THE EFFECTS OF SEASON AND LACTATION NUMBER ON THE COMPOSITION OF HOLSTEIN CATTLE RAW MILK IN TURKIYE

KAYA, R.[1] – TUTKUN, M.[2*]

[1]*Department of Animal Science, Institute of Natural and Applied Science, Dicle University, 21280 Diyarbakır, Türkiye*

[2]*Department of Animal Science, Faculty of Agriculture, Dicle University, 21280 Diyarbakır, Türkiye*
(phone: +90-532-668-7313; fax: +90-412-241-1048

[*]*Corresponding authors*
e-mail: muhittin.tutkun@dicle.edu.tr

(Received 14th Oct 2024; accepted 24th Jan 2025)

Abstract. This study was conducted to determine the somatic cell count for 210 milk samples taken Holstein Friesian cows in quarterly periods according to season and lactation order in a private dairy cattle farm in Diyarbakır province, Turkiye. The effects of lactation order and season were analyzed using the Least Squares Method, with multiple comparisons conducted using Duncan’s test. The average fat, protein, dry matter, lactose, and SCC contents of raw milk samples throughout the year were determined to be 3.61%, 3.22%, 12.71%, 4.68%, and 211.70 cells/ml, respectively. The study found statistically significant differences between lactation orders in terms of fat, dry matter, protein, and SCC contents, while no significant differences were observed in lactose content. Significant and positive correlations were detected between lactation order and both dry matter ($r = 0.383$, $p < 0.001$) and SCC ($r = 0.355$, $p < 0.001$). There were negative correlations observed between season and both milk fat ($r = -0.333$, $p < 0.001$) and SCC ($r = -0.333$, $p < 0.001$). A negative correlation was also found between season and dry matter ($r = -0.278$, $p < 0.001$). As a result, lactation order and season have significant effects on milk composition and somatic cell count.

Keywords: *Holstein-Friesian, somatic cell count, milk composition, milk protein*

Introduction

Livestock breeding programs have primarily aimed to improve economically significant production traits (Oltenocu and Broom, 2010). Among these traits, milk production has consistently been a key focus and with numerous studies dedicated to enhancing milk yield in dairy cows (Zadoks and Fitzpatrick, 2009; Oltenocu and Broom, 2010; O’Hara et al., 2020).

Today, optimizing environmental conditions is considered a crucial step for improving financial efficiency on dairy farms. In this context, monitoring somatic cell count (SCC) and the chemical composition of milk is strongly recommended to dairy farmers (Memiši et al., 2011).

Improving both the quality and quantity of milk is essential for dairy herd owners to maximize their income. Besides genetic factors, numerous elements significantly influence milk yield and composition, including parity, season, lactation stage, milking intervals, and feeding strategies (Auldist et al., 1998; Ayasan et al., 2011). Typically, changes in milk yield are closely linked to variations in milk composition (Dürr et al., 2011). The primary constituents of bovine raw milk include water, fat, protein, ash, lactose, and minerals (Bueno et al., 2005). Studies have reported a wide range of genetic

DOI: http://dx.doi.org/10.15666/aeer/2303_50255039

correlations between milk fat content and lactation persistence (Gerald, 2005; Koc, 2007; Heck et al., 2009).

Milk composition analysis is routinely performed worldwide to assess the hygienic, nutritional, and health status of dairy herds (Auldist et al., 1998). Hygiene, a key parameter in both the milking process and milk preservation, is often used as a payment criterion by the dairy industry. However, despite its significance, this aspect is not covered in the present study. Instead, our focus is on the chemical and cellular composition of milk.

Numerous factors influence milk's chemical and cellular components, leading to variations that must be carefully evaluated for accurate interpretation of milk analysis. Key factors include season, lactation stage, feed management and parity (Noro et al., 2006; Heck et al., 2009; Lambertz et al., 2014).

Both milk yield and its composition including fat, protein, lactose, total solids, and somatic cell count are critical indicators. These parameters not only serve as benchmarks for milk quality but also determine the price paid for raw milk (Dürr et al., 2004).

Sharif et al. (2007) stated that the nutritional content of raw milk can vary based on parameters such as species, breed, lactation period and stage, feed ratio, and udder health.

The chain of financial losses from producers to the national level is particularly related to the increase in the production costs of dairy products due to the decrease in milk yield and these factors increase the financial losses of producers and negatively impact the national economy.

In this study, the effects of season and lactation number on the composition of Holstein cattle raw milk were determined.

Material and methods

Study area

Study was conducted in a private dairy farm in Diyarbakır Province, Turkey at 37°85'00"N, 40°66'91"E; 535 m above sea level (*Fig. 1*).

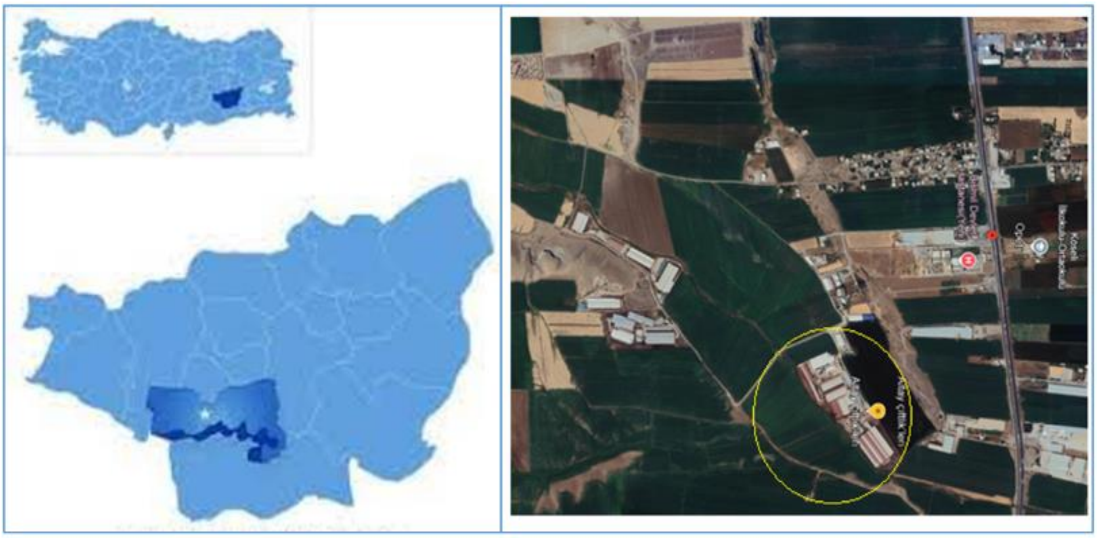

Figure 1. *The location of the study area*

DOI: http://dx.doi.org/10.15666/aeer/2303_50255039

Animal material

The study material consists of 120 Holstein Friesian cows. Raw milk samples were collected during the four seasons (spring, summer, autumn, and winter) at three-month intervals, from March 2023 to March 2024. The farm, which has a capacity for 2000 lactating cows, operates a free-stall barn system. Milking is performed twice a day using machine milking.

Feed rations

The ration content used of lactating cows was adjusted according to the changing energy and nutritional needs throughout the lactation period (*Table 1*).

Table 1. *The seasonal ration content for lactating cows*

Season	Energy (MJ/kg)	Protein (%)	Fat (%)	Fiber (%)	Key Feeds and Adjustments
Winter	11-13	16-18	3.5-4.5	18-22	High-quality roughage (hay, corn silage), energy-boosting feeds, vitamins, and mineral supplementation.
Spring	10-12	15-17	3-4	17-21	Fresh grass
Summer	9-11	14-16	2.5-3.5	16-20	Quality fresh grass, and low-fat feeds.
Autumn	10-12	15-17	3-4	17-21	Dried hay and silage, balanced protein and energy.

Collection of milk samples

A total of 210 milk samples were collected between March 2023 and March 2024. The milk samples were taken during the morning milking by hand. Milk samples were collected from each udder quarter individually. The milk samples placed in 50 ml sterile tubes were delivered to the laboratory on the same day under cold chain conditions. The somatic cell count in the raw milk samples was determined using the Somatos Mini device with a direct measurement technique and The contents of dry matter, protein, fat, and lactose were analyzed using the Milkotester Master Classic in the Animal Breeding Laboratory of the Department of Animal Science (*Figs. 2,3*).

Figure 2. *Somatos Mini device*

Figure 3. *Milkotester Master Classic*

DOI: http://dx.doi.org/10.15666/aeer/2303_50255039

Statistical analysis

To determine the analysis method to be used, Skewness and Kurtosis values (±3.29) were examined, and it was determined that the data conformed to a normal distribution (Mayers, 2013). The measurements were analyzed using the Least Squares method according to the 22 factorial randomized split-plot experimental design (*Equation 1*). The Least Squares (LS) method is one of the most commonly used methods in regression analysis and is crucial for evaluating assumptions. In the regression analysis, models consisting of curve estimation methods with the highest coefficients were selected and interpreted.

$$\gamma_{ijk} = \mu + \alpha_i + \beta_j + (\alpha\beta)_{ij} + \varepsilon_{ijk} \qquad \text{(Eq.1)}$$

where,
Y_{ijk} is the observed value obtained according to the i-th season-lactation sequence,
μ is the population mean,
α_i is the effect of the i-th level of the lactation sequence factor,
β_j is the effect of the j-th level of the season factor,
$(\alpha\beta)_{ij}$ is the interaction effect between the lactation sequence and season factors, and
ε_{ijk} represents the random error.

The differences between lactation sequences and seasons were determined using Duncan's multiple comparison test, based on the significance level (<0.05 or <0.01).

Result

The relationships between somatic cell count and milk composition in Holstein cows were examined in relation to lactation number and season. In this study, descriptive statistics for the characteristics were determined.

Effect of lactation order on milk composition

As a result of the variance analysis, it was determined that the order of lactation had no effect on lactose, but had a significant effect on fat ($p<0.05$) and protein ($p<0.05$), and a highly significant effect on dry matter ($p<0.01$) and SSC ($p<0.01$). It was also found that the seasons had no effect on lactose, but had a highly significant effect on fat, protein, and dry matter ($p<0.01$), and a significant effect on SSC ($p<0.05$) (*Table 2*).

Table 2. *The effect of lactation order on milk components*

Lactation Order	N	Fat	Dry Matter	Protein	Lactose	SSC
1	49	3,65±0,32^{a}	12,49±0,29^{c}	3,19±0,18^{b}	4,69±0,30^{a}	197,90±23,62^{c}
2	56	3,59±0,36^{ab}	12,74±0,30^{b}	3,18±0,18^{b}	4,67±0,17^{a}	204,66±23,51^{bc}
3	56	3,72±0,39^{a}	12,65±0,32^{b}	3,29±0,22^{a}	4,63±0,28^{a}	217,11±30,89^{ab}
4	49	3,49±0,33^{b}	12,96±0,39^{a}	3,21±0,27^{ab}	4,73±0,32^{a}	227,23±36,79^{a}
p		**0,03**	**<0,001**	**0,033**	0,268	**<0,001**

Different letters such as a, b indicate the statistical difference between the means in the same column

Milk fat content by lactation number

The statistical data regarding milk fat content based on lactation order was shown in *Table 2*. The highest average milk fat content was observed in the 3rd lactation (3.72±0.39), while the lowest was in the 4th lactation (3.49±0.33). The 1st and 3rd lactation orders were similar in terms of milk fat content, whereas a statistically significant difference was observed between the 2nd and 4th lactation orders (*Fig. 4*).

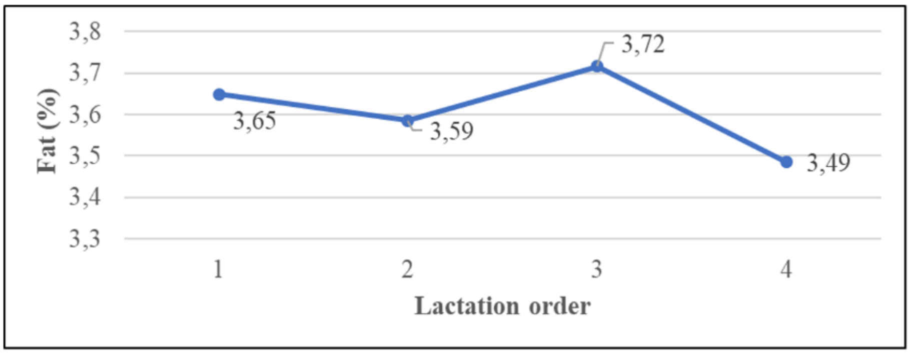

Figure 4. *Milk fat content according to lactation order*

Dry matter content according to lactation order

The dry matter content according to the lactation order was shown in *Table 2*. It was determined that the highest average dry matter content according to lactation order was in the 4th lactation (12.96±0.39), while the lowest dry matter content was in the 1st lactation (12.49±0.29). The 2nd and 3rd lactation orders were similar in terms of dry matter content, while a statistically significant difference was observed between the 1st and 4th lactation orders (*Fig. 5*).

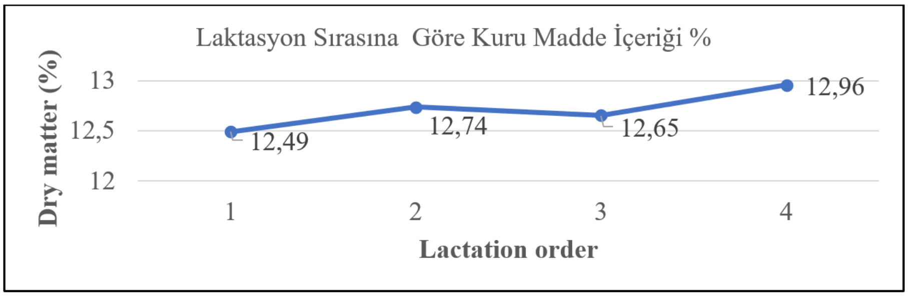

Figure 5. *Dry matter content according to lactation order*

Milk protein content by lactation order

The protein content of milk depending on the lactation order was given in *Table 2*. It was determined that the protein content of milk was highest in the 3rd lactation (3.29±0.22) and lowest in the 2nd lactation (3.18±0.18). The 1st and 2nd lactation orders showed similarity in terms of milk protein content, while there was a statistically significant difference compared to the 3rd and 4th lactation orders (*Fig. 6*).

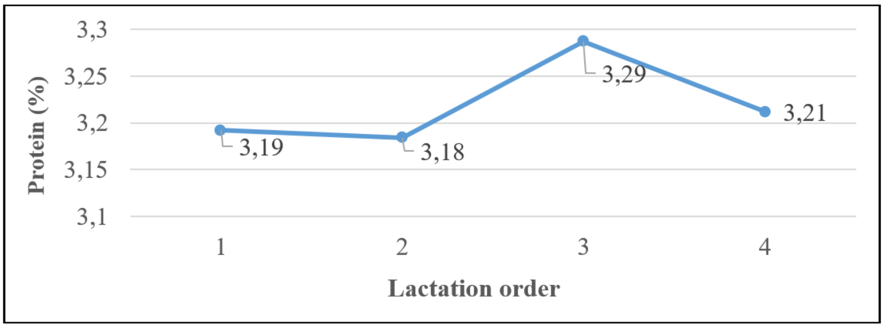

Figure 6. *Milk protein content by lactation order*

Milk lactose content by lactation order

The lactose content of milk across different lactation orders was presented in *Table 2*. The highest average lactose content was observed during the 4th lactation (4.73±0.32), while the lowest was recorded during the 3rd lactation (4.63±0.28). Statistical analysis revealed no significant differences in lactose content among the lactation orders (*Fig. 7*).

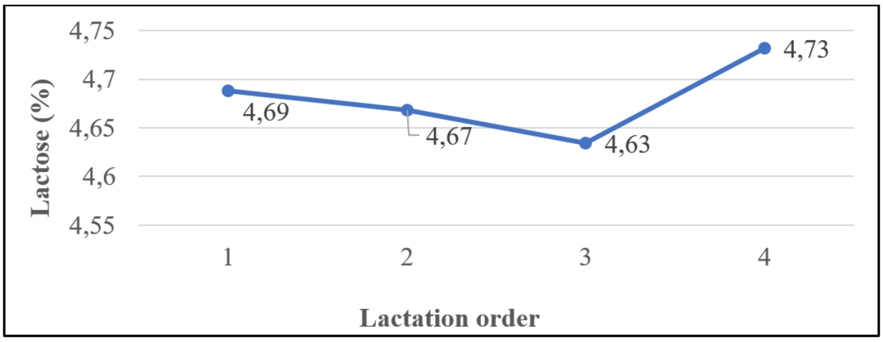

Figure 7. *Lactose content by lactation order*

Milk somatic cell count (SCC) content by lactation order

The somatic cell count in milk according to the lactation order was shown in *Table 2*. It was determined that the highest somatic cell count in milk was during the 4th lactation (227.23±36.79), and the lowest was during the 1st lactation (197.90±23.62). A statistically significant difference was found between the lactation orders in terms of the somatic cell count in the milk (*Fig. 8*).

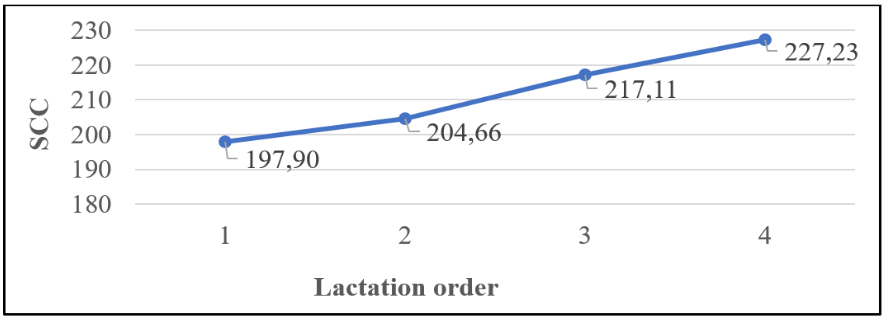

Figure 8. *Milk somatic cell count (SCC) by lactation order*

The effect of season on milk composition

The Effect of Season on Milk Components was presented in *Table 2*.

Milk fat content by season

The determining statistical values related to the fat content of milk by season was shown in *Table 3*. It was determined that the highest average fat content in milk was during the Spring (3.77±0.34), while the lowest fat content was observed in the Autumn (3.35±0.23). A statistically significant difference was noted in the fat content of milk between the Autumn and other seasons (*Fig. 9*).

Table 3. *The effect of season on milk composition*

Season	N	Fat	Dry Matter	Protein	Lactose	SCC
Spring	49	3,77±0,34^{a}	12,85±0,26^{a}	3,22±0,23^{ab}	4,70±0,27^{a}	212,19±31,78^{ab}
Summer	56	3,72±0,38^{a}	12,80±0,30^{a}	3,27±0,17^{a}	4,67±0,18^{a}	219,51±31,53^{a}
Autumn	56	3,35±0,23^{b}	12,48±0,38^{b}	3,13±0,26^{b}	4,73±0,31^{a}	207,36±29,84^{ab}
Winter	49	3,60±0,28^{a}	12,71±0,40^{a}	3,31±0,11^{a}	4,56±0,32^{a}	203,56±27,94^{b}
p		**<0,001**	**<0,001**	**<0,001**	0,051	**0,048**

Different letters such as a, b indicate the statistical difference between the means in the same column

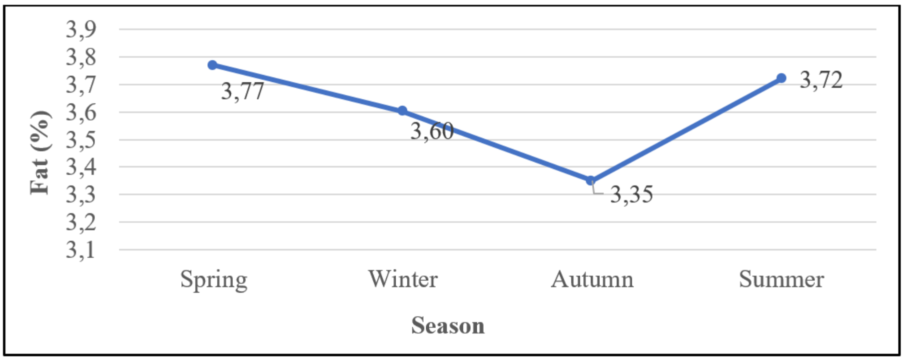

Figure 9. *Milk fat content by season*

Milk dry matter content by season

The determining statistical values related to the dry matter content of milk by season was shown in *Table 3*. It was determined that the highest average dry matter content in milk was during the Spring (12.85±0.26), while the lowest was observed in the Autumn (12.48±0.38). A statistically significant difference was noted in the dry matter content of milk between the Autumn and other seasons (*Fig. 10*).

Milk protein content by season

The determining statistical values related to the protein content of milk by season are shown in *Table 3*. It was determined that the protein content of milk was highest in the Winter (3.31±0.11) and lowest in the Autumn (3.13±0.26). There was no statistical difference in protein content between the Winter and Summer seasons, while a statistically significant difference was observed between the Autumn and Spring seasons (*Fig. 11*).

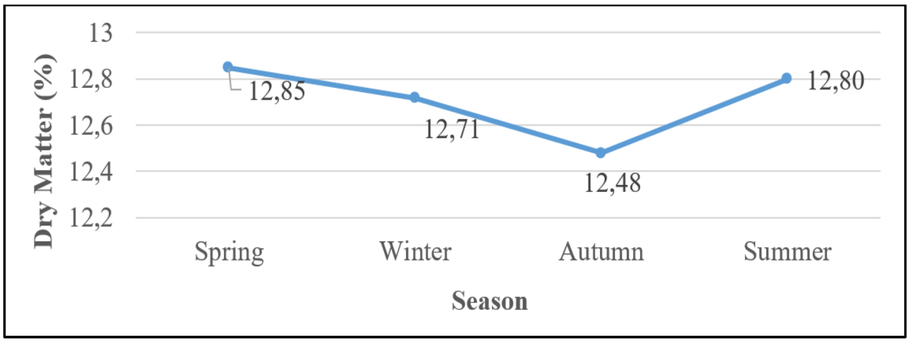

Figure 10. *Milk dry matter content by season*

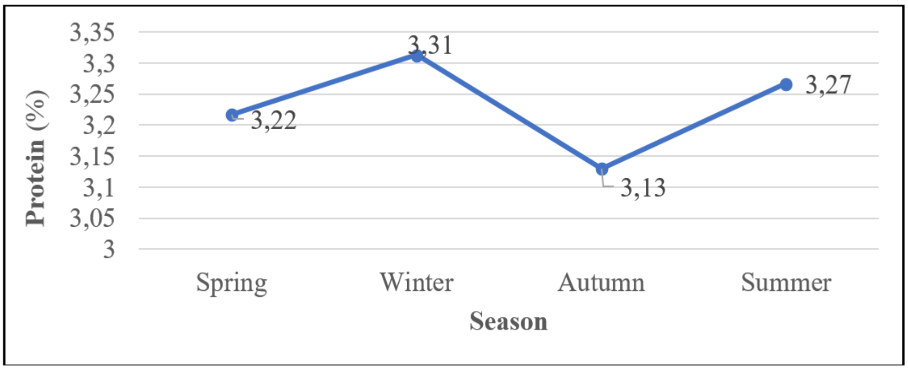

Figure 11. *Milk protein content by season*

Milk lactose content by **season**

The determining statistical values related to the lactose content of milk by season was shown in *Table 3*. It was determined that the lactose content of milk was highest in the Autumn (4.73±0.31) and lowest in the Winter (4.56±0.32). No statistically significant difference was found between the seasons in terms of lactose content (*Fig. 12*).

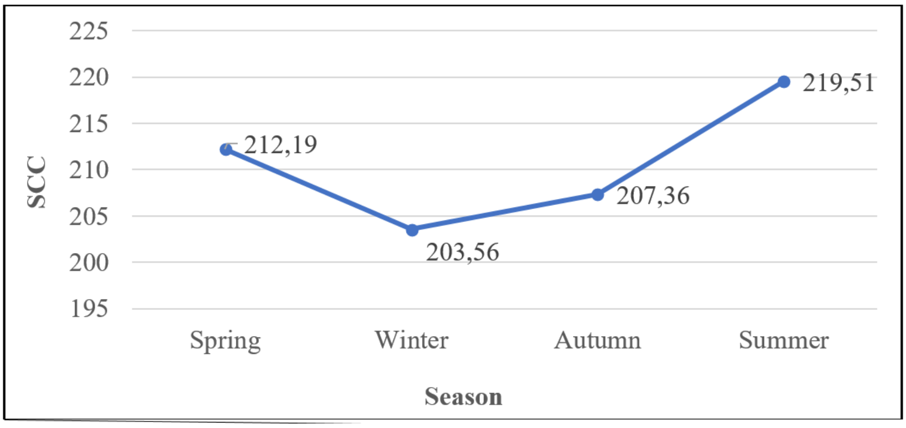

Figure 12. *Milk lactose content by season*

Relationship between SCC and milk components

The correlation relationships between lactation order, milk components (fat, dry matter, protein, lactose), season, and somatic cell count (SCC). In this table, the correlation coefficient (r) and significance value (p) for each parameter was presented (*Table 4*).

Table 4. *The correlation table*

		Fat	Dry Matter	Protein	Lactose	Season	SCC
Lactation order	r	-,102	,383**	,089	,038	,000	,355**
	p	,140	**<0,001**	,201	,583	1,000	**<0,001**
Fat	r	1	,098	,033	-,086	-,333**	-,020
	p		,157	,633	,214	**<0,001**	,769
Dry Matter	r		1	,152*	-,062	-,278**	,265**
	p			**<0,001**	,368	**<0,001**	**<0,001**
Protein	r			1	,277**	,009	-,029
	p				**<0,001**	,902	,677
Lactose	r				1	-,084	-,227**
	p					,225	**,001**
Season	r					1	-,116
	p						,093

According to the analyses presented in *Table 4*, the following conclusions have been drawn:

Correlations with lactation order

A significant positive correlation was found between lactation order and dry matter content in milk ($r = 0.383$, $p < 0.001$), indicating that milk dry matter content rises with increasing lactation order. Similarly, a positive and significant relationship was observed between lactation order and somatic cell count (SCC) ($r = 0.355$, $p < 0.001$), suggesting that SCC tends to grow as lactation progresses. This pattern implies a potential increase in udder health challenges during later lactation stages.

Correlations with fat content

There is a significant negative correlation between milk fat content and season ($r = -0.333$, $p < 0.001$), indicating that milk fat levels decline with seasonal changes, with the most pronounced reduction occurring in the summer. Additionally, a negative correlation was noted between milk fat content and somatic cell count (SCC); however, this relationship was not statistically significant ($r = -0.020$, $p = 0.769$), suggesting no meaningful association between these variables.

Correlations with dry matter

There is a significant positive relationship between dry matter and protein ($r = 0.152$, $p < 0.01$), indicating that as the dry matter content increases, the protein content in the milk also increases. A negative and significant correlation exists between dry matter and season (r = -0.278, p < 0.001), suggesting that the dry matter content in milk decreases with changing seasons, demonstrating the seasonal influence on milk composition. A positive and significant relationship is observed between dry matter and SCC (r = 0.265, p < 0.001), indicating that as the somatic cell count increases, the dry matter content also rises, reflecting its impact on milk quality and composition.

Correlations with protein

A positive and significant correlation exists between protein and lactose (r = 0.277, p < 0.001), indicating that as the protein content in milk increases, the lactose content also rises. There is no significant relationship between protein and SCC (r = -0.029, p = 0.677).

Correlations with lactose

There is a negative and significant correlation between lactose and SCC (r = -0.227, p = 0.001), indicating that as the somatic cell count increases, the lactose content decreases, suggesting that the lactose amount declines as the infection in the milk increases.

Season with SCC

There is no significant relationship between season and SCC (r = -0.116, p = 0.093), indicating that seasonal variations do not have a statistically significant effect on the somatic cell count.

Discussion

Önal et al. (2021) conducted a study on Holstein cows and found no statistically significant differences in milk composition specifically fat, protein, dry matter, and average daily yields across different lactation orders (p > 0.05). In contrast, the findings from this study deviate from those results, except for the parameter of lactose, which similarly showed no significant difference (p > 0.05). Gerald (2005) investigated the relationship between milk components and somatic cell count (SCC) in their studies, categorizing SCC into four groups: <100,000, 100,000–250,000, 500,000–1,000,000, and >1,000,000 cells/ml. According to this grouping, they reported fat percentages of 3.74%, 3.69%, 3.51%, and 3.13%, respectively. They noted that the changes in fat values were significant for all parameters based on somatic cell count. However, the results obtained in this study do not align with their findings. This discrepancy may be attributed to factors such as sample size, analytical methods or environmental influences on milk components. In particular, the effects of somatic cell count on milk quality can vary across different cattle breeds and environment conditions.

Ng-Kwai-Hang et al. (1984) conducted a study on Holstein cattle, reporting that as lactation order increased, the protein percentage gradually decreased by approximately 4%, with the highest protein percentage observed in cows during the second lactation. This indicates that protein levels decrease slowly as lactation order increases. These findings are consistent with the results obtained in this study. The data clearly demonstrate the effect of lactation order on protein levels, which in turn affects milk quality. Similarly, the observed decrease in protein percentage as lactation progresses emerges as an important parameter for evaluating milk productivity and nutritional strategies. In this context, considering lactation order in milk production is highlighted as a critical factor for more effectively organizing the nutritional programs of cows.

Ayaşan et al. (2011) examined the effects of low (<268,000 cells/ml) and high (>268,000 cells/ml) somatic cell counts (SCC) on milk components in Holstein cattle. They found that the lactose percentages in milk were 4.34% for the low SCC and 4.15% for the high SCC group, noting that the difference between these groups was statistically significant (P<0.05). The results obtained in this study do not align with the current findings; this discrepancy may be attributed to differences in methodologies, sample sizes, or research conditions. Additionally, recent changes in the literature regarding this topic and environmental factors may have influenced the results.

Mrode et al. (1996) reported somatic cell counts (SCC) in milk for Holstein cattle in England as follows: 88,700 cells/ml in the first lactation, 109,400 cells/ml in the second lactation, 141,300 cells/ml in the third lactation, 178,200 cells/ml in the fourth lactation, and 220,000 cells/ml in the fifth lactation.

Hagnestam-Nielsen et al. (2009) examined the relationship between daily milk yield and SCC during different stages of lactation in cows without clinical mastitis, finding that the geometric mean of SCC was 55,000 cells/ml in first-lactation cows and 95,000 cells/ml in cows that had calved twice or more. They noted that both the number of lactations and the lactation stage significantly affect SCC, especially in the later stages of lactation, where SCC can rise sharply.

The findings from Mrode and Hagnestam-Nielsen's studies (1996; 2009) align with the results of this research. The data indicates that SCC increases with lactation order, which can negatively impact milk quality. The rise in SCC as lactation progresses is a significant factor affecting milk yield and quality. Therefore, monitoring milk health and controlling SCC is critical for high-yielding milk production. This study presents findings consistent with the existing literature, highlighting the importance of considering lactation order and stage in milk health management.

Özkan (2017) conducted a study on Holstein cattle, reporting that the lowest milk fat content was observed in the autumn (3.436±0.0583). This finding is consistent with our research, indicating that seasons significantly affect milk components. The reduction in fat content during the autumn period highlights how nutritional conditions and environmental factors influence milk quality. The similar results obtained in our thesis emphasize the need to reconsider production strategies by taking seasonal variations into account.

Moreover, it is essential to adjust the nutrition and management programs of the animals according to seasonal changes to optimize milk fat content. Such approaches play a critical role in enhancing milk quality and ensuring economic efficiency in dairy production.

Bueno et al. (2005) examined the relationship between somatic cell count (SCC) and milk composition, as well as the effects of SCC and seasonality. They classified SCC into five groups: ≤ 200, 201-400, 401-750, 751-1,000, and >1,000 (×1,000 cells/ml). According to their findings, the dry matter percentages for these groups were reported as 12.61%, 12.54%, 12.39%, 12.27%, and 12.20%, respectively. They emphasized that the changes in dry matter values due to SCC were statistically significant across all parameters (P<0.05).

These findings align with current study, indicating a clear impact of SCC on milk composition, particularly showing that an increase in SCC leads to a decrease in dry matter content. This highlights an important issue regarding milk quality, as controlling

SCC has a direct effect on milk health and productivity. The results of this study are consistent with existing literature, underscoring the critical importance of monitoring and managing SCC in milk production. Therefore, considering the effects of somatic cell count during the production process will be a key strategy for improving milk quality.

Ng-Kwai-Hang et al. (1984) reported that the milk protein content in Holstein cattle is higher in winter and lower in summer. These findings align with this research results, indicating that environmental conditions significantly affect nutrition and metabolism. High temperatures in summer create stress for cows, negatively impacting both milk production and composition. Heat stress can reduce feed intake, leading to decreased protein synthesis. Furthermore, it increases metabolic load, contributing to a decline in milk protein content.

In contrast, during winter, cattle are typically fed richer, high-quality silage and hay, which positively influences milk protein levels. The increased energy requirement in cold weather supports metabolic processes and milk protein production. In summer, however, high temperatures can slow metabolic processes, resulting in reduced protein synthesis. Additionally, increased water consumption in summer may lead to higher milk volume but lower protein concentration, as the volume increases while the protein percentage decreases. These combined factors explain why milk protein levels are generally higher in winter and lower in summer, emphasizing the importance of adjusting feeding strategies based on seasonal variations to optimize milk quality.

Bueno et al. (2005) examined the relationship between somatic cell count (SCC) and milk composition, considering seasonal effects. They categorized SCC into five groups based on the count (≤ 200, 201-400, 401-750, 751-1,000, and >1,000 x 1000 cells/ml) and reported corresponding lactose levels of 4.60%, 4.54%, 4.49%, 4.42%, and 4.36%. Their findings indicated that changes in lactose levels were significantly associated with SCC ($P<0.05$), which aligns with current study and confirms the effects of SCC on milk composition.

Specifically, it was found that high SCC negatively impacts milk quality and reduces lactose levels. This highlights the importance of monitoring SCC in milk production. Although seasonal feeding changes are not a primary factor directly affecting lactose levels, they can indirectly influence them. Lactose production is primarily linked to glucose metabolism; thus, inadequate nutrition and reduced energy intake can lead to lower overall milk yield, consequently affecting lactose concentrations.

Reikerink et al. (2007) investigated the seasonal effects on somatic cell count (SCC) in tank milk and individual samples, finding significant seasonal influences. They reported the highest SCC in tank milk during September (209,000 cells/ml) and the lowest in March (150,000 cells/ml). Similarly, the highest individual SCC values were found in August, while the lowest were in February.

Bueno et al. (2005) also explored the relationship between SCC and milk composition, noting that in Brazil, significant differences in SCC were observed between the rainy season (November and April) and the dry season (May and October). They indicated that higher temperatures were associated with increased SCC.

Reikerink et al. (2007) found that SCC peaked between May and August, aligning with the results of this study, which demonstrated that SCC responded to seasonal changes, particularly rising during the summer months. This increase can be attributed to heat stress and a higher risk of mastitis. Additionally, environmental changes in housing conditions during hot weather may heighten the susceptibility of animals to stressors, further impacting SCC levels. Conversely, the lower SCC observed during the winter months might be explained by cooler temperatures positively influencing the immune system of the animals.

These findings emphasize the significant impact of seasonal changes on udder health and milk quality in dairy cattle, highlighting the importance for producers to optimize management strategies according to these seasonal variations.

In contrast, Topaloğlu and Güneş (2013) reported that seasonal effects on SCC in Holstein cattle were negligible. This finding does not align with the current study, which confirmed that SCC is significantly influenced by seasonal changes, particularly increasing during the summer. The discrepancies between studies may arise from variations in research conditions, animal husbandry practices, environmental factors, and geographical differences.

Conclusion

In the study, it was found that there are statistically significant differences in fat, dry matter, somatic cell count (SCC), and protein content of milk among different lactation orders in Holstein cattle, while no significant difference was detected in lactose content across lactation orders. The study also observed statistically significant differences in fat, dry matter, protein, and SCC among seasons, but no significant difference in lactose content. A positive and significant correlation was found between lactation order and dry matter and SCC, indicating that changes in milk composition can occur as lactation progresses, potentially affecting milk quality. The weak relationships with fat and protein suggest that these parameters do not vary significantly with lactation order.

A negative and significant correlation was identified between fat and SCC with the season, suggesting that seasonal changes can affect milk fat content and SCC, particularly noting a decrease in milk fat and an increase in SCC during hot summer months. There is a positive correlation between protein and lactose, whereas no significant relationship exists between fat and lactose. This implies that the relationships between milk components can be complex, with each component responding differently to various biological and environmental factors.

To minimize changes in milk composition due to lactation order, stricter quality control measures should be implemented in the later stages of lactation, along with nutritional adjustments as needed. Given the significant impact of seasons on milk composition, strategies should be implemented to protect cows from stress, particularly during hot summer months, to preserve milk fat. The feeding regime can be adjusted to compensate for fat loss during this period. High SCC can lead to negative outcomes for milk quality and animal health, so steps should be taken to improve udder health while considering seasonal factors. Strict hygiene protocols and regular monitoring should be in place to keep SCC under control.

Detailed analyses of milk composition changes in cows across different lactation orders and a deeper examination of seasonal effects would be beneficial for improving production efficiency and milk quality. Particularly, studies could be conducted to mitigate the effects of heat stress on milk composition.

Improving udder health in a farm contributes to the farm's economy by enhancing milk quality and production quantity, thereby maximizing profitability. Effective general and individual hygiene practices (such as housing and udder cleanliness, milking equipment, and personnel hygiene) should be implemented in milk production processes.

Additionally, regular screenings for SCC and bacterial colony counts can help identify and separate animals with subclinical mastitis, leading to more efficient treatment methods. Utilizing supplements, feeds, and probiotics that strengthen the immune system can provide advantages in reducing SCC.

In dairy operations, adopting and promoting systems such as Good Manufacturing Practices (GMP), Hazard Analysis and Critical Control Points (HACCP), along with Total Quality Management, is essential to improve milk quality and food safety. These practices promote the production of high-quality raw milk, preserving its nutritional properties, while also improving microbiological and physicochemical characteristics, offering technological advantages, and facilitating greater access to state milk subsidies.

Acknowledgements. This research article was derived from a master's thesis with the same title.

Conflicts of interest. The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

REFERENCES

[1] Auldist, M. J., Walsh, B. J., Thomsonet, N. A. (1998): Seasonal and lactational influences on bovinemilk composition in New Zealand. – J. Dairy Res. 65: 401-411. https://doi.org/ 10.1017/s0022029998002970.

[2] Ayaşan, T., Hızlı, H., Yazgan, E., Kara, U., Gok, K. (2011): Somatik hücre sayısının süt üre nitrojen ile süt kompozisyonuna olan etkisi. – Kafkas Üniversitesi Veteriner Fakültesi Dergisi 17(4): 659-662. https://doi.org /10.9775/kvfd.2011.4489.

[3] Bueno, V. F. F., de Mesquita, A. J., Nicolau, E. S., de Oliveira, A. N., de Oliveira, J. P., Soares Neves, R. B., Garcia Mansur, J. R., Thomaz, L. W. (2005): Somatic cell count: relationship to milk composition and period of the year in Goiás State, Brazil. – Microbiologia Ciencie Rural 35: 4. https://doi.org/10.1590/S0103-84782005000400016.

[4] Dürr, J. W., Newton, P. R., Claudio, N. C., Horst, J. A., Bondan, C. (2011): Milk recording as an indispensable procedure toassure milk quality. – Rev. Bras. Zoot. 40: 76-81.

[5] Gerald, M. J. (2005): How does somatic cell count affect milk quality and safety. – Virginia Tech, Blacksburg. http://www.dasc.vt.edu/faculty/ jones/MilkSafe.htm.

[6] Heck, J. M. L., Van Valenberg, H. J. F., Dijkstra, J., Van Hooijdonk, A. C. M. (2009): Seasonal variation in the Dutch bovine raw milk com-position. – J. Dairy Sci. 92(10): 4745-4755. https: //doi.org/10.3168/jds.2009-2146.

[7] Koç, A. (2007): Daily milk yield, non-fat dry matter content and somatic cell count of Holstein-Fersian and Brown Swiss cows. – Acta Vet (Beograd) 57: 523-535. https:// doi.org/10.2298/AVBO706523K.

[8] Lambertz, C., Sanker, C., Gauly, M. (2014): Climatic effects on milkproduction traits and somatic cell score in lactating Holstein-Friesian cowsin different housing systems. – J. Dairy Sci. 97(1): 319-329. https:// doi.org/ 10.3168/jds.2013-7217.

[9] Mayers, A. (2013): Introduction to statistics and SPSS in psychology. – Harlow Pearson Education Limited.

[10] Memiši, N., Bogdanoviæ, V., Tomiæ, Z., Kasalica, A., Žujovic, M., Stanišic, N., Delic, N. (2011): Variability and correlation between basic quality parameters of raw cow milk. – Biotech. Anim. Husband. 27: 959-967.

[11] Milligo, V., Quedraogo, G. A., Agenas, S., Svennersten-Sjaunja, K. (2009): Day to day variation, in yield composition and somatic cell count saleable in hand-milked zebu dairy cattle. – Afr J Agric Res. 4(3): 151-155.

[12] Mrode, R. A., Swanson, G. J. T. (1996): Geneticand statistical properties of somatic cell countand its suitability as an indirect means ofreducing the incidence of mastitis in dairycattle. – Anim. Breed. Abstr. 64: 847-857.

[13] Ng-Kwai-Hang, K. F., Hayes, J. F., Moxley, J. E., Monardes, H. G. (1984): Variability of test-day milk production and composition and relation of somatic cell counts with yield and compositional changes of bovine milk. – Journal of Dairy Science 67(2): 361-366.

[14] Noro, G., González, F. H. D., Campos, R., Dürr, J. W. (2006): Fatores ambientais que afetam a produção e a composição do leite em rebanhos assistidos por cooperativas no Rio Grande do Sul. – Revista Brasileira de Zootecnia 35: 1129-1135. https://doi.org/10.1590/S1516-35982006000400026.

[15] O’Hara, E. A., Holtenius, K., Båge, R., Von Brömssen, C., Emanuelson, U. (2020): An observational study of the dry period length and its relation to milk yield, health, and fertility in two dairy cow breeds. – Prev Vet Med 175: 104876. https:// doi.org/ 10.1016/j.prevetmed.2019.104876.

[16] Olde Riekerink, R. G. M., Barkema, H. W., Stryhn, H. (2007): The Effect of Season on Somatic Cell Count and the Incidence of Clinical Mastitis. – J. Dairy Sci. 90: 1704-1715. https:// doi.org/ 10.3168/jds.2006- 567.

[17] Oltenacu, P. A., Broom, D. M. (2010): The impact of genetic selection for increased milk yield on the welfare of dairy cows. – Animal Welfare 19(5): 39-49. https:// doi.org/ 10.1017/S0962728600002220.

[18] Önal, A. R., Özkan, M., Tuna, Y. T. (2021): Siyah Alaca Süt Sığırlarında Mevsim ve Laktasyon Sırasının Sütün Bileşimi ve Kalitesine Etkisi. – Tekirdağ Ziraat Fakültesi Dergisi 18(2): 368-374. https:// doi.org/ 10.33462/jotaf.831567.

[19] Özkan, M. (2017): Süt sığırlarında somatik hücre sayısının süt bileşimi ve kalitesine etkisi (Tez No: 457201). [Yüksek Lisans Tezi, Namık Kemal Üniversitesi Fen Bilimleri Enstitüsü Zootekni Ana Bilim Dalı]. – Yükseköğretim Kurulu Ulusal Tez Merkezi.

[20] Sharif, A., Ahmad, T., Bilal, M. Q., Yousaf, A., Muhammed, G. (2007): Effect of severity of sub-clinical mastitis on somatic cell count and lactose contents of Buffalo milk. – Pakistan Veterinary Journal 27(3): 142-144.

[21] Shook, G. E. (1989): Selection for disease resistance. – Journal of Dairy Science 72(5): 1349-1362.

[22] Topaloğlu, N., Güneş, H. (2013): İngiltere’deki siyah-alaca sığırların döl verimi özellikleri üzerinde araştırmalar. – İstanbul Üniversitesi Veteriner Fakültesi Dergisi 31(1): 99-118.

[23] Zadoks, R. N., Fitzpatrick, J. L. (2009): Changing trends in mastitis. – Ir Vet Journal 62: 1-12. https:// doi.org/10.1186/2046-0481-62-S4-S59.