THE INFLUENCE OF SEASONAL AND CLIMATIC CHANGES ON THE BIOCHEMICAL PROPERTIES OF COW'S MILK FROM SOUTHERN SERBIA

Jovan Ćirić[1]*, Aleksandar Veličković[1], Đorđe Lazarević[2], Marko Ristić[3]

[1]Toplica Academy of Applied Studies, Department of Agriculture and Food Technology Studies, Prokuplje, Serbia
[2]University of Niš, Faculty of Electronic Engineering, Niš, Serbia
[3]University of Niš, Faculty of Agriculture, Kruševac, Department of Animal Husbandry, Kruševac, Serbia

(ORIGINAL SCIENTIFIC PAPER)
UDC: 579.67:637.12(497.11)
DOI: 10.5937/savteh2502041C

The yield and chemical composition of cow's milk, and consequently the quality of raw milk and its derived products, exhibit significant seasonal variations. These oscillations are largely influenced by factors such as feeding practices and seasonal variations. In recent years, climate changes, including mild winters and hot summers, have increasingly contributed to these fluctuations. This study examined the effects of seasonal transitions, specifically between summer and winter, on key biochemical parameters and physical properties of milk produced in the Nišava and Pirot districts of Southern Serbia. The research analyzed bulk milk samples collected from the "Milk House" dairy in Niš, sourced from nine collection points, primarily from individual households. The average daily milk quantity per collection site was approximately 300 l. Samples, each 0.5 l in volume, were collected daily from January to March and from June to August 2024, ensuring a comprehensive comparison of seasonal effects. Laboratory analyses at the dairy focused on biochemical components such as protein, fat, lactose, and minerals, as well as physical properties like density and pH. For all parameters, average values were calculated for the specified periods. The results provide insights into milk composition changes driven by seasonal factors, which have significant implications for the quality of final dairy products. Moreover, these findings underscore the necessity of adapting processing technologies to align with seasonal variations in raw milk properties.

Keywords: Seasonal milk composition, Climatic influence on milk, Raw milk quality in Serbia, Dairy product adaptation

Introduction

The diet of dairy cows is a critical factor in milk production, significantly influencing not only the quantity but also the qualitative composition of milk as a biological secretion [1]. The adage "milk enters through the mouth and exits through the udder" aptly illustrates the fundamental connection between nutrition and milk production, highlighting the importance of proper livestock feeding, a topic of great importance [1, 2]. Research in this field primarily aims to increase milk yield while minimizing feeding costs and optimizing milk composition, with particular emphasis on enhancing milk fat and protein content, which are crucial for its nutritional and technological value [3-5].

Dairy cow nutrition must meet the demands of basal metabolism, milk synthesis, growth, and fetal development in pregnant cows. For younger cows, it must also support ongoing physical development and long-term productivity [4, 5]. Adequate amounts of energy-rich and physiologically balanced nutrients are essential for maintaining high milk production levels and quality [6]. The feed must be diverse and biologically valuable, providing energy, vitamins, minerals, and essential amino acids necessary for milk protein synthesis [2].

Examining the impact of nutrition on milk production is vital from both physiological and economic perspectives [5]. Research in this area generally falls into two categories: the first focuses on the specific effects of individual nutrients or nutrient groups on milk yield and quality, while the second examines the balance between roughages and concentrates in dairy cow diets [7]. Roughages, including green grass, silage, and other succulent feeds, positively impact milk yield but may slightly reduce milk fat and protein content. Nevertheless, the absolute amounts of fat, protein, and dry matter increase due to the higher milk volume [5, 8].

Conversely, concentrated feeds significantly enhance milk production but can slightly reduce milk fat concentration when they dominate the diet [8, 9]. Nonetheless, the total fat yield increases due to higher milk output. This highlights the complex physiological mechanisms of milk synthesis, where the dry matter concentration depends not only on the nutrients ingested but also on

*Author address: Jovan Ćirić, Toplica Academy of Applied Studies, Department of Agriculture and Food Technology Studies, Ćirila i Metodija 1, 8400 Prokuplje, Serbia
E-mail: joca.ciric@gmail.com
The manuscript received: April 4, 2025
Paper accepted: June 12, 2025

the efficiency of the mammary gland in synthesizing milk components [10].

In addition to diet, seasonal factors also significantly influence milk composition, reflecting changes in the availability and quality of feed throughout the year [1, 11]. During summer, when green forages are more accessible, there is a slight reduction in fat and protein concentration; however the increased milk yield results in higher absolute quantities of fat and protein [11]. In winter, when cows primarily consume dry roughage and concentrates, fat and protein concentrations increase, although overall milk yield decreases [11,12].

Seasonal dietary changes, influenced by different feeding regimes in summer and winter, significantly affect the organoleptic and technological properties of milk. For instance, summer diets rich in succulent feeds may result in lower fat concentrations, potentially impacting the production of high-fat dairy products like cheese and butter [11]. Conversely, increased milk volumes in summer are advantageous for producing liquid dairy products, such as yogurt and kefir [2, 13].

These findings underscore the importance of continuous monitoring and evaluation of milk quality parameters [14], an integrated approach to nutrition, and the adaptation of feeding strategies to seasonal changes. This ensures stable milk yield and quality throughout the year [6, 15], optimizing dairy processing technologies and enhancing the economic sustainability of production.

The aim of this work was to analyze the seasonal and climatic variations in the physicochemical composition and physical properties of cow's milk from the Nišava and Pirot districts in Southern Serbia, providing insights into their impact on milk quality and dairy production processes.

Materials and methods

The study involved a detailed analysis of the physicochemical composition and physical characteristics of milk produced in the Nišava and Pirot districts, to identify seasonal variations in its composition. Sampling was conducted within the collection area of the "Milk House" dairy in Niš, from small farms and holdings raising Simmental and Holstein cows. Milk was collected from nine procurement locations, including the cities and municipalities of Niš, Aleksinac, Ražanj, Svrljig, Gadžin Han, Merošina, Pirot, Babušnica, and Bela Palanka. Each procurement site provided an average daily volume of approximately 300 l of milk, ensuring a representative sample for analysis.

Bulk milk samples were taken in standardized volumes of 0.5 l per sample, and laboratory analyses were performed in the technologically equipped laboratory of the dairy. Sampling covered the winter period (January 15 – March 15) and the summer period (June 10 – August 10) of 2024, allowing for a comparison of the effects of seasonal changes on milk quality. All analyses were conducted daily during these periods to ensure the reliability and precision of the results.

The examined parameters included key biochemical components of milk, such as fat, protein, lactose, and mineral content, as well as physical properties like density, pH value, and freezing point. All analyses and measurements were carried out in the Dairy Laboratory for Chemical Analyses. Average values for each parameter were calculated based on multiple samples taken in both seasonal periods, providing reliable data on potential variations in milk quality between winter and summer seasons. This comprehensive analysis offers significant insights into the changes occurring in milk due to seasonal variations in cow diets, climatic conditions, and other external factors, which are of particular importance for the dairy industry and the optimization of production processes.

Milk fat, protein, and total dry matter content were analyzed spectrophotometrically in the infrared spectrum using the Milkoscan S 50 device, with results expressed as percentages. The content of fat-free dry matter (FFDM) was calculated based on standard formulas and also expressed as a percentage. The titratable acidity of milk was determined using the Soxhlet-Henkel method, and reported in degrees Soxhlet-Henkel (°SH), a standard method for assessing acidity in the dairy industry [16].

The amount of added water in milk was determined using the cryoscopic method, employing the Cryoscope 4D3 device. This method is based on the principle of lowering the freezing point of milk due to the presence of water. Results were expressed as percentages based on the difference between the freezing point of milk with normal composition (−0.55 °C) and the freezing point of the tested sample [17].

Milk density was determined using a lacto-densimeter, with values expressed in kilograms per cubic meter (kg/m³), a standard measure of liquid sample density in the food industry [2]. Milk density is a critical parameter for detecting possible manipulations of milk content, such as water addition or fat removal [1].

The data obtained were analyzed using standard statistical methods for variation, enabling the quantification of variability within the tested samples and the identification of significant differences between seasonal variations in the chemical composition of milk [10]. All statistical analyses were performed using Microsoft Excel (Office 365).

Results and discussion

Milk samples collected from nine procurement locations of the “Milk House” dairy in Nišava and Pirot districts were analyzed during the winter period (Period 1) and summer period (Period 2). The evaluated parameters included acidity, milk fat, total dry matter, fat-free dry matter (FFDM), and protein content. The average results are presented in Table 1 and Figure 1, highlighting

significant seasonal variations. The acidity of milk during the summer period (7.27 °SH) was 4% higher compared to the winter period (6.97 °SH), which can be attributed to increased microbiological activity. Conversely, the contents of milk fat (4.03%), dry matter (12.57%), and protein (3.30%) were higher during the winter by 2%, 1%, and 6%, respectively, compared to summer samples (Figure 1). These results align with findings from the literature[2, 18, 19]. Such seasonal oscillations demonstrate the significant impact of feeding practices and microclimatic conditions on milk composition, with the winter period providing nutritionally richer milk due to concentrated feed. Similar observations have been reported in studies from other regions with different climatic conditions [18, 20, 21].

The analysis of results by procurement locations revealed notable differences in milk quality parameters between winter (Period 1) and summer (Period 2) (Table 1). The highest acidity (8.48 °SH) was recorded in milk from cows in the region of Niš during the summer, while the lowest (6.51 °SH) was observed in Svrljig during the winter, confirming elevated microbiological activity in warmer months. Milk fat content was highest in Pirot during the winter (4.12%) and lowest in Niš during the summer (3.79%), correlating with seasonal changes in cow diets.

Dry matter showed a similar trend, with the highest value in Niš during the winter (12.78%) and the lowest in Ražanj during the summer (12.34%). Fat-free dry matter exhibited minimal variation, with the highest value recorded in Bela Palanka during the winter (8.73%) and the lowest in Aleksinac during the same period (8.47%). Protein content was highest in Niš during the winter (3.35%) and lowest in Niš during the summer (2.43%), indicating a reduced energy-protein balance during warmer months. Water adulteration was most prominent in Svrljig during the winter (3.82%) and least in Babušnica during the summer (0.65%). Variations between collection locations were less pronounced compared to seasonal differences, highlighting the dominant influence of climatic factors.

The results underline the significant impact of climatic conditions on milk quality. The mild winter of 2023/24, particularly in southern Serbia, facilitated a stable energy-protein balance in cow diets, resulting in higher levels of milk fat (4.03%), protein (3.30%), and dry matter (12.57%). In contrast, the extremely hot and dry summer (June–August) negatively affected nutritional intake and water consumption, reducing protein (3.11%) and milk fat (3.94%) concentrations while increasing acidity (7.27 °SH). The dry conditions worsened the availability of fresh forage, while increased microbiological activity further compromised milk quality during the summer.

These findings emphasize the importance of addressing seasonal challenges in dairy production to optimize milk quality and maintain stable nutrient content throughout the year.

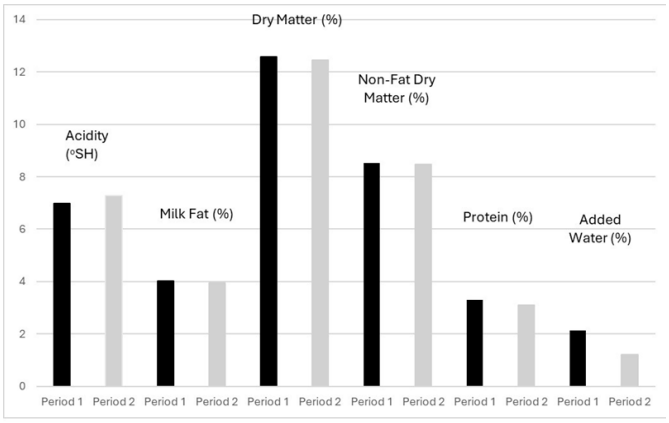

Figure 1 Average values of milk quality parameters in winter (Period 1) and summer (Period 2) season

Table 1. Comparative analysis of seasonal variations in milk quality parameters: winter (January–March) and summer (June–July) periods

COLLECTION POINT	ACIDITY (°SH)		MILK FAT (%)		DRY MATTER (%)		NON-FAT DRY MATTER (%)		PROTEIN (%)		ADDED WATER (%)	
	Period 1	Period 2	Period 1	Period 2	Period 1	Period 2	Period 1	Period 2	Period 1	Period 2	Period 1	Period 2
Niš	7,21 ±0,27	8,48 ±0,26	4,09 ±0,18	3,79 ±0,05	12,78 ±0,13	12,67 ±0,20	8,69 ±0,29	8,43 ±0,18	3,35 ±0,10	2,43 ±0,19	1,92 ±0,42	1,28 ±0,40
Aleksinac	6,99 ±0,26	7,12 ±0,29	3,97 ±0,12	3,88 ±0,09	12,43 ±0,15	12,36 ±0,14	8,47 ±0,27	8,48 ±0,30	3,24 ±0,15	3,17 ±0,10	1,76 ±0,54	0,88 ±0,45
Ražanj	7,35 ±0,25	7,16 ±0,27	3,94 ±0,16	3,91 ±0,10	12,40 ±0,27	12,34 ±0,15	8,46 ±0,07	8,43 ±0,19	3,21 ±0,07	3,19 ±0,16	1,60 ±0,53	0,73 ±0,29
Svrljig	6,51 ±0,28	7,10 ±0,18	3,97 ±0,18	3,96 ±0,18	12,37 ±0,24	12,49 ±0,12	8,40 ±0,13	8,54 ±0,14	3,21 ±0,09	3,19 ±0,19	3,82 ±0,56	1,59 ±0,39
Gadžin Han	6,86 ±0,22	7,16 ±0,24	4,08 ±0,16	3,96 ±0,11	12,67 ±0,22	12,44 ±0,11	8,59 ±0,20	8,49 ±0,16	3,35 ±0,18	3,21 ±0,18	3,40 ±0,59	2,55 ±0,43
Merošina	7,15 ±0,27	7,13 ±0,15	4,02 ±0,09	3,92 ±0,12	12,51 ±0,29	12,29 ±0,09	8,50 ±0,15	8,36 ±0,27	3,33 ±0,14	3,14 ±0,20	2,20 ±0,48	1,01 ±0,40
Pirot	6,72 ±0,35	7,14 ±0,26	4,12 ±0,17	3,96 ±0,08	12,65 ±0,11	12,46 ±0,19	8,53 ±0,08	8,51 ±0,05	3,29 ±0,12	3,20 ±0,10	1,86 ±0,41	1,09 ±0,36
Babušnica	6,93 ±0,18	7,15 ±0,23	4,00 ±0,12	3,96 ±0,10	12,43 ±0,25	12,44 ±0,18	8,44 ±0,13	8,49 ±0,06	3,36 ±0,08	3,19 ±0,06	1,24 ±0,65	0,65 ±0,32
Bela palanka	6,91 ±0,18	7,01 ±0,26	4,11 ±0,19	3,96 ±0,14	12,48 ±0,12	12,58 ±0,12	8,73 ±0,12	8,62 ±0,21	3,40 ±0,15	3,22 ±0,11	1,46 ±0,32	1,10 ±0,48
AVG	**6,97 ±0,25**	**7,27 ±0,24**	**4,03 ±0,15**	**3,94 ±0,11**	**12,57 ±0,20**	**12,45 ±0,14**	**8,53 ±0,16**	**8,48 ±0,17**	**3,30 ±0,12**	**3,11 ±0,14**	**2,14 ±0,50**	**1,21 ±0,39**

Period 1 January -March

Period 2 – June - August

The analysis of milk quality parameters across different seasonal periods (winter - P1 and summer - P2) provided valuable insights into the variability of the biochemical composition and physical properties of milk. Through statistical data processing and correlation analysis, significant correlations were found between certain parameters, while others showed no statistically significant relationships. These results indicate that seasonal factors, primarily diet, and climate changes, exert varying impacts on specific milk quality parameters.

The correlation analysis of milk acidity between periods P1 and P2 yielded a Pearson correlation coefficient of 0.39 with a *p*-value of 0.30, indicating no statistically significant association. This suggests that seasonal variations do not substantially influence titratable acidity changes, although a slight increase is observed during the summer period (P2). Elevated acidity in the summer may result from dietary specifics during this period, such as the increased intake of succulent green forage, which promotes improved metabolism in cows and higher water consumption. Additionally, elevated temperatures may contribute to slightly higher acidity values [13, 22]. Conversely, in the winter (P1), a diet dominated by concentrated feed and silage—rich in fermentable carbohydrates—may result in restrained lactic acid production [6, 19].

The correlation analysis for milk fat content between periods P1 and P2 revealed a very low correlation (r = 0.02) with a *p*-value of 0.96, suggesting complete independence of this parameter from seasonal changes. While absolute fat content values are slightly lower in the summer period, possibly due to increased milk production efficiency with succulent forage, the overall amount of fat produced remains relatively constant. The lack of correlation confirms that milk fat synthesis is primarily dependent on physiological processes in the mammary gland rather than directly on seasonal dietary variations [4, 5].

Correlation analysis for dry matter content showed a positive association (r = 0.51) with a *p*-value of 0.16, which, although not statistically significant, suggests a trend toward higher dry matter content during the winter period. This result aligns with previous studies, which confirm that reduced water intake and increased nutrient concentration in winter diets lead to the concentration of biochemical milk components [11, 19, 23]. In the summer period, increased consumption of succulent forage with a higher water content may slightly "dilute" milk, as reflected in marginally lower dry matter values [6].

Milk protein content exhibited a negative correlation (r = -0.22) between periods P1 and P2, with a *p*-value of 0.57, indicating no significant seasonal association. While protein content was slightly higher during the winter period, likely due to increased intake of protein-rich concentrated feed and nutritionally enriched dietary supplements [9], this variation was insufficient to achieve statistical significance. Milk protein levels largely depend on the energy-protein balance of the diet, with the transition from forage-based to concentrated feed during winter slightly increasing protein concentration in milk [3, 5, 6].

This parameter exhibited a significant positive correlation (r = 0.81) with a *p*-value of 0.008, indicating a strong association between the winter (P1) and summer (P2) periods. The values for added water were significantly higher during the winter period, which can be attributed to the increased intake of silage and forage with higher moisture content, as well as potential mishandling of milk during transport and storage under lower temperatures [2, 21]. The summer period, characterized by more stable microbiological conditions and reduced risks of condensation due to higher temperatures, resulted in lower values of added water, reflecting improved milk quality during this time. The lack of comparative literature on this topic highlights the need for stricter milk quality control during winter months to prevent potential manipulations that could compromise its quality and safety.

The results of this study regarding the impact of seasonal variations on milk quality align with previously published research analyzing changes in milk composition across different seasons. For instance, certain studies [13, 20, 24, 25] suggest that increased intake of succulent forage during the summer leads to a reduction in the concentration of dry matter and milk proteins. This is primarily due to the higher milk yield and increased water intake in dairy cows under warm climatic conditions. Conversely, studies confirm that diets with higher proportions of concentrated feed during winter positively influence the concentration of proteins and dry matter [9, 23], while milk fat demonstrates minimal seasonal variability.

The findings regarding the elevated values of added water during the summer also correspond to studies [13, 26] emphasizing that high temperatures and poor storage conditions during summer contribute to greater variability in this parameter. This agreement with prior research confirms that seasonal factors, including diet, temperature fluctuations, and production management, are critical determinants of milk quality across different periods.

Seasonal variations in milk quality significantly influence its suitability for human consumption and the production of dairy products [18]. During the summer period, the predominance of forage-based diets increases milk yield but reduces fat, protein, and dry matter content, complicating the production of fermented products such as cheese due to lower coagulation properties and yield [13, 22]. Conversely, the winter period, characterized by increased intake of concentrated feed and lower ambient temperatures, produces milk richer in fat and proteins, making it more suitable for the production of cheese and butter [19, 23].

According to previously published research [24, 26], the optimal milk composition observed during the winter period enhances the technological properties of dairy products and their market value. Thus, seasonal fluctua-

tions emerge as a significant factor in both cow nutrition and milk processing strategies.

Conclusion

The findings of this study confirm that the climatic conditions in 2024, characterized by a mild winter and a warm summer, had a significant influence on milk quality parameters. The mild winter enabled a stable feed intake in dairy cows, resulting in a slightly improved nutritional status and the preservation of milk fat and protein content. The effect of the seasons on milk quality is directly reflected in dietary changes as well as the physiological adaptation of dairy cows to varying climatic conditions.

The results of this study highlight the notable impact of seasonal variations on milk quality parameters, with milk fat, protein, and dry matter content being higher during the mild winter. A more stable energy-protein balance during this period is directly linked to the use of higher-quality feed and reduced energy demands on cows. Conversely, the extremely warm and dry summer led to a reduction in protein and milk fat concentrations, accompanied by increased milk acidity due to reduced availability of forage and intensified microbiological activity.

These results form a foundation for further research aimed at improving the nutritional management of dairy cows and optimizing milk production under varying climatic conditions. It is particularly important to analyze adaptive strategies during periods of extreme weather conditions, such as the hot summer of 2024, to ensure the stability of milk quality and mitigate the effects of climate change on the dairy industry.

Acknowledgments

The authors are sincerely grateful to the management and courteous staff of the “Milk House” dairy in Niš for their collaboration and permission to conduct this scientific research.

This work was supported by the Ministry of Science, Technological Development and Innovation of the Republic of Serbia [Grant Number: 451-03-136/2025-03/200102].

Literatura

[1] Nešić V. *Milk Technology*. University of Niš, Serbia, 2013. ISBN: 978-86-82367-85-7 (Serbian)

[2] Fox PF, McSweeney PLH. *Dairy Chemistry and Biochemistry.* Springer, Switzerland, 2015. https://doi.org/10.1007/978-3-319-14892-2

[3] Khalili H, Mäntysaari P, Sariola J, Kangasniemi R. Effect of concentrate feeding strategy on the performance of dairy cows fed total mixed rations. *Agricultural and Food Science.* 2006, 15, 268–279. https://doi.org/10.2137/145960606779216272

[4] Đoković R, Ilić Z, Kurćubić V, Petrović MP, Caro-Petrović V, Milošević B, Omerović I. Determination of metabolic and nutritional status in dairy cows during early and mid-lactation. (Serbian) *Biotechnology in Animal Husbandry.* 2016, 32(1), 1–8. https://doi.org/10.2298/BAH1601001D

[5] Ben Meir YA, Nikbachat M, Portnik Y, Jacoby S, Adin G, Moallem U, Mabjeesh SJ. Effect of forage-to-concentrate ratio on production efficiency of low-efficient high-yielding lactating cows. *Animal.* 2021, 15(1), 100012. https://doi.org/10.1016/j.animal.2020.100012

[6] Maltz E, Barbosa LF, Bueno P, Scagion L, Kaniyamattam K, Greco LF, Santos JEP. Effect of feeding according to energy balance on performance, nutrient excretion, and feeding behavior of early lactation dairy cows. *Journal of Dairy Science.* 2013, 96(8), 5249–5266. https://doi.org/10.3168/jds.2013-6549

[7] Cabezas-Garcia EH, Gordon AW, Mulligan FJ, Ferris CP. Revisiting the relationships between fat-to-protein ratio in milk and energy balance in dairy cows of different parities, and at different stages of lactation. *Animals.* 2021, 11(11), 3256. https://doi.org/10.3390/ani11113256

[8] Arti T, Smita S, Oberoi PS. Influence of roughage: Concentrate ratio in the ration and feed prices on profitability of commercial dairy farms. *Indian Journal of Animal Nutrition.* 2018, 35(3), 320–325. https://doi.org/10.5958/2231-6744.2018.00048.8

[9] Mozart GG, Köptcke FBN, Pinto LA, Moebus VF, Tamy WP, Aronovich M, Keller LAM. Enhancement of dairy cow milk quality with probiotic and inorganic selenium supplementation. *Dairy.* 2024, 5, 336–345. https://doi.org/10.3390/dairy5020027

[10] Montgomery DC. *Design and Analysis of Experiments*. John Wiley & Sons, Hoboken, NJ, 2019. ISBN: 978-1-119-49244-3

[11] Parmar P, Lopez-Villalobos N, Tobin JT, Murphy E, McDonagh A, Crowley SV, Shalloo L. The effect of compositional changes due to seasonal variation on milk density. *Foods*. 2020, 9(8), 1004. https://doi.org/10.3390/foods9081004

[12] Li S, Ye A, Singh H. Seasonal variations in composition, properties, and heat-induced changes in bovine milk in a seasonal calving system. *Journal of Dairy Science*. 2019, 102(9), 7747–7759. https://doi.org/10.3168/jds.2019-16685

[13] Habibi E, Qasimi M, Ahmadzai N, Stanikzai N, Sakha M. Effect of season and lactation number on milk production of Holstein Friesian cows in Kabul Bini-Hesar Dairy Farm. *Open Journal of Animal Sciences*. 2021, 11, 369–375. https://doi.org/10.4236/ojas.2021.113026

[14] Iweka P, Kawamura S, Mitani T, Kawaguchi T. Cow milk quality determination using a near-infrared spectroscopic sensing system for smart dairy farming. *Engineering Proceedings.* 2023, 58(1), 118. https://doi.org/10.3390/ecsa-10-16020

[15] Roche JR, Friggens NC, Kay JK, Fisher MW, Stafford KJ, Berry DP. Invited review: Body condition score and its association with dairy cow productivity, health, and welfare. *Journal of Dairy Science*. 2009, 92(12), 5769–5801. https://doi.org/10.3168/jds.2009-2431

[16] IDF (International Dairy Federation). *Determination of titratable acidity of milk*. IDF Standard 16:2000.

[17] Brito RF, Rodrigues R, Diniz SA, Fonseca LM, Leite MO, Souza MR, Cerqueira MMOP. Analysis of the freezing point of milk by precision method and Fourier Transform Infrared (FTIR) spectroscopy. *Arquivos Brasileiros de Medicina Veterinária e Zootecnia.* 2020, 72(5), 1713–

1718. https://doi.org/10.1590/1678-4162-11961
[18] Becker-Algeri TA, Souza C, Bortoli K, Castagnaro D, Scaglioni PT, Drunkler DA, Dors G, Valderrama P, Badiale-Furlong E. Seasonal variation of milk quality: Physiochemical, microbiological, and toxicological. *Journal of Food Safety*. 2020, e12796. https://doi.org/10.1111/jfs.12796
[19] Han J, Wang J. Dairy cow nutrition and milk quality. *Agriculture.* 2023, 13(3), 702. https://doi.org/10.3390/agriculture13030702
[20] Ozrenk E, Inci OS. The effect of seasonal variation on the composition of cow milk in Van Province. *Pakistan Journal of Nutrition*. 2008, 7(1), 161–164. https://doi.org/10.3923/pjn.2008.161.164
[21] Heck JML, Van Valenberg HJF, Dijkstra J, Van Hooijdonk ACM. Seasonal variation in the Dutch bovine raw milk composition. *Journal of Dairy Science.* 2009, 92, 4745–4755. https://doi.org/10.3168/jds.2009-2146
[22] Fabro MA, Milanesio HV, Robert LM, Speranza JL, Murphy M, Rodriguez G, Castaneda R. Determination of acidity in whole raw milk: Comparison of results obtained by two different analytical methods. *Journal of Dairy Science*. 2006, 83(3), 859–861. https://doi.org/10.3168/jds.S0022-0302(06)72149-X
[23] Chen B, Lewis MJ, Grandison AS. Effect of seasonal variation on the composition and properties of raw milk destined for processing in the UK. *Food Chemistry.* 2014, 158, 216–223. https://doi.org/10.1016/j.foodchem.2014.02.118
[24] Kliem KE, Givens DI. Dairy products in the food chain: Their impact on human health and the role of seasonality. *Journal of Animal Science.* 2011, 89(8), 2244–2256. https://doi.org/10.1146/annurev-food-022510-133734
[25] Ferland MC, Guesthier MA, Cue RI, Lacroix R, Burgos SA, Lefebvre D, Wade KM. Effect of feeding system and grain source on lactation characteristics and milk components in dairy cattle. *Journal of Dairy Science*. https://doi.org/10.3168/jds.2017-13787
[26] Bernabucci U, Basiricò L, Morera P. Impact of hot environmental conditions on milk quality. *Cellular and Molecular Biology*. 2014, 59(1), 67–83. https://doi.org/10.1170/T948

Izvod

UTICAJ SEZONSKIH I KLIMATSKIH PROMENA NA BIOHEMIJSKA SVOJSTVA KRAVLJEG MLEKA U JUŽNOJ SRBIJI

Jovan Ćirić[1], Aleksandar Veličković[1], Đorđe Lazarević[2], Marko Ristić[3]

[1]Toplička akademija strukovnih studija, Odsek za poljoprivredno prehrambene studije Prokuplje
[2]Elektronski fakultet, Univerzitet u Nišu
[3]Poljoprivredni fakultet u Kruševcu, Univerzitet u Nišu

(ORIGINALNI NAUČNI RAD)
UDK: 579.67:637.12(497.11)
DOI: 10.5937/savteh2502041C

Prinos i hemijski sastav kravljeg mleka, a time i kvalitet sirovog mleka i njegovih proizvoda, pokazuju značajne sezonske varijacije. Ove oscilacije su uglavnom pod uticajem faktora kao što su način ishrane i godišnje doba. U poslednjih nekoliko godina, klimatske promene, uključujući blage zime i vrela leta, dodatno doprinose tim promenama. U ovom istraživanju ispitivan je efekat sezonskih prelaza, posebno između leta i zime, na ključne biohemijske parametre i fizička svojstva mleka proizvedenog u Nišavskoj i Pirotskoj regiji južne Srbije. Analizirani su uzorci mleka prikupljeni iz devet otkupnih tačaka mlekare „Milk House“ u Nišu, uglavnom sa individualnih farmi. Prosečna dnevna količina mleka po otkupnom mestu iznosila je oko 300 litara. Uzorci zapremine 0,5 litara prikupljani su svakodnevno u periodima od januara do marta i od juna do avgusta 2024. godine, čime je omogućena sveobuhvatna analiza sezonskih uticaja. Laboratorijske analize sprovedene u laboratoriji mlekare obuhvatale su biohemijske komponente poput proteina, masti, laktoze i minerala, kao i fizička svojstva poput gustine i pH vrednosti. Za sve parametre izračunate su prosečne vrednosti za analizirane periode. Rezultati pružaju uvid u promene sastava mleka izazvane sezonskim faktorima, što ima značajne implikacije na kvalitet finalnih mlečnih proizvoda. Nadalje, ovi nalazi naglašavaju potrebu za prilagođavanjem tehnologija prerade kako bi se uskladile sa sezonskim varijacijama u svojstvima sirovog mleka.

Ključne reči: sezonski sastav mleka, klimatski uticaj na mleko, kvalitet sirovog mleka Srbija, adaptacija mlečnih proizvoda

CRediT authorship contribution statement:
Jovan Ćirić: Conceptualization, Methodology, Writing – review & editing, Supervision.
Aleksandar Veličković: Investigation, Laboratory analysis, Writing – original draft.
Đorđe Lazarević: Data curation, Formal analysis, Visualization.
Marko Ristić: Resources, Validation.