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THE IMPACT OF INCREASED SOMATIC CELL COUNT ON COW MILK ACIDITY AND LACTOSE CONTENT

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Abstract

Milk quality is increasingly important for producers and consumers as it relates to processing, production, and price. The aim of the present study was to determine the relationship between somatic cells count, lactose content, and acidity of cow milk. A total number of 100 milk samples, from cows with mastitis were processed and analyzed. Increasing acidity and decreasing lactose content were correlated with an increased number of somatic cells in the collected milk samples. The lactose ratio decreased as the number of somatic cells in the milk increased, thus leading to an increase in the titratable acidity of the milk. It can be concluded that a higher number of somatic cells adversely affects milk quality and subsequently processing capacity. Lactose content and titratable acidity can be used as indicators as complimentary to monitor udder health and for early diagnosis of subclinical mastitis in milk cows.

Key words*: acidity, lactose, milk cow, number of somatic cells.*

INTRODUCTION

The quality of cow milk is a critical aspect of dairy production, with somatic cell count (SCC) being a key indicator of udder health and milk quality. Elevated SCC is associated with inflammatory processes in cows and reflects the udder health status and raw milk quality. In the case of clinical mastitis, it causes visibly abnormal milk and an alteration of the udder (Granaci et al., 2023; Schukken et al., 2003).

Subclinical mastitis, on the other hand, does not show any symptoms and can only be evidentiated by counting the somatic cells of a single cow or by analysing microbiological cultures (Ashraf et al., 2020; Hameed et al., 2007). Season, breed, age, condition of the mammary glands, lactation stage, and nutritional management are some variables that affect milk composition (Hristev et al., 2022).

Previous research has shown that the number of somatic cells, as well as the amount of protein and lactose in milk, have a significant impact on milk production (Chen et al., 2021; Pegolo et al., 2021; Rearte et al., 2022). According to Beni et al. (2018), physical damage to the milk-producing epithelial cells is the main cause of the decrease in milk output that occurs along with an increase in milk SCC. Damage to alveolar epithelial cells has also been proposed as a possible explanation for the lactose decrease. Because lactose plays an important role in maintaining milk's osmotic pressure, a decrease in its amount results in a considerable reduction in milk output. Furthermore, sodium chloride ions are transported from the circulation into milk to maintain the osmotic balance, boosting their overall content to an excessively high level (Alhussien et al., 2018; Neculai-Văleanu et al., 2022). Mastitis affects milk's composition, yield, and physical-chemical properties (Cunha et al., 2008). These modifications are linked to changes in the enzymatic activity of somatic cells or microorganisms in the infected mammary gland (Benić et al., 2018; Reis et al., 2013).

Sub-clinically infected cows have somatic cell counts greater than $2.0 x 10^5$ cells/mL (Miglior et al., 2007). Because mastitis infection alters the mammary glands' homeostasis, a drop in the amount of lactose in milk has been linked to an increase in somatic cells. According to Berglund et al. (2007), there is a correlation between a decrease in lactose levels (from 4.86 to 4.69%) and an increase in somatic cell count (from $3.1 x 10^4$ to $4.5 x 10^5$ somatic cells/mL) (Antanaitis et al., 2021).

Researchers have also noted that milk is the primary source of lactose utilized in industry and that lactose is widely employed in the food and pharmaceutical industries (Ferrari et al., 2004). Lactose is a disaccharide composed primarily of glucose and galactose molecules, accounting for about 40% of the total solids and 50% of the fat-free solids. The health of the udder, the cow's energy balance, and her metabolism all have an impact on the synthesis and concentration of lactose in milk (Antanaitis et al., 2021; Costa et al., 2019; Reis et al., 2013). Additionally, high SCC levels have been linked to decreased milk yield and altered milk components, including lactose. Furthermore, an increase in SCC has been associated with changes in milk acidity, as reflected by alterations in milk composition, such as increased NaCl concentration. These findings underscore the importance of understanding the impact of increased SCC on milk acidity and lactose content (Silva et al., 2018). Because of the lactic acid that bacteria produce during fermentation, cow milk has a mild acidity. Increased SCC has had a mixed effect on milk acidity, according to studies. Some studies suggest a modest rise in acidity with increased SCC, whereas others show no significant difference.

This inconsistency is most likely caused by a combination of factors, including the specific bacteria that cause mastitis, the degree of the inflammation, and individual cow variances (Navarro et al., 2021). The suggested ways that SCC is connected to acidity and lactose are complicated. They involve how inflammatory processes, enzyme activity, and the makeup of bacteria interact with each other. Understanding these mechanisms is crucial for developing mitigation strategies to minimize quality deterioration and the potential health risks associated with elevated SCC milk.

Elevated SCC might lead to lactose degradation by enzymes released from somatic cells or bacteria, resulting in lower lactose levels. This decrease can pose challenges for lactose-intolerant consumers and affect cheesemaking processes that rely on lactose fermentation.

The lactation stage and genetic factors have an impact on the fatty acid composition of milk, which can further alter the acidity and lactose content of the milk (Ben Fraj et al., 2023; Bobe et al., 2007). Additionally, the presence of particular fatty acids as well as other ingredients like minerals and amino acids can affect milk's overall nutritional value and acidity (Li et al., 2011). Although the detrimental effects of high SCC on milk composition-such as protein content and yield-have long been known, the impact on acidity and lactose concentration has received less attention. To close this gap, our study looked into possible connections between changes in these important milk components and elevated SCC.

The dry and wet seasons have a substantial impact on milk quality while also influencing the physicochemical properties of milk (Reis et al., 2013). This study investigates how increasing somatic cell count impacts lactose content and titratable acidity in milk samples from cows with mastitis, regardless of harvest season (warm or cold).

MATERIALS AND METHODS

Experimental Design

Samples were collected from Holstein dairy cows in a farm from north-eastern Romanian, during cold and warm seasons. Animals with high milk conductivity were identified using the loggings from AfiMilk system. The AfiMilk program is the most advanced software in the world for dairy farm management, and we can say that diagnosing subclinical mastitis is considerably easier when the cows' dynamic activity is correlated with the amount of produced milk, and electrical conductivity.

Before the collection of the milk samples, the udder and the milkers' hands were carefully cleansed with soap and water and disinfected with 70 percent ethyl alcohol. The first jets of milk were discarded, and then about 50 ml of milk were collected in sterile containers. The collected samples were analysed, the number of somatic cells, the lactose content, and the titrable acidity were assessed. The collected samples were transported under optimal temperature conditions to the analysis laboratory where to evaluate the number of somatic cells and the lactose content, they were heated in a water bath at 37^{o}C, and for the determination of titratable acidity, the samples were heated in a water bath at temperature of 22^{o} C.

Evaluation of the number of somatic cells in milk

There are several types of methods and equipment available for counting somatic cells in milk, including the direct microscopic cell count, which is used as a high-accuracy test. A quick technique to evaluate the number of somatic cells is SomaScope LFC 600/300.

Figure 1. Analyzer SomaScope LFC 600/300 (Original Image, Laboratory of Nutrition, Quality and Food Safety, R & D Station for Cattle Breeding Dancu, Iasi)

The automated Analyzer SomaScope LFC 600/300 was used to determine somatic cell count (SCC), a technique that offers the advantages of reducing analysis time (200 milk samples/hour), costs, and reagent consumption. The collected milk samples were heated in a water bath at 37ºC, maintained for approximately 30 minutes, stirred, and then analysed (Ariton et al., 2022). To obtain results, we ran a controlled experiment with a group of cows with varied SCC levels (> 4.0 x 10^5 cells/mL). Milk samples were collected in different seasons and tested for the number of somatic cells, lactose content, and level of acidity using standard methods.

Evaluation of the lactose content in milk

The automated analyzer - FTIR Lacto Scope 600/300 was used to determine Lactose content from samples collected. The solutions used for the analysis were: 0.01% Triton solution and 0.4% Decon solution. With this analyser, can determine the main constituents of milk (fat, protein, lactose, casein, urea).

Figure 2. Analyzer - FTIR LactoScope 600/300 (Original Image, Laboratory of Nutrition, Quality and Food Safety, R & D Station for Cattle Breeding Dancu, Iasi)

Evaluation titrable acidity of milk

The acidity of the milk is determined by an acid reaction involving free acids and salts, and it is an indicator of its freshness. Freshly milked milk has a somewhat acidic reaction, but it becomes more acidic with time due to microbial fermentation of lactose and its transformation into lactic acid. The acidity of the milk sample prepared for analysis is neutralized by titration with 0.1 N sodium hydroxide solution and phenolphthalein as an indicator (1%). Milk acidity is measured quantitatively using the titration method (standardized method) and expressed in Thörner degrees (ºT).

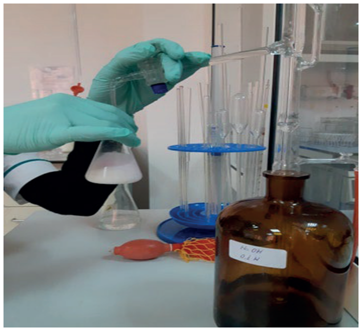

Figure 3. Determination of milk acidity (Original Image, Laboratory of Nutrition, Quality and Food Safety, R & D Station for Cattle Breeding Dancu, Iasi)

Milk acidity, in Thörner degrees, is calculated with the formula:

$$\text{Acidity } (°T) = 10 \times V$$

where:

V - is the volume of the 0.1 N sodium hydroxide solution used in the titration, in ml;

10 - is the volume of the product used, in ml.

As a result, the arithmetic means of three parallel determinations that meet the repeatability condition, values that fall within the range of 15-19 °T, is taken.

Data Analysis and Statistics

Statistical analysis was carried out to assess the relationship between milk parameters and the influence of season. Data on lactose content, acidity titrable, and SCCs were analyzed by one-way analysis processing done in Microsoft Excel, using ANOVA variance analysis test of variance (ANOVA). Pearson's correlation coefficients (r) were computed between total

SCC, milk lactose content and acidity using data from cold and warm season.

RESULTS AND DISCUSSIONS

The purpose of this study was to examine the relationship between somatic cell count (SCC), lactose content, and titrable acidity in both cold and warm seasons. Figure 4 shows the Dynamics of the tested parameters (SCC, Lactose and acidity) according to the collection season of milk samples from cows identified with an increased number of somatic cells (> 400,000 cells/mL).

The comparative analysis of the dynamics of the evaluated parameters according to the sampling season showed that the differences between the values that characterized the two seasons were distinctly significant for the number of somatic cells.

The data were processed statistically to determine the main statistical estimators (mean, variation, standard deviation, standard error of the mean, and coefficient of deviation).

The differences between the averages of the same parameters in the two seasons were calculated and expressed as relative deviations. The ANOVA test was also used to express the degree of significance of the differences between the values of the tested parameters and the seasons (Table 1).

A significant difference was observed between cold and warm seasons considering the SCC, lactose content, and titrable acidity. Moreover, a negative correlation (r = 0.731) was observed between lactose and SCC (Table 2).

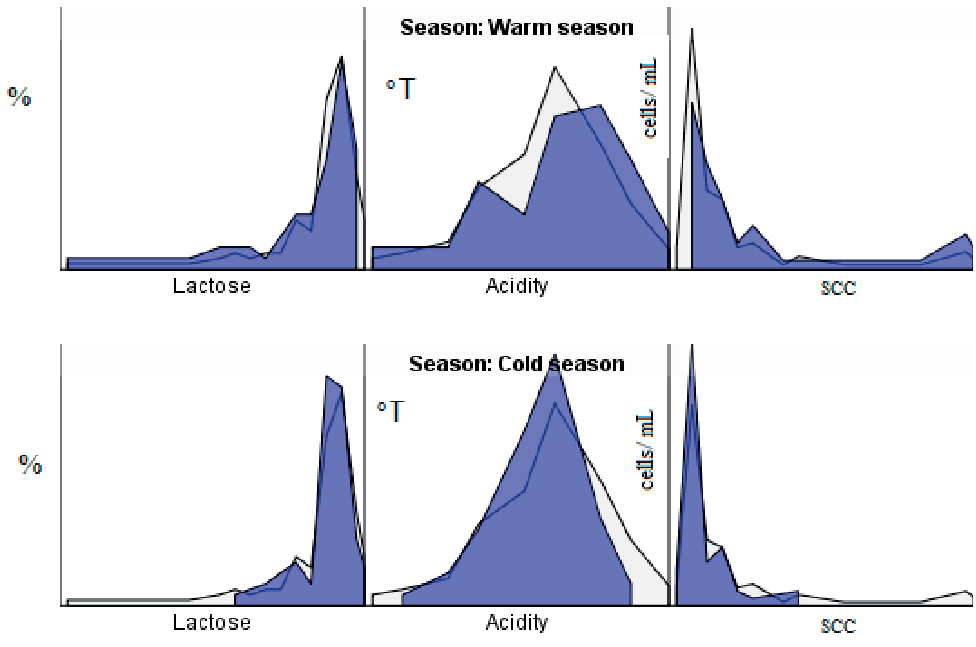

Figure 4. Dynamics of the tested parameters (SCC, Lactose and acidity) according to the collection season of milk samples from cows identified with an increased number of somatic cells

Table 1. Analytical statistical analysis - milk parameters and season dynamic

	Warm season			Cold season			
	Mean ± SD	**Minimum**	**Maximum**	**Mean ± SD**	**Minimum**	**Maximum**	**ANOVA**
Lactose	4.18±.87	0.09	4.92	4.42±0.40	2.94	5.02	$p > 0.05$
Acidity	18.93±1.89	14.00	22.00	18.48±1.21	15.00	21.00	$p > 0.05$
SCS	2350433.33± 2476698.39^{a}	54900000	8534000.00	908616.67± 695928.87^{b}	95000	3710000.00	$p < 0.001$***

Table 2. Pearson correlations

	Lactose	Acidity	SCC
Lactose	1	-.274**	-.731**
Acidity		1	0.429**
SCC			1

**. Correlation is significant at the 0.01 level (2-tailed)

While the direct effect of increased SCC on cow milk acidity and lactose content may be small, it is nonetheless an important signal of future udder health issues and overall milk quality. Alessio et al. (2016) have indicated that lactose content in milk is influenced by SCC levels, parity, and seasonality, with no significant relationship to breed, milk yield, fat content, or protein levels. Furthermore, environmental factors like temperature and humidity can impact milk composition, with higher temperatures leading to decreased protein, fat, and lactose content, as well as increased microbial counts and SCC (Toghdory et al., 2022).

Intramammary infections can increase SCC and decrease protein, lactose, and fat content in milk (Paape et al., 2001; Vasil et al., 2016). Studies have reported conflicting results. Some suggest a potential increase in milk acidity with higher SCC, potentially due to the release of inflammatory mediators. However, others show no significant change. In our study, acidity was directly influenced by the increase in SCC.

Increased SCC might lead to a slight increase in milk acidity due to the influx of immune cells and enzymes from the inflammatory response. Regarding the lactose content, our findings are consistent with the ones from previous studies which report a decrease in lactose content associated with higher SCC, potentially linked to altered milk synthesis or enzymatic activity.

Maintaining healthy cow populations with low SCC levels is critical for producing high-quality, safe, and nutritional milk for consumers. Understanding the influence of SCC on milk acidity and lactose content is crucial for various stakeholders in the dairy industry. For farmers, this knowledge can help identify cows with potential udder health issues and implement appropriate management strategies.

For processors, information on acidity and lactose content is essential for optimizing processing methods and product quality. Additionally, consumers benefit from understanding how milk quality can be affected by factors like SCC.

CONCLUSIONS

This study provides valuable insights into the relationship between SCC and milk composition, specifically focusing on lactose and acidity. High somatic cell counts (> 4.0 x 10^5 cells per mL) suggest bacterial infection, as evidenced by a strong negative connection between this parameter and lactose concentration. Somatic cell counts correlate negatively with lactose and acidity levels.

Lactose content and titratable acidity can be used as indicators to monitor udder health and for early diagnosis of mastitis in milk cows.

Thus, it is regularly recommended to revise the management practices on the farm and evaluate the basic parameters of the milk.

REFERENCES

Alessio, D.R.M., Neto A.T., Velho J.P., Pereira I.B., Miquelluti D.J., Knob D.A., & Silva, C.G. (2016). Multivariate analysis of lactose content in milk of Holstein and Jersey cows. *Semina: Ciências Agrárias*, *Londrina*, 37, 4(1), 2641-2652.

Alhussien, M.N., & Dang, A.K. (2018). Milk Somatic Cells, Factors Influencing Their Release, Future Prospects, and Practical Utility in Dairy Animals: An Overview. *Vet. World*, *11*, 562–577.

Antanaitis, R., Juozaitien, E.V., Jonike, V., Baumgartner, W., & Paulauskas, A. (2021). Milk Lactose as a Biomarker of Subclinical Mastitis in Dairy Cows. *Animals*, 11, 1736.

Ariton, A.M., Poroșnicu, I., Neculai-Văleanu, A.S., Crivei, I.C., Sănduleanu, C., Postolache, A.N., & Trincă L.C. (2022). Strategies for identifying and preventing fungal mastitis in dairy cows. *Scientific Papers Animal Science and Biotechnologies,* 55(2).

Ashraf, A., & Imran, M. (2020). Causes, types, etiological agents, prevalence, diagnosis, treatment, prevention, effects on human health and future aspects of bovine mastitis. *Anim. Health Res. Rev.*, *21*, 36–49.

Ben Fraj, S., Enea, D.N., Marin, M., Marginean, G.E., & Vidu, L. (2023). Research on different types of protein in cow's and sheep's milk according to different influencing factors (season, feed ration, breed, physiological condition). *Scientific Papers. Series D. Animal Science, LXVI* (1), 259-267.

Benić, M., Maćešić, N., Cvetnić, L., Habrun, B., Cvetnić, Ž., Turk, R., Đuričić, D., Lojkić, M., Dobranić, V., Valpotić, H., Juraj Grizelj, H., Gračner, D., Grbavac, J., & Samardžija, M. (2018). Bovine Mastitis: A persistent and evolving problem requiring novel approaches for its control - A Review. *Vet. Arh.*, *88*, 535–557.

Berglund, I., Pettersson, G., Östensson K., & Svennersten-Sjaunja, K. (2007). Quarter Milking for Improved Detection of Increased SCC. *Reprod. Dom. Anim.*, 42, 427–432.

Bobe, G., Lindberg, G.L., Freeman, A.E., & Beitz, D.C. (2007). Short Communication: Composition of Milk Protein and Milk Fatty Acids Is Stable for Cows Differing in Genetic Merit for Milk Production. *J. Dairy Sci*., 90, 3955–3960.

Chen, H., Weersink, A., Kelton, D., & Massow, M. (2021). Estimating Milk Loss Based on Somatic Cell Count at the Cow and Herd Level. *J. Dairy Sci.*, *104*, 7919–7931.

Costa, A., Lopez-Villalobos, N., Sneddon N.W., Shalloo, L., Franzoi, M., DeMarchi, M., & Penas, M. (2019). Invited review: Milk lactose - Current status and future challenges in dairy cattle. *Journal of Dairy Science, 102*(7), 5883-5898.

Cunha, R.P.L., Molina, L.R., Carvalho, A.U, Facury Filho, E.J., Ferreira, P.M., & Gentilini, M.B. (2008). Subclinical mastitis and relationship between somatic cell count with number of lactations, production and chemical composition of milk. *Arq. Bras. Med. Vet. Zootec., 60*(1), 19-24.

Ferrari, R.A, Colussi, F., & Ayub, R.A. (2004). Caracterização de subprodutos da industrialização do maracujá - Aproveitamento das Sementes. *Rev. Bras. Frutic.,* 26, 101-102.

Granaci, V., Focsha, V., Konstandoglo, A., Vasily Curuliuc, V., & Ciubatco, V. (2023). Reproductive qualities of dairy cows at different age and levels of milk yield. *Scientific Papers. Series D. Animal Science, LXVI* (1), 195-201.

Hameed, K.G.A., Sender, G., & Korwin-Kossakowska, A. (2007). Public health hazard due to mastitis in dairy cows. *Anim. Sci. Pap. Rep.*, *25*, 73–85.

Hristev, H., & Ivanova, R. (2022). Influence of certain environmental factors on basic physiological, hematological and blood cell parameters in free-range dairy cows. *Scientific Papers. Series D. Animal Science, LXV* (2), 242-248.

Li, S., Khafipour, E., Krause, D.O., & Plaizier, J.C. (2011). Effects of subacute ruminal acidosis (SARA) challenges on feeding behavior of lactating dairy cows Can. *J. Anim. Sci.*, 91, 323 -330.

Miglior, F., Sewalem, A., Jamprozik, J., Bohmanova, J., Lefebvre, D.M., & Moore, R.K. (2007). Genetic analysis of milk urea nitrogen and lactose and their relationships with other production traits in Canadian Holstein cattle. *J. Dairy Sci.,* 90, 2468–2479.

Navarro, R.B., Bánkuti, F.I., Santos, F.D.S, Almeida, R., Dias, A.M., Ítavo, C.C.B.F., Ítavo, L.C.V., Ramos, C.E.C.O., & Santos, G.T. (2021). A multivariate statistical analysis of milk yield and quality in intensive dairy production systems in paraná State, Brazil. *Tropical And Subtropical Agroecosystems,* 24(3).

Neculai-Văleanu, A.S., & Ariton A.M. (2022). Udder Health Monitoring for Prevention of Bovine Mastitis and Improvement of Milk Quality. *Bioengineering, 9*(11), 608.

Paape, M.J., Poutrel, B., Contreras, A., Marco, J.C., & Capuco, A.V. (2001). Milk Somatic Cells and Lactation in Small Ruminants. *J. Dairy Sci.,* 84 (E. Suppl.), E237-E244.

Pegolo, S., Giannuzzi, D., Bisutti, V., Tessari, R., Gelain, M.E., Gallo, L., Schiavon, S., Tagliapietra, F., Trevisi, E., Ajmone Marsan, P., Bittante G., & Cecchinato, A., (2021). Associations between differential somatic cell count and milk yield, quality, and technological characteristics in Holstein cows. *J. Dairy Sci., 104*, 4822–4836.

Rearte, R., Corva, S.G., de la Sota, R.L., Lacau-Mengido, I.M., & Giuliodori, M.J. (2022). Associations of Somatic Cell Count with Milk Yield and Reproductive Performance in Grazing Dairy Cows. *J. Dairy Sci.*, 105, 6251–6260.

Reis, C.B.M, Barreiro J.R., Mestieri, L., Porcionato M.A.F, & Santos, M.V. (2013). Effect of somatic cell count and mastitis pathogens on milk composition in gyr cows. *BMC Veterinary Research*, 9, 67.

Schukken, Y., Wilson, D., Welcome, F., Garrison-Tikofsky, L., & Gonzalez, R. (2003). Monitoring udder health and milk quality using somatic cell counts. *Veterinary Research*, 34 (5), 579-596.

Silva, V.P.S, Mesquita, C.B., Nunes, J.S., Prunes, B.B., Rados, P.V., & Visioli, F. (2018). Effects of extracellular acidity on resistance to chemotherapy treatment: a systematic review. *Medical Oncology*, 35:161.

Toghdory, A., Ghoorchi, T., Asadi, M., Bokharaeian, M., Najafi, M., & Ghassemi Nejad, J. (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, 2484.

Vasil, M., Pecka-Kielb, E., Eleèko, J., Zachwieja, A., Zawadzki, W., Zigo, F., Illek, J., & Farkašová, Z. (2016). Effects of udder infections with *Staphylococcus xylosu*s and *Staphylococcus warneri* on the composition and physicochemical changes in cows milk. *Polish Journal of Veterinary Sciences*, 19, 841-848.