

Some factors influencing milk somatic cell count of Holstein Friesian and Brown Swiss cows under the Mediterranean climatic conditions

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Abstract

The aim of this study was to determine the influencing factors on somatic cell count (SCC) in the milk of Holstein Friesian (HF) and Brown Swiss (BS) cows raised on three dairy farms under the Mediterranean climatic conditions in Turkey. For a two-year period, farms were visited monthly to measure daily milk yield (DMY) and collect milk samples from each cow during the morning and evening milking. Total of 1 429 SCC readings from 67 HF and 16 BS cows were analyzed by using repeated measures. Breed ($P<0.01$), lactation number (LN) ($P<0.01$), milking time (MT) ($P<0.05$), lactation month (LM) ($P<0.01$) and the interactions of breed-LM ($P<0.05$), herd-LM ($P<0.01$) and LN-LM ($P<0.01$) effects on SCC were statistically significant as did the co-variable DMY effect ($P<0.01$). The effect of herd and herd-MT interactions on SCC were statistically insignificant ($P>0.05$). The SCC means for BS and HF cows were 5.464 ± 0.060 (291 072 cells/ml) and 5.654 ± 0.029 (450 817 cells/ml), respectively. The SCC mean for morning milking (338 065 cells/ml) was 25 850 cells/ml lower than that of evening milking. The LN4 had the highest SCC mean (490 908 cells/ml) and was statistically different from those of LN1 ($P<0.01$) and LN2 ($P<0.05$). The SCC level was the highest in the first LM (601 174 cells/ml) and this level then decreased in the later months. Possible reasons for the difference in SCC means between the breeds are different resistance mechanisms against mastitis, different morphological conformations of udders and different milk yields between these two breeds. The insignificant differences found among herds show the similarities of management, milking hygiene and barn conditions. In order to decrease SCC in milk and increase udder health, some precautions need to be taken like improving milking management, hygiene and barn conditions, milking the cow at uniform intervals, feeding the cows after the milking and applying a mastitis control program.

Keywords: somatic cell count, Holstein Friesian, Brown Swiss, lactation month, milking time

Zusammenfassung

Einige die somatische Zellzahl beeinflussende Faktoren bei Holstein Friesian und Brown Swiss Kühen unter mediterranen Klimabedingungen

Untersucht wurden die somatische Zellzahl (SCC) beeinflussende Faktoren bei 67 Holstein Friesian (HF) und 16 Brown Swiss (BS) Kühen in drei Farmherden unter mediterranen Bedingungen der Türkei. In einem Zeitraum von zwei Jahren konnten monatlich die

täglichen Milchleistungen und insgesamt 1 429 Milchproben der Morgen- und Abendgemelke erfasst werden. Signifikante Einflüsse ($P < 0,01$) auf die SCC wurden nachgewiesen für die Rasse, Laktationsnummer (LN) ($P < 0,01$), Melkzeit ($P < 0,05$), den Laktationsmonat (LM) ($P < 0,01$) und die Interaktionen zwischen Rasse : LM ($P < 0,05$), Herde : LM ($P < 0,01$) und LN : LM ($P < 0,01$) sowie den covariablen Effekt der Milchleistung. Nicht signifikant war der Einfluss der Herde sowie der Interaktion Herde : Melkzeit ($P < 0,05$). Die durchschnittlichen SCC Zahlen betrugen für BS bzw. HF 291 071 bzw. 450 817 Zellen/ml, für das Morgengemelk 338 065 und für das Abendgemelk 363 915 Zellen/ml. Mit steigender Laktationsnummer erhöhten sich die SCC. Die Laktationsmonate beeinflussten signifikant die SCC. Der höchste Wert ergab sich im ersten Laktationsmonat mit 601 174 Zellen/ml und verringerte bereits im zweiten Monat auf 391 742 und im Laufe der Laktation auf 272 898 Zellen/ml. Als mögliche Ursachen für die Unterschiede zwischen den Rassen werden unterschiedliche Resistenzmechanismen gegenüber der Mastitis, unterschiedliche eutermorphologische Eigenschaften oder die Höhe der Milchleistung angenommen. Die nicht signifikanten Differenzen zwischen einzelnen Einflussgrößen werden auf Ähnlichkeiten im Betriebsmanagement, die Melkhygiene und Betriebsbedingungen zurückgeführt. Zur Reduzierung des SCC-Gehaltes wird eine Reihe von notwendigen Veränderungen im Betriebsmanagement empfohlen.

Schlüsselwörter: somatische Zellzahl, Holstein Friesian, Brown Swiss, Laktationsmonat, Melkzeit

Introduction

Somatic cell count (SCC) is one of the most important indicators of hygienic quality of milk. SCC level is also an indicator for the managerial conditions of the dairy farm and a primary trait for improving udder health in breeding programs in many countries (EUROPEAN COMMUNITY 1992, FAHR 2002, KALM 2002). Inefficient management and lack of mastitis control program increase SCC in milk (OMORE *et al.* 1999). ERSKINE (2001) reported that accepting 200 000 cells/ml as a threshold appears to be reasonable. It is assumed that this threshold distinguishes between healthy and diseased udders (HAAS 2003, SKRZYPEK *et al.* 2004).

RUPP and BOICHARD (2003) and GULYAS and IVANCSICS (2001) reported that resistance to mastitis varies by breed and genetic variability within a breed. Some European dairy breeds such as Montbeliarde, Abondance, Simmental and Brown Swiss (BS) had lower SCC levels and clinical mastitis frequency than Holsteins (BUSATO *et al.* 2000, AMIN *et al.* 2002, RUPP and BOICHARD 2003). The frequency of clinical mastitis increased over time for Holstein populations, due to genetic antagonism between milk production and mastitis resistance (GULYAS and IVANCSICS 2001, IMBAYARWO-CHIKOSI *et al.* 2001, RUPP and BOICHARD 2003). Morphological conformation of udder was also associated with SCC and the occurrence of mastitis (BUSTAO *et al.* 2000, BALTAY 2002, MIJIC *et al.* 2004). It was reported that udder health was one of the strong features of the BS breed (BULOT 2006).

Some research conducted in Turkey showed that the quality of milk is one of the most problems of dairy sector, because the SCC and total bacteria count was generally measured to be higher than EU countries (EYDURAN 2002, GÖNCÜ and ÖZKÜTÜK 2002, FAO 2007).

Production conditions in Turkey vary considerably between the western and the eastern parts of the country. Climatic conditions are more favorable in the western region, allowing the development of commercially oriented dairy farming. The farms in this region are generally small or middle-scale family farms and large scale dairy farms has been increasing mostly in the west part of Turkey, recently. The predominant cattle genotypes in the region are pure-bred HF or its crosses. BS, Simmental and Montbeliarde and their crosses are also raised in the province of Aydin.

This research was aimed to determine the influencing factors on SCC in milk produced at three HF and BS dairy farms under the conditions of Mediterranean climate.

Material and methods

Milk samples from 67 HF and 16 BS cows raised at three dairy farms were collected by monthly visits. Herds were selected randomly and assumed as representative of BS and HF rearing dairy herds in the province. The main source of income for these farms is milk. In addition to clover, hay, roughage and polybra, maize and barley are some of the major crops grown for silage in these farms. However, almost all of these farms buy concentrated feed from the feed factories as well. Some of the characteristics of the farms used in this study are shown in Table 1. The milk production, traits and lactation SCC means of these farms were discussed by KOÇ (2006) and the lactation milk yield mean of HF was reported to be 1 616.7 kg higher than that of BS.

Table 1
Characteristics of the dairy farms
Versuchsmaterial und -betriebe

	Herd 1	Herd 2	Herd 3
Cows (n=83)	33	26	24
HF (n=67)	30	19	18
BS (n=16)	3	7	6
305 d MY per cow, kg	4 769.5±233.35	4 887.5±182.06	5 592.7±301.63
	Open	Open	Open
Barn type	Free stall-natural	Free stall-natural	Free stall-natural
Milking	At the barn	At the barn	At the barn
Milking machine	Pipe-line, stable	Pipe-line, mobile	Pipe-line, stable
Feeding	During milking	During milking	After milking
Udder massage	No	No	Yes
Milking interval, h	9-15	9-15	11-13

The milk samples were stored in an icebox and the direct microscopic somatic cell count (DMSCC) procedure as outlined in form FDA-2400d was used to determine the SCC in the milk. The milk samples from the morning milking were analyzed on the same day, but the evening samples were stored in a refrigerator overnight and analyzed on the next day. Samples used for the analyses had no visible abnormality nor came from an abnormal udder.

Cows having at least 4 and at most 12 lactation months' data were included into the analysis. The total number of observations used in the analyses were 1 429 test day SCC. Based-10-logarithmic transformation was applied to the SCC data to create a normal distribution (SHOOK 1982) and the linear mixed model was applied. This statistical model was used:

$$\log_{10} \text{SCC}_{ijklmn} = \mu + H_i + B_j + P_k + M_l + T_m + (HM)_{il} + (HT)_{im} + (BM)_{jl} + (PM)_{kl} + b(X_{ijklmn} - \bar{X}) + e_{ijklmn} \quad (1)$$

where μ is the overall mean, H_i the i^{th} herd effect ($i=1,2,3$), B_j the j^{th} breed effect ($j=\text{BS, HF}$), P_k the k^{th} lactation number effect ($k=1,2,3,4$), M_l the l^{th} lactation month effect ($l=1, 2, \dots, 12$), T_m the m^{th} milking time effect ($m=\text{morning, evening}$), $(HM)_{il}$ the interaction between herd and lactation month, $(HT)_{im}$ the interaction between herd and milking time, $(BM)_{jl}$ the interaction between breed and lactation month, $(PM)_{kl}$ the interaction between lactation number and lactation month, b the regression coefficient of daily milk yield (DMY) per milking on $\log_{10}\text{SCC}$, \bar{X} the average DMY per milking, X_{ijklmn} the DMY and e_{ijklmn} the residual random error.

The SAS mixed procedure (SAS Inst. 1999) was used to fit the linear mixed model shown in Equation 1 with corresponding \mathbf{R} matrix, which is a block diagonal with blocks corresponding to the individuals and with each block having the compound-symmetry (CS) structure. The form of the \mathbf{R} matrix was as follows:

$$\mathbf{R} = \begin{bmatrix} R_i & 0 & 0 \\ 0 & \ddots & 0 \\ 0 & 0 & R_{83} \end{bmatrix}, \quad (2)$$

$$\text{where } \mathbf{R}_i = \begin{bmatrix} \sigma^2 + \sigma_1 & \sigma_1 & \cdots & \sigma_1 \\ \sigma_1 & \sigma^2 + \sigma_1 & \cdots & \sigma_1 \\ \vdots & \vdots & \ddots & \vdots \\ \sigma_1 & \sigma_1 & \cdots & \sigma^2 + \sigma_1 \end{bmatrix} \text{ and } i=1, 2, \dots, 83 \text{ animals}$$

Individual observations at each time interval (lactation month) were treated as repeated measurements of the corresponding experimental unit (cow within herd and breed). The compound-symmetry covariance structure, which was optimal for the $\log_{10}\text{SCC}$ data set, was determined using Schwarz's Bayesian Criterion (LITTELL *et al.* 1997). Two unknown parameters, one modeling a common covariance (σ) and the other a residual variance (σ^2) of \mathbf{R} matrix and the common correlation $\sigma_1 / (\sigma_1 + \sigma^2)$ were estimated in SAS. After significant effects of fixed factors were identified, differences between least square means of fixed factor levels were considered significant at $P < 0.05$ (2-tailed) based on the Tukey adjustment type I error rate.

Results

The SCC least squares means, standard errors and differences between the means for breeds, herds, LN, LM and MT are given in Table 2. The effects of breed ($P < 0.01$), LN ($P < 0.01$), LM ($P < 0.01$), MT ($P < 0.05$) and co-variable DMY ($P < 0.01$) on SCC were found statistically significant. The interactions of LM with herd ($P < 0.01$), breed ($P < 0.05$) and LN ($P < 0.01$) effects were also found statistically significant. However, the influences of herd and the interaction between herd and MT were statistically insignificant ($P > 0.05$).

HF breed had 159 745 cells/ml higher SCC in milk than BS breed and this difference between the breeds was found statistically significant ($P < 0.01$). On the other hand,

morning milking had 25 850 cells/ml lower SCC than that of evening milking. For LM, the highest SCC mean of 601 174 cells/ml was found in the first month of the lactation, the mean was decreased below 400 000 cells/ml level in the second month and it remained below this level until the month 11. The SCC level for the first LM was found to be different from the months 2-10 ($P<0.01$), but it was similar to the months 11 and 12 ($P>0.05$). The SCC level for the second LM was also found to be different from the 8th LM ($P<0.01$) and 108 603 cells/ml difference was determined between these two months.

Table 2

Somatic cell count, least squares means and standard error for breed, herd, lactation number, milking time, lactation month and significance levels of the factors and differences between the means

Somatische Zellzahl, Standardfehler für Rasse, Herde, Laktationsnummer, Melkzeit, Laktationsmonat und Signifikanzen

Factor (no. of cow)	$\bar{X} \pm S_{\bar{X}} (\log_{10} \text{SCC})$	SCC (cell/ml)
Breed (83)	**	
HF (67)	5.654±0.029 ^{Aa}	450 817
BS (16)	5.464±0.060 ^{Bb}	291 072
Herd	ns	
H1 (33)	5.544±0.047	349 945
H2 (26)	5.583±0.048	382 825
H3 (24)	5.510±0.046	323 594
LN	**	
1 (38)	5.468±0.038 ^{Aa}	293 765
2 (10)	5.440±0.071 ^{ABa}	275 423
3 (17)	5.581±0.053 ^{ABab}	381 066
4 (18)	5.691±0.055 ^{Bb}	490 908
MT	*	
Morning (83)	5.529±0.034 ^{Aa}	338 065
Evening (83)	5.561±0.034 ^{Ab}	363 915
LM	**	
1 (72)	5.779±0.043 ^{Aa}	601 174
2 (74)	5.593±0.042 ^{Bb}	391 742
3 (75)	5.571±0.041 ^{Bbc}	372 392
4 (74)	5.522±0.041 ^{Bbc}	332 660
5 (72)	5.532±0.041 ^{Bbc}	340 408
6 (73)	5.474±0.041 ^{Bbc}	297 852
7 (69)	5.479±0.042 ^{Bbc}	301 301
8 (68)	5.452±0.042 ^{Bc}	283 139
9 (61)	5.511±0.045 ^{Bbc}	324 340
10 (45)	5.536±0.059 ^{Bbc}	343 558
11 (31)	5.657±0.080 ^{ABabc}	453 942
12 (18)	5.436±0.110 ^{ABabc}	272 898
DMY	**	-0.027±0.003
Breed × LM	*	-
Herd × LM	**	-
LN × LM	**	-
Herd × MT	ns	-

* $P<0.05$, ** $P<0.01$, ns not significant, A, B significant differences for $P<0.01$, a, b, c significant differences for $P<0.05$

As shown in Table 2, the highest SCC mean was found for the fourth LN. The SCC mean for LN4 was similar to the SCC mean of LN3 ($P>0.05$), but it was statistically different from LN1 ($P<0.01$) and LN2 ($P<0.05$). LN4 had 197 143 and 215 485 cells/ml higher SCC in milk than those of LN1 and LN2, respectively.

The effect of DMY on SCC was also found to be statistically significant ($P<0.01$) and a negative association was determined between SCC and DMY. As shown in Figure 1, the LM SCC means for BS cows were different from those of HF cows. The mean SCC level for BS cows decreased until month eight, and then increased gradually to the month 11. However, for HF cows, the SCC level was decreased until the third month and then fluctuated until the end of lactation. For every LM, BS breed had lower SCC level in milk than that of HF breed. The first LM SCC mean for HF was 346 139 cells/ml higher than that of BS. For HF, the first month was found to be different from the other months ($P<0.05$). However, for BS the first month was found to be statistically different only from months 6-8 ($P<0.01$). For both breeds, there was an increase during the last few LMs SCC levels until the month 11, but the level then decreased during the last month.

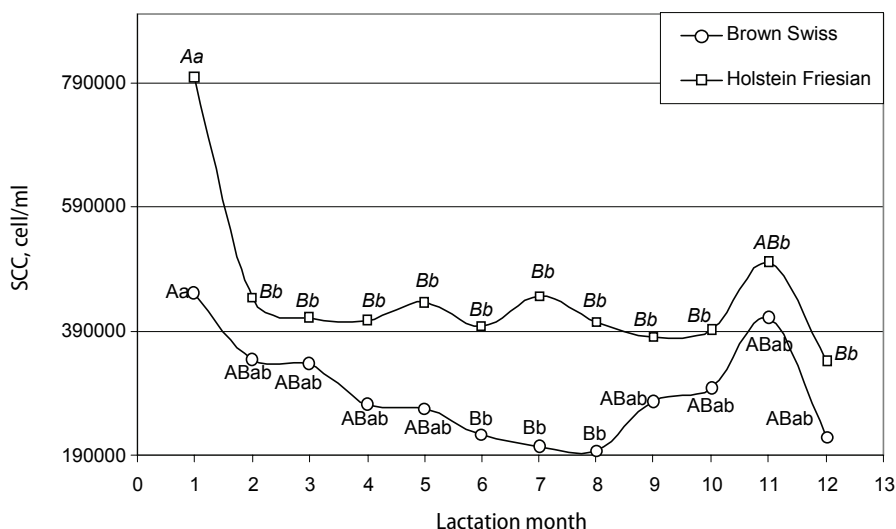


Figure 1
Lactation month SCC means and differences within breeds
SCC nach Laktationsmonaten und Rassen

Figure 2 shows the LM SCC means within LN. The SCC levels for the first six months for LN4 were clearly higher than those of other LNs. For the months 7-10, the levels become very close to each other. After a reduction from the beginning of lactation, an increase was observed until the end of lactation for all LNs.

The first month SCC level for LN4 was found to be different from months 6-9 ($P<0.05$). For LN1, the first month was different from 3-8 ($P<0.05$). For LN2, the first month was different from the months 2, 4-8 and for LN3, the first month was different from months 6 and 8 ($P<0.05$).

The interaction between herd and LM was found to be statistically significant ($P < 0.01$). As shown in Figure 3, all herds SCC means at the first month of lactation were high, the levels were decreased sharply during the second month of lactation and the reduction were continued until the months 8, 4 and 7 for Herd1, Herd2 and Herd3, respectively. The SCC means then increased to the 11th month of lactation for Herd1 and Herd2. The first LM SCC means for all herds were different from almost all of the middle LMs ($P < 0.05$) but it was similar to the last few months ($P > 0.05$).

Discussion

A statistically significant difference between the SCC means of BS and HF found in this study agrees with the studies of BUSATO *et al.* (2000), RUPP and BOICHARD (2003). BUSATO *et al.* (2000) and GOYACHE *et al.* (2005) reported that different morphological conformations of udders and different milking characteristics between the breeds could cause varying infection risks of mammary glands. The SCC level for BS cows found in this study was higher than the results of BUSATO *et al.* (2000). EYDURAN (2002) and GÖNCÜ and ÖZKÜTÜK (2002) reported relatively higher SCC levels for dairy farms in Turkey than the levels found in this study. Similarly, AMIN *et al.* (2001) reported that mastitis incidence was higher in Egyptian HF than in German HF. However, the average herd SCC levels found in this study were higher than those found in research conducted in European countries (BUSATO *et al.* 2000, TOLEDO *et al.* 2002, GOYACHE *et al.* 2005).

A statistically significant effect of MT on SCC found in this study agreed with BALTAY (2002), KOÇ (2004) and NIELSEN *et al.* (2005). ERSKINE (2001) reported a lower SCC level for morning milking than evening milking. The statistically significant difference between MTs SCC means could result mainly from the different milking intervals and different milk yield.

A higher SCC level for the first LM found in this study agrees with the studies of HAAS (2003) and HINRICHS *et al.* (2006). ERSKINE (2001) reported a temporarily but greatly elevated SCC just after calving due to adaptation of the udder from non-lactating to lactating status. A gradual increase towards the end of lactation before drying off for HF and BS breeds found in this study agreed with ERSKINE (2001), SANTOS *et al.* (2004) and HINRICHS *et al.* (2006).

IMBAYARWO-CHIKOSI *et al.* (2001), GÖNCÜ and ÖZKÜTÜK (2002), AMIN *et al.* (2002), HAAS (2003), BIELFELDT *et al.* (2004) and HINRICHS *et al.* (2006) reported an increase in SCC level as the LN increased. The differences among the LNs found in this study are obvious for the first six months of lactation (Figure 2). The higher SCC level for LN4 could be resulted from higher yielding stress and also different defense mechanisms against mammary infection late in life (HAAS 2003). A negative association between SCC and DMY was found in this study agrees with the results of AMIN (2001), IMBAYARWO-CHIKOSI *et al.* (2001), BIELFELDT *et al.* (2004) and MIJIC *et al.* (2004).

An insignificant herd effect on SCC found in this study shows that the milking management and hygiene were not very different among the herds. However, higher herd SCC means shows that some extra precautions need to be taken. These precautions are milking the cow in a parlor, feeding the cow after milking, using teat dipping before and after milking, using dry cow therapy, applying udder massage, giving extra care to the cow just before and after calving especially for HF cows and also the high yielding

cows, keeping equal milking intervals, practicing CMT periodically, improving managerial factors, barn conditions and hygiene. In conclusion the lower SCC means found in this study in comparison to other studies in Turkey could be the result of an increasing effort to produce quality milk by improving managerial factors, barn conditions and hygiene. A lower SCC mean for BS in comparison to HF for all lactation months could be attributed to breed differences in milk yield, resistance mechanisms against mastitis and udder conformation. The higher herd SCC mean also shows higher prevalence of sub-clinic mastitis among these herds. To reduce the occurrence of mastitis and to increase milk quality, milking management, hygiene and barn conditions need to be improved in addition to applying a mastitis control program for each herd.

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