *IBM SPSS STATISTICS 25* software package. In our paper, we performed the calculations applying the general linear model (GLM), which took into account the following factors:

$$y_{ij} = \mu + mm_i + gSCC_j + e_{ij},$$

where y_{jm}– observation; μ – general mean; mm_i– effect of i^{th} month of milking; $gSCC_j$– effect of j^{th} group of SCC e_{ij}; – random error.

The correlation analysis was also carried out. The significance of influence of factors was determined using Fisher's test.

The degree of influence was derived as follows (Kerlinger, 1966):

$$\eta^2 = \frac{SS_{effect}}{SS_{total}},$$

where SS_{effect}– sum of squares for the effect studied;

SS_{total}– total sum of squares.

The means were compared with Duncan's multiple range test.

RESULTS AND DISCUSSION

As a result of the research, the influence of the month of milking factors, the SCC, and the interaction of factors on the indicators of milk quality and the trait of milk ability of cows (Table 1) was assessed. As shown in Table 1, the factor of the month of sampling significantly ($p < 0.001$; $p < 0.05$) influenced the analysis results for most of the evaluated traits, with the exception of the PC in milk ($p > 0.001$; $p > 0.05$). Simultaneously, the influence of the factors was not large and ranged from 0.1 to 1.4% for the traits SCS, SMY, and AMF, respectively. Among all the traits, the greatest influence of the month factor was found for the MUN (7.6%). A similar result was observed when assessing the influence of the factor "SCC group." Actually, most traits were significantly influenced by this factor, but with a low degree of influence, which is less than 1.6%. An exception is the LC, for which the degree of influence was 10.7%. At the same time, no significant interaction effect was found for the abovementioned factors (month×SCC group) on most of the traits studied, except for the FC and PC in milk, at an exposure level of 0.1 to 0.2%.

Table 1. Significance (P) and the degree of influence (η^2, %) of individual factors on breeding traits

Tablica 1. Značajnost (P) i stupanj utjecaja (η^2, %) pojedinačnih čimbenika na uzgojna svojstva

Factor / *Čimbenik*	**Parameters** / *Pokazatelj*	**SMY**	**AMF**	**FC**	**PC**	**F/P**	**LC**	**MUN**	**ECM**	**SCS**
Month / *Mjesec*	Sign	*	***	***	n.s.	***	***	***	***	*
	η^2	0.1	1.4	0.4	0.1	0.7	0.5	7.6	0.3	0.1
SCC group / *SCC grupa*	Sign	***	***	n.s.	***	**	***	n.s.	***	-
	η^2	1.4	0.6	0.1	1.1	0.2	10.7	0.0	1.6	-
Month × SCCgroup	Sign	n.s.	n.s.	*	**	n.s.	n.s.	n.s.	n.s.	n.s.
	η^2	0.000	0.1	0.2	0.2	0.1	0.0	0.0	0.0	0.1

Note: *** – $p < 0.001$; ** – $p < 0.01$; * – $p < 0.05$; ns – not significant. SMY – single milk yield; AMF – average milk flow; FC – fat content; PC – protein content; F/P – fat-to-protein ratio; LC – lactose content; MUN – milk urea nitrogen; ECM – energy corrected milk; SCS – somatic cell score, SCC – somatic cell count.

The dynamics of changes in the studied traits in the summer months are shown in Table 2. As can be seen from the table, the cows milked in August had the highest MUN concentrations in milk, which was by 2.06 and 3.04 (mg/100 ml) higher than its content in June and July, respectively ($p < 0.05$). Other researchers also indicate the influence of the stage and month of lactation, as well as the parity on the MUN concentrations in the cow's milk. Similar results were obtained by Zhang et al. (2018) in the milk of cows of the second lactation, while the first-parity cows had the lowest MUN concentrations in August. It is also worth noting the change in the milk flow in cows during the summer period. Thus, the highest value of AMF was recorded in June (Table 2). The cows milked in June had an average milk flow 0.25 (l/min) faster than those milked in July and 0.20 (l/min) faster than those milked in August ($p<0.05$). The results obtained are confirmed by other studies (Berry et al., 2013), which established a significant ($p < 0.001$) effect of the lactation month factor on AMF. It was found that milk obtained in different summer months significantly differed in the number of SCS. These data, however, contradict the results of other authors (Chavarría et al., 2025), who found no significant difference between the SCC in milk produced in different periods of the year.

Table 2. The average values of the studied traits depending on the control-milking month

Tablica 2. Prosječne vrijednosti proučavanih obilježja ovisno o mjesecu kontrolne mužnje

Month / *Mjesec*	**n**	**SMY**	**AMF**	**FC**	**PC**	**F/P**	**LC**	**SCS**	**MUN**	**ECM**
June / *Lipanj*	2058	11.7 ± 0.08^{b}	2.62 ± 0.016^{a}	3.59 ± 0.017^{b}	3.32 ± 0.008^{a}	1.08 ± 0.005^{b}	4.70 ± 0.005^{a}	3.42 ± 0.048^{a}	10.26 ± 0.076^{b}	10.9 ± 0.07^{b}
July / *Srpanj*	2029	11.7 ± 0.07^{b}	2.37 ± 0.014^{c}	3.49 ± 0.016^{c}	3.27 ± 0.009^{b}	1.07 ± 0.004^{b}	4.65 ± 0.005^{b}	3.33 ± 0.046^{b}	10.18 ± 0.071^{b}	10.7 ± 0.06^{c}
August / *Kolovoz*	2007	12.2 ± 0.08^{a}	2.42 ± 0.015^{b}	3.69 ± 0.016^{a}	3.28 ± 0.00^{9}b	1.13 ± 0.00^{4}a	4.66 ± 0.005^{b}	3.04 ± 0.04^{8}c	13.22 ± 0.06^{2}a	11.5 ± 0.07^{a}
Total / Ukupno	6094	11.9±0.04	2.47±0.009	3.59±0.009	3.29±0.005	1.09±0.003	4.67±0.003	3.26±0.028	11.21±0.044	11.1±0.04

$^{a-c}$ - differences between different superscripts in the same column are significant ($P < 0.05$). SMY – single milk yield; AMF – average milk flow; FC – fat content; PC – protein content; F/P – fat to protein ratio; LC – lactose content; MUN – milk urea nitrogen; ECM – energy corrected milk; SCS – somatic cell score.

In our paper, we conducted a study of a relationship between the SCS and milk yield, milk quality indicators, and milkability traits of cows (Table 3). In particular, a tendency was found to decrease the LC with an increase in the SCS in milk. In the group with the highest SCC, the LC was averagely lower by 0.18 percentage points than in the group with the highest SCC content ($p < 0.05$).

Table 3. Average values of the traits studied depending on the group by the somatic cell count (SCC group)

Tablica 3. Prosječne vrijednosti proučavanih obilježja ovisno o skupini prema broju somatskih stanica (skupina SCC)

SCC group / *SCC grupa*	**SMY**	**AMF**	**FC**	**PC**	**F/P**	**LC**	**ECM**
1	12.1 ± 0.05^{a}	2.49 ± 0.010^{a}	3.58 ± 0.010^{b}	3.27 ± 0.005^{b}	1.10 ± 0.003^{a}	4.71 ± 0.003^{a}	11.3 ± 0.04^{a}
2	11.6 ± 0.18^{b}	2.48 ± 0.034^{a}	3.66 ± 0.036^{a}	3.34 ± 0.020^{a}	1.10 ± 0.010^{a}	4.64 ± 0.010^{b}	10.9 ± 0.16^{b}
3	11.0 ± 0.11^{c}	2.36 ± 0.024^{b}	3.59 ± 0.025^{b}	3.37 ± 0.016^{a}	1.07 ± 0.007^{b}	4.53 ± 0.008^{c}	10.2 ± 0.10^{c}
Total / *Ukupno*	11.9 ± 0.04	2.47 ± 0.009	3.59 ± 0.009	3.29 ± 0.005	1.09 ± 0.003	4.67 ± 0.003	11.1 ± 0.04

$^{a-c}$ - differences between different superscripts in the same column are significant ($P<0.05$). SMY – single milk yield; AMF – average milk flow; FC – fat content; PC – protein content; F/P – fat to protein ratio; LC – lactose content; ECM – energy corrected milk; SCC – somatic cell count.

The results are consistent with the data of other researchers, who indicated that the cows with the highest SCC in milk had the lowest lactose content (Ermetin et al., 2024), and a significant effect of somatic cell factor on MUN (Cinar et al., 2015) was also noted. In addition, the single midday milk yield of cows with the highest somatic cell content in milk was the lowest.

The analysis of the existing correlations provided an opportunity to further analyze the obtained data (Table 4). As can be seen from Table 4, the highest correlation was found between the ECM and MY traits ($r = 0.930$) and F/P and FC ($r = 0.829$), which is explained by the fact that the formula for calculating these traits includes the corresponding components.

A significant ($p < 0.001$) negative correlation was established between the LC and the content of other milk components (FC and PC).

Table 4. Correlation coefficients between the studied traits

Tablica 4. Koeficijenti korelacije između proučavanih obilježja

	SMY	**MD**	**AMF**	**FC**	**PC**	**F/P**	**LC**	**SCS**	**MUN**
MD	0.410^{***}								
AMF	0.687^{***}	-0.306^{***}							
FC	-0.347^{***}	-0.110^{***}	-0.281^{***}						
PC	-0.455^{***}	-0.194^{***}	-0.310^{***}	0.446^{***}					
F/P	-0.106^{***}	0.010	-0.132^{***}	0.829^{***}	-0.095^{***}				
LC	0.293^{***}	0.005	0.305^{***}	-0.098^{***}	-0.208^{***}	0.008			
SCS	-0.22^{5**}*	-0.12^{9**}*	-0.115^{***}	0.070^{***}	0.163^{***}	-0.017	-0.387^{***}		
MUN	0.011	0.063^{***}	-0.042^{***}	0.166^{***}	-0.061^{***}	0.205^{***}	$- 0.038^{***}$	$- 0.034^{**}$	
ECM	0.930^{***}	0.389^{***}	-0.635^{***}	-0.025*	-0.261^{***}	0.138^{***}	0.328^{***}	-0.222^{***}	0.051^{***}

Note: *** – $p < 0.001$; ** – $p < 0.01$; *– $p < 0.05$. SMY – single milk yield; MD – milking duration; AMF – average milk flow; FC – fat content; PC – protein content; F/P – fat to protein ratio; LC – lactose content; MUN – milk urea nitrogen; SCS – somatic cell score.

The obtained results indicate that, with an increasing SCS, there was a decrease in both the single-yield and ECM quantity, $r = -0.225$, $p < 0.001$ and $r = -0.222$, $p < 0.001$, respectively. Similar conclusions were derived by Kul et al. (2019) and Ermetin et al. (2025), in which the group with the highest somatic cell content in milk had the lowest daily yield. Other authors have reported a decrease in daily milk yield in the cows of the first, second, and third parities, with an increase in somatic cell content in milk (Rearte et al., 2022; Niemi et al., 2022). In addition, it was found that, with an increase in the number of somatic cells in milk, both the total duration of milking and the AMF decreased ($r = -0.129$ and -0.115 [$p < 0.01$]), respectively. In this research, a negative correlation was established between the SCS and LC ($r=0.387$), which coincides with other researchers' data (Forsbäck et al., 2010; Cinar et al., 2015; Vilas Boas et al., 2017; Alessio et al., 2021; Antanaitis et al., 2021). This is because the LC is an indicator of udder health (Fox et al., 2015) and is supported by the presence of negative genetic correlations between the LC and mastitis (Costa et al., 2024). The LC in milk is closely related to *Streptococcus agalactiae* as a causative agent of subclinical mastitis (Antanaitis et al., 2021). That is why, in the absence of a machine-learning algorithm model for SCC in the world practice, it was the LC that had the most significant weight for predicting subclinical mastitis (Ebrahimie et al., 2018).

CONCLUSIONS

The study results revealed that the milking month during the summer significantly influenced milk composition and some technological parameters of the milking process. It was found that most parameters/traits, such as the SMY, FC, ECM, F/P, and MUN, increased in August if compared to other summer months. Conversely, the parameters such as the LC, PC, and AMF decreased in August if compared to the beginning of summer. The SCS decreased every month during the summer and was lowest in August. Additionally, the cows with a higher SCC content in milk had the lowest lactose content and cow's single milk yield, which was also confirmed by the calculated correlation coefficients.

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UTJECAJ BROJA SOMATSKIH STANICA NA KEMIJSKI SASTAV MLIJEKA TIJEKOM LJETNOG RAZDOBLJA

Sažetak

Cilj rada bio je analizirati odnos između broja somatskih stanica, mliječne produktivnosti i pojedinih tehnoloških parametara postupka mužnje kod krava tijekom ljetnog razdoblja. Istraživanje je provedeno na komercijalnoj farmi u središnjoj Ukrajini tijekom lipnja, srpnja i kolovoza 2024. na kravama holsteinske pasmine s jednom do pet laktacija. Analiza mlijeka obavljena je u komercijalnome laboratoriju uporabom opreme tvrtke Bentley Instruments. Analizirani su sljedeći pokazatelji: udio masti (FC, %), udio bjelančevina (PC, %), udio laktoze (LC, %), broj somatskih stanica (SCC, tisuća/cm^3) te sadržaj dušika u ureji mlijeka (MUN, mg/100 ml). Primijenjeni su opći linearni model (GLM) i korelacijska analiza. Radi procjene utjecaja čimbenika „skupina prema SCC-u", svi su uzorci mlijeka razvrstani u tri skupine prema SCC vrijednosti: 1) ≤ 300, 2) 300 – 500 i 3) ≥ 500 tisuća/cm^3. Utvrđena je negativna korelacija između LC-a i skora broja somatskih stanica (SCS-a, −0,387, $p < 0,001$), kao i između SCS-a i jednokratnoga udoja (−0,225, $p < 0,001$). Nadalje, u kolovozu su se, u odnosu na ostale ljetne mjesece, povećale vrijednosti većine svojstava, primjerice FC-a, omjera masti i bjelančevina (F/P) te koncentracije MUN-a. Vrijednosti SCS-a smanjivale su se iz mjeseca u mjesec tijekom ljeta i bile su najniže u kolovozu (3,04 ± 0,048).

Ključne riječi: mliječne krave, somatske stanice, uzgojna svojstva, laktoza, GLM

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