The effect of somatic cell count on milk yield and milk composition on day seven postpartum in cows

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ABSTRACT

The aim of this study was to evaluate the effects of somatic cell count (SCC) on the milk yield and milk composition (nonfat solid, fat, protein, lactose, casein) on day 7 postpartum in Holstein cows. Milk samples (n=794) were assessed with consideration of parity (primiparous and multiparous) and seasonal effect (spring, summer, fall, winter). The SCCs of the milk samples were divided into three groups as follows: G1: $<10^5$ cells/mL; G2:10^5 - 4×10^5 cells/mL; and G3:$> 4\times10^5$ cells/mL. The mean $\log_{10}$ SCC was 5.19 cells/mL on day 7 postpartum. The SCC values were transformed into $\log_{10}$ SCC. The mean $\log_{10}$ SCC was determined as 4.72 cells/mL for G1, 5.31 cells/mL for G2, and 5.77 cells/mL for G3. The lowest $\log_{10}$ SCC was determined in winter, while the highest milk yield was determined in the spring. While the nonfat solid, fat, protein, and casein were higher in primiparous cows, the $\log_{10}$ SCC numerically increased (5.17 vs. 5.24 cells/mL, respectively) with the higher milk yield of multiparous cows. The nonfat solid, fat, protein, lactose, casein, and milk yield were 9.14%, 3.63%, 3.66%, 5.01%, 2.69% and 33.49kg/day for G1, respectively. A reduction in milk components was evident when the SCC exceeded the healthy udder threshold (>100,000 cells/mL). The critical threshold for SCC can be determined as 100,000 cells/mL for evaluation of the milk component loss in the early postpartum period. In addition, determination of increased somatic cell count by individual measurements as early as possible after parturition can prevent the exacerbation of milk composition loss throughout lactation in cows.

Key words: somatic cell count; milk composition; postpartum; milk yield; cow

Introduction

Mastitis is a significant inflammation in terms of the economic loss due to its high incidence (GUIMARÃES et al., 2017; NEDIĆ et al., 2019; SAIDI et al., 2021). Subclinical mastitis is obviously more important than clinical mastitis because of its high incidence, loss of milk yield, and difficulty in control (MALEK DOS REIS et al., 2013; KOVAČIĆ et al., 2019; BUROVIĆ, 2020). Somatic cell count is classified for determination of the status of udders and the severity of mastitis.

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According to this classification, healthy cows have lower SCC than 10^5 cells/mL. Cows with SCC between 10^5-2×10^5 in their milk are arguably considered healthy, so values in this range should be monitored for mastitis (LIEVAART et al., 2007; BENIĆ et al., 2018). Milk samples containing SCC above 2×10^5 cells/mL are also divided into three different SCC groups. The first of these groups has between 2×10^5-3×10^5 cells/mL and is categorized as "low risk for subclinical mastitis", the second group has between 3×10^5-4×10^5 cells/mL and is categorized as "high risk for subclinical mastitis", and the third group has SCC $\geq4\times10^5$ cells/mL and is categorized as "udder with mastitis", even if the cow does not show any clinical mastitis symptoms (EL-TAHAWY and EL-FAR, 2010). In addition to the increased somatic cell count with subclinical mastitis, a milk loss of 5-20% is accompanied by changes in milk quality and composition (BOBBO et al., 2017).

Milk collected from cows with SCC is a potential danger in terms of food safety and security because pathogenic microorganisms cause health problems for consumers (HAMEED et al., 2007; CVETNIĆ et al., 2016; TURK et al., 2017). These changes result in a reduction in the nutritional value of the milk for human consumption (SHARIF and MUHAMMAD, 2008) and cause losses for dairy products such as yoghurt and cheese, along with a series of quality issues (BYTYQI et al., 2010).

It is well known that animal age, udder anatomy, seasons, lactation period, milking hygiene, milking frequency, personnel practices, and nutrition conditions can also influence the SCC (PYÖRÄLÄ, 2008; YANG et al., 2013). Colostrum physiologically contains more than 1 million cells/mL, but it falls back to normal levels ($\leq10^5$ cells/mL) between the 5 and 10 days postpartum (BARKEMA et al., 1999). The first two weeks after calving are considered to involve the highest risk in terms of udder health (GRAČNER et al., 2006; PYÖRÄLÄ, 2008; TURK et al., 2012). Previous studies have mostly reported milk sample results in different lactation periods (GONÇALVES et al., 2018) or a bulk tank (EL-TAHAWY and EL-FAR, 2010). However, the incidence of mastitis increases in the early postpartum period in high yielding dairy cows, and individual SCC measurement is feasible in this period (PYÖRÄLÄ, 2008).

Somatic cell count in the early postpartum period appears as an early predictor for mastitis. However, previous studies investigating the effect of SCC on milk composition and milk yield in this period are limited (GONÇALVES et al., 2018). For this reason, the present study aimed to investigate the effects of SCC on the milk composition and milk yield on day seven postpartum in dairy cows.

Materials and methods

Collection of Milk Samples. Çanakkale province in Turkey is located in the Aegean Region of Turkey, where multiple climates (Mediterranean, Black Sea) are present. This study was conducted on a total of 794 Holstein lactating cows kept on a commercial dairy farm (39°53'39''N, 26°12'12''E) in Çanakkale, between January and December 2018. The cows were fed three times a day with total mixed rations that met or exceeded the requirements of the NRC recommendations (2001). Within the farm, lactating cows were kept in free-stall barns equipped with axial flow fans and sprinklers, and were grouped on the basis of their day count in terms of lactation and breeding periods in partially open pens. Fans and sprinklers were thermostatically switched on at 25 °C. Milk samples were collected on day seven postpartum from each cow for research purposes. The SCC values were transformed into $\log_{10}$ SCC. The milk yield records for each milking were also collected using Dataflow II software (SCR Engineers Ltd., Netanya, Israel). The cows were milked three times each day using a hygienic milking procedure and a 2 × 25 milking unit. A 100 ml milk sample was collected from each animal on the morning of the seventh day postpartum, ensuring that equal amounts of milk were collected from each teat. Collected milk samples were transferred to the laboratory at +4° C, and the analyses were performed.

Milk Sample Analysis. The somatic cell count was determined using the flow cytometer method, and the nonfat solid, fat, protein, casein, and lactose levels in the milk samples were determined using a spectrometer technique (Bentley Combi FTS, ABD).

Classification of Samples. Milk samples were classified in relation to the season (Spring: March-May, Summer: June-August; Fall: September-November; Winter: December-February), parity (Primiparous: 1st lactation, Multiparous: ≥ 2nd lactation), and SCC groups (G1: <10^5 cells/mL; G2: 10^5 - 4×10^5 cells/mL; G3: > 4×10^5 cells/mL.

Statistical Analysis. All statistical analyses were performed using SPSS 20 package software. The general linear model (GLM) procedure was used to determine the effect of parity, season and SCC on milk yield and milk components (nonfat solid, fat, protein, lactose, casein). Differences between the group means were determined using the Duncan Multiple Comparison Test.

Results

A total of 794 milk samples were collected seven days after calving. The percentages of the samples from spring to winter were: 19.3% (153/794), 37.3% (296/794), 31.2% (248/794) and 12.2% (97/794), respectively. The milk yield in spring (35.66 kg/day) was statistically higher than the milk yield in other seasons (P<0.05). The mean $\log_{10}$ SCC (cells/mL) of the milk samples for spring, summer, fall, and winter months were 5.16, 5.21, 5.20, and 5.13, respectively. While the SCC was found to be statistically lower in winter compared to those of the summer and fall, the highest lactose content was determined in winter (P<0.05). The differences between milk components (nonfat solid, fat, proteins, lactose, casein, yield) based on the season are presented in Table 1.

Table 1. The effects of seasons on somatic cell count, milk yield and milk composition at 7 days postpartum in Holstein cows

Seasons	Spring (n:153)			Summer (n:296)			Fall (n:248)			Winter (n:97)		
SCC Groups ($\log_{10}$ cells/mL ± S.E.M.)	1	2	3	1	2	3	1	2	3	1	2	3
	(n:103)	(n:32)	(n:18)	(n:172)	(n:91)	(n:33)	(n:142)	(n:80)	(n:26)	(n:61)	(n:29)	(n:7)
$\log_{10}$ SCC ± S.E.M.	5.16 ± 0.03^{ab}			5.21 ± 0.02^{b}			5.20 ± 0.02^{b}			5.13 ± 0.04^{a}		
Nonfat solid (%) ± S.E.M.	9.25 ± 0.04^{a}			9.09 ± 0.02^{b}			8.84 ± 0.04^{c}			9.17 ± 0.06^{ab}		
Fat (%) ± S.E.M.	3.52 ± 0.05^{b}			3.61± 0.02^{b}			3.69 ± 0.09^{a}			3.71 ± 0.06^{a}		
Protein (%) ± S.E.M.	3.75 ± 0.02^{a}			3.60± 002^{b}			3.54 ± 0.03^{b}			3.71 ± 0.35^{a}		
Lactose (%) ± S.E.M.	4.99 ± 0.01^{b}			4.90 ± 0.01^{c}			4.96 ± 0.01^{b}			5.14 ± 0.02^{a}		
Casein (%) ± S.E.M.	2.78 ± 0.02^{a}			2.64± 0.02^{b}			2.54 ± 0.02^{c}			2.74 ± 0.03^{a}		
Milk Yield (kg) ± S.E.M.	35.66 ± 0.78^{a}			32.45 ± 0.51^{b}			31.82 ± 0.54^{b}			31.06 ± 0.99^{b}		

^{a,b,c} Values with different superscripts within a row differ at P<0.05.

The average parity of cows was 2.26 in the present study. It was determined that 21.16% (168/794) of milk samples were from the first parity and 78.84% (626/794) of milk samples were from the second parity and subsequent parities. The mean milk yield was 32.6 kg/day on day 7 postpartum. The mean milk yield of multiparous cows (35.14 kg/day) was higher than that of primiparous cows (23.61 kg/day) (P<0.01). No statistical difference was determined between the $\log_{10}$ SCC of multiparous cows (5.17 cells/mL) and primiparous cows (5.24 cells/mL) (P>0.05). The parity did not influence the milk lactose level (P>0.05). However, the nonfat solid (9.09%), fat (3.54%), protein (3.66%), and casein (2.67%) contents of multiparous cows were higher than those of primiparous cows (Table 2, P<0.05).

Table 2. The effects of parity on somatic cell count, milk yield and milk composition in Holstein cows

Parity	Primiparus n=168			Multiparus n=626		
Somatic Cell Groups ($\log_{10}$ cells/mL ± S.E.M.)	≤100	100-400	≥400	≤100	100-400	≥400
	(n:84)	(n:65)	(n:19)	(n:394)	(n:167)	(n:65)
Log_{10} SCC ± S.E.M.	5.24 ± 0.03^{a}			5.17 ± 0.02^{a}		
Nonfat solid (%) ± S.E.M.	8.93 ± 0.05^{a}			9.09 ± 0.02^{b}		
Fat (%) ± S.E.M.	3.63 ± 0.25^{a}			3.54 ± 0.09^{b}		
Protein (%) ± S.E.M.	3.51 ± 0.03^{a}			3.66 ± 0.02^{b}		
Lactose (%) ± S.E.M.	4.95 ± 0.02^{a}			4.96 ± 0.01^{a}		
Casein (%) ± S.E.M.	2.54 ± 0.03^{a}			2.67 ± 0.02^{b}		
Milk yield (kg) ± S.E.M.	23.61 ± 0.72^{a}			35.14 ± 0.38^{b}		

^{a,b} Values with different superscripts within a row differ at P<0.05.

Irrespective of season and parity, the mean $\log_{10}$ SCC was 5.19 on day seven postpartum in the present study. The distribution of milk samples according to SCC groups was 60.2% in G1, 29.2% in G2, and 10.6% in G3. Classification based on the $\log_{10}$ SCC revealed the averages of 4.72 cells/mL for G1, 5.31 cells/mL for G2, and 5.77 cells/mL for G3. The mean milk yields were 33.49 kg/day, 31.12 kg/day, and 32.5 kg/day for each group, respectively. The mean milk yield of the G1 group was found to be statistically higher compared to that of the G2 group (P<0.05). Also, the nonfat solid, fat, protein, lactose, and casein values of the G1 group were found to be statistically higher than those of other groups (Table 3, P<0.05).

Table 3. The effects of somatic cell count on the milk yield and milk composition on day 7 postpartum in Holstein cows

SCC Groups / Parameters	1st Group	2nd Group	3rd Group
	≤100×103 cells/mL ± S.E.M. (n:478)	100-400×103 cells/mL ± S.E.M. (n:232)	≥400×103 cells/mL ± S.E.M. (n:84)
Log_{10} SCC ± S.E.M.	4.72 ± 0.02^{a}	5.31 ± 0.03^{b}	5.77 ± 0.05^{c}
Nonfat solid (%) ± S.E.M.	9.14 ± 0.03^{a}	8.91 ± 0.04^{b}	8.89 ± 0.07^{b}
Fat (%) ± S.E.M.	3.63 ± 0.01^{a}	3.52 ± 0.09^{b}	3.58 ± 0.01^{b}
Protein (%) ± S.E.M.	3.66 ± 0.02^{a}	3.56 ± 0.03^{b}	3.58 ± 0.04^{b}
Lactose (%) ± S.E.M.	5.01 ± 0.01^{a}	4.90 ± 0.02^{b}	4.85 ± 0.03^{b}
Casein (%) ± S.E.M.	2.69 ± 0.02^{a}	2.57 ± 0.03^{b}	2.58 ± 0.04^{b}
Milk yield (kg) ± S.E.M.	33.49 ± 0.43^{a}	31.12 ± 0.62^{b}	32.57 ± 1.02^{ab}

^{a,b,c} Values with different superscripts within a row differ at P<0.05.

The nonfat solid, fat, protein, lactose, casein, and milk yield values for the G1 group were determined as 9.14%, 3.63%, 3.66%, 5.01%, 2.69% and 33.49 kg, respectively. The same values for G2 group were 8.91%, 3.52%, 3.56%, 4.90%, 2.57% and 31.12 kg/day, respectively. Besides, these components and milk yield for G3 were 8.89%, 3.58%, 3.58%, 4.85%, 2.58% and 32.57 kg/day, respectively. These parameters revealed that the nonfat solid, fat, protein, lactose, and casein of the healthy cows were statistically higher than the other groups (Table 3, P<0.01).

Discussion

Somatic cell count was also found to be numerically higher in summer than in the spring and fall seasons in the present study. Although most previous studies similarly reported increased SCC in the hot and humid summer months due to heat stress compared to other seasons (BERTOCCHİ et al., 2014; LİEVAART et al., 2007; YANG et al., 2013), other studies reported higher SCC due to the fact that the cows stay in closed barns during the winter months (EL-TAHAWY and EL-FAR, 2010; KUL et al., 2019). Although there has been no consensus in terms of the seasons in relation to increased somatic cell count, our study, with numerically increased SCC in the summer, supports previous reports (BERTOCCHİ et al., 2014; LİEVAART et al., 2007; YANG et al., 2013). Some studies revealed higher levels of nonfat solid, protein, casein in the spring, and higher levels of fat, and lactose levels in the winter. Other studies similarly reported lower milk fat, protein, and casein values for cows that were particularly exposed to heat stress during the summer months (BERNABUCCI et al., 2010; BERTOCCHI et al., 2014). The highest milk yield was determined in the spring. In a previous report, KUL et al. (2019) reported that higher milk yield was obtained in the summer months in Turkey. Season was also found to be a significant factor for changes in milk components, but no specific season was determined for higher levels of milk components except for milk yield in this study. It is possible that the differences between the studies in terms of SCC, milk composition, and milk yields could result from geographical location, season, as well as the negative energy balance during the postpartum period (BERNABUCCI et al., 2010; EL-TAHAWY and EL-FAR, 2010).

Regarding the effects of SCC on milk yield loss, it was reported that every increment of 50,000 SCC resulted in 0.4 kg/day milk loss in primiparous cows and 0.6 kg/day milk loss in multiparous cows (MILLOGO et al., 2009). Parity is considered to be an internal factor that affects SCC and milk composition in dairy cow herds (YANG et al., 2013). The present study clearly revealed the effects of parity on the milk yield, SCC, and milk composition. It is known that multiparous cows have higher milk yield during the early lactation period and lactation peak compared to primiparous cows (MILLER et al., 2006). As expected, the present study also showed that the multiparous cows had higher mean milk yield than primiparous cows on day seven postpartum. In addition, GONÇALVES et al. (2018) reported that SCC lower than <200,000 cells/mL reduced the milk yield loss between the 5 and 19 days postpartum. Although the milk yield of multiparous cows is higher than that of primiparous cows, SCC was not statistically different between primiparous and multiparous cows in this study. This result was consistent with previous studies, revealing the SCC remains unaffected by parity (CINAR et al., 2015). In addition, intra-udder infection risk is reported to increase when SCC increases with increased parity (JAMALI et al., 2018; ZHANG et al., 2016). The differences between the studies in terms of the relationship of parity and SCC can be explained by the genetic correlation of SCC and low milk yield. In addition, it is also possible that the SCC (<200,000 cells/mL) was too low to influence the milk yield in a significant manner in the present study (GONÇALVES et al., 2018).

All components in the milk samples of the multiparous cows, with the exception of the lactose content, were found to be higher than those of the primiparous cows. Previous studies reported that the increase in SCC would explain the expected reduction in certain parameters such as nonfat solid, fat, protein, lactose, and casein in the milk (GONÇALVES et al., 2018). Some studies showed that parity has no significant influence on milk fat and protein levels (MILLER et al., 2006), while other studies reported the parity influences milk parameters (BARBANO, 2017; YANG et al., 2013). It is possible that SCC levels below the threshold for subclinical mastitis might be the reason for the lack of any expected decrease in the nonfat solid, fat, protein, lactose, and casein levels in high-yielding multiparous cows (SHARIF and MUHAMMAD, 2008).

The permeability of the blood-udder barrier increases in mastitis. Accordingly, Na-Cl ions, proteins, and inflammatory cells increase in the milk, altering milk composition (COSTA et al., 2019). In the present study, a similar reduction in all milk components was observed when the healthy udder SCC threshold of 100,000 cells/mL increased. MALEK DOS REIS et al. (2013) reported that every 100,000 cells/mL increase in somatic cell count caused a decrease in milk nonfat solid content by 0.02%. Similar results were reported in other studies indicating dramatic decreases in the milk components when the threshold was exceeded (100,000 cells/mL) (JAMALI et al., 2018). There have been differences between previous studies in terms of the SCC threshold value that changes milk fat levels. Some studies reported a reduction in milk fat content as the SCC increases beyond 500,000 cells/mL (KUL et al., 2019) or 200,000 cells/mL (MILLOGO et al., 2009), while others reported that SCC has no influence on milk fat levels (CINAR et al., 2015). The reduced milk fat encountered in the high SCC group in the present study may be explained by the alteration of the metabolic status of the cows in the early postpartum period (TONI et al., 2011).

Previous studies reported positive (MALEK DOS REIS et al., 2013) and negative (BOBBO et al., 2017; CINAR et al., 2015; KUL et al., 2019) correlations between the increments of SCC and milk protein. The negative correlation between SCC and milk protein in the present study could result from the altered serum protein fractions following the SCC increase. Supporting our results, higher proteolytic activity along with a reduction in milk casein level were determined when SCC increased above 100,000 cells/mL (RAMOS et al., 2015). SCC values significantly higher than ≥400,000 cells/mL cause physical and organoleptic defects in cheese consumption due to high amounts of free amino acid formation and rapid cheese maturation. The association of physical and organoleptic qualities with SCC is an indication that SCC is not only an indicator of udder health, but is also a very significant factor for the quality of dairy products (BOBBO et al., 2017; MURPHY et al., 2016).

Lactose is the primary carbohydrate of milk, and it is responsible for the osmotic balance between the alveolar lumen and blood. In the case of increased SCC due to an inflammation in the udder, the developing glandular edema prevents glucose from reaching the udder glands, resulting in a reduction in lactose production (COSTA et al., 2019). The decrease in the lactose level of the milk causes the loss of the osmotic balance, and in turn, reduced milk yield. Moreover, lactose has a negative correlation with the chloride ion in the milk which is used for the diagnosis of clinical mastitis cases, making the change in the lactose content of the milk even more important (SHARIF and MUHAMMAD, 2008). Consistent with previous studies, increased SCC resulted in reduced lactose levels in the present study. The reduction in lactose levels was evident when the SCC exceeded the critical threshold of >100,000 cells/mL (MALEK DOS REIS et al., 2013). Milk fat and protein changes due to increased SCC are also influenced by ration (TONI et al., 2011). Lactose can be evaluated regardless of ration content (COSTA et al., 2019). Therefore, lactose levels can be used as a secondary predictor of the somatic cell count increments and diagnosis of subclinical mastitis in early postpartum period in cows.

Conclusion

Season and parity were found to have an effect on milk yield and milk composition. In particular, reductions in milk components were detected as the SCC exceeded the healthy udder threshold (>100,000 cells/mL). The critical somatic cell count threshold can be determined as 100,000 cells/mL to evaluate the loss of milk components in the early postpartum period. Determining the increase in the somatic cell count by individual measurements as early as possible after parturition can prevent the exacerbation of milk composition loss throughout lactation in cows.

Conflict of interest

The authors have declared no conflict of interest.

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GUNER, B., M. ERTURK, H. TAVSANLI, T. E. GUNER: Utjecaj broja somatskih stanica na prinos i sastav mlijeka sedmi poslijeporođajni dan u krava. Vet. arhiv 92, 145-153, 2022.

SAŽETAK

Cilj istraživanja bio je procijeniti utjecaj broja somatskih stanica (SCC) na prinos i sastav mlijeka (bezmasnu suhu tvar, mliječnu mast, proteine, laktozu, kazein) sedmi dan poslije porođaja u holštajnskih krava. Uzorci mlijeka (n = 794) procijenjeni su s obzirom na paritet (primipare i multipare) i sezonski učinak (proljeće, ljeto, jesen, zima). Broj somatskih stanica u uzorcima mlijeka podijeljen je u tri skupine: G1: < 105 stanica/mL, G2: 105 – 4 × 105 stanica/mL i G3: > 4 × 105 stanica/mL. Prosječan $\log_{10}$ SCC bio je 5,19 stanica/mL sedmi dan poslije porođaja. Vrijednosti SCC-a pretvorene su u $\log_{10}$ SCC. Prosječan $\log_{10}$ SCC određen je kao 4,72 stanice/mL za G1, 5,31 stanice/mL za G2 i 5,77 stanice/mL za G3. Najniži $\log_{10}$ SCC bio je zimi, dok je najveći prinos mlijeka bio u proljeće. Dok su vrijednosti bezmasne suhe tvari, mliječne masti, proteina i kazeina bile veće u primipara, vrijednost $\log_{10}$ SCC-a porasla je (5,17 prema 5,24 stanice/mL) s visokim prinosom mlijeka u multipara. Vrijednosti su bile sljedeće: bezmasna suha tvar 9,14%, mliječna mast 3,63 %, protein 3,66 %, laktoza 5,01 %, kazein 2,69 % i prinos mlijeka 33,49 kg/dan za G1. Smanjenje sastojaka u mlijeku bilo je očito kad je broj somatskih stanica prešao prag ispod kojega se vime smatra zdravim (> 100 000 stanica/mL). Kritičan prag za SCC može se odrediti kao 100 000 stanica/mL kako bi se procijenio gubitak mliječnih sastojaka u ranom poslijeporođajnom razdoblju. Određivanje porasta broja somatskih stanica pojedinačnim mjerenjima, što je moguće ranije, u poslijeporođajnom razdoblju može spriječiti porast gubitka mliječnih sastojaka tijekom laktacije u krava.

Ključne riječi: broj somatskih stanica; sastav mlijeka; poslijeporođajno razdoblje; prinos mlijeka; krava