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DAILY MILK YIELD, NON-FAT DRY MATTER CONTENT AND SOMATIC CELL COUNT OF HOLSTEIN-FRIESIAN AND BROWN-SWISS COWS

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The aim of this study was to determine the factors affecting the Daily Milk Yield (DMY) per milking, Non-fat Dry Matter percentage (NFDM%) and Somatic Cell Count (SCC) from Holstein-Friesian (HF) and Brown-Swiss (BS) cows managed in the Mediterranean climatic conditions in Turkey. The farms considered in this study were visited monthly for two years to measure DMY and to collect milk samples from each cow during morning and evening milkings. A total of 1,415 sets of data from 67 HF and 16 BS cows for each trait were analyzed by using repeated measures. Breed, lactation month, milking time and the interaction between herd and lactation month were found to be statistically significant for all traits ($P<0.05$). The co-variable effects of NFDM% ($P<0.05$) and $Log_{10}SCC$ ($P<0.01$) on DMY, and DMY on $Log_{10}SCC$ ($P<0.01$) were significant. The averages of DMY, NFDM% and SCC for HF cows were 8.92 ± 0.188 kg, 9.61 ± 0.048% and 491,813 cells/mL and for BS cows were 7.09 ± 0.367 kg, 10.12 ± 0.093% and 312,464 cells/mL, respectively. For all traits some important differences were determined between the breeds, due to the different physiological mechanisms, milking characteristics and the morphological conformations of udders. In order to increase the quality and quantity of milk, additional measures need to be taken, such as improving milking management, hygiene, nutrition and barn conditions.

Key words: daily milk yield, somatic cell count, non-fat dry matter, Holstein-Friesian, Brown-Swiss

INTRODUCTION

Milk yield, milk constituents and hygienic quality are important traits for the productivity of dairy farms. Cow level (Chongkasikit *et al.*, 2002; Haas, 2003; Ahn *et al*., 2005; Koç, 2006b), environmental and managerial factors (Omore *et al*., 1999; Skrzypek *et al*., 2004; Green *et al*., 2006a), barn conditions (Kremer *et al*., 2006) and milking machine and system (Garces *et al*., 2006; Stenzel *et al*., 2002) have important effects on milk yield, milk constituents and the hygienic quality of milk. These traits have co-variable effects on each other as well (Bielfeldt *et al*., 2004; Koç, 2006b).

As milking interval increases, daily milk yield (DMY) decreases and milk composition is modified (O'Brien *et al*., 2002; Delamaire and Guinard-Flament, 2006). Green *et al*. (2006b) reported that somatic cell count (SCC) decreases as milk yield increases due to the absence of inflammation and a potential dilution in SCC level.

Negative correlations of non-fat dry matter of milk with milk yield and 305-d milk yield for HF cows were reported (Sekerden, 2002). However, the importance of the correlation between SCC and milk constituents in individual cow milk sample depended on the SCC level (Fernandes *et al*., 2004). Green *et al*. (2006a) also reported a negative correlation between milk yield and SCC. Similar, but inverted lactation curves for somatic cell scores and milk yield were reported by Biefeld *et al*. (2004).

Some European dairy breeds such as Montbeliarde and Brown-Swiss (BS) had lower milk yield, SCC levels and clinical mastitis frequency, but higher solid content in milk than Holsteins (Busato et al. 2000; Rupp & Boichard 2003; Bulot 2006; Koç 2006a). Welper and Freeman (1991) reported higher percentages of fat, protein and somatic cells in milk for the BS breed than that of the HF breed.

The objectives of this study were to determine the influencing factors on daily milk yield (DMY), non-fat dry matter percentage (NFDM%) and somatic cell count (SCC) in the milk of HF and BS cows managed on three family dairy farms in Mediterranean climatic conditions in the Aydin province of Turkey.

MATERIAL AND METHODS

This study was conducted on 67 HF and 16 BS cows on three family dairy farms in the Aydin Province of Turkey. Over two years from August 2003 to July 2005, the monthly DMY, NFDM% and SCC data for the morning and evening milking was collected and analyzed. The 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 analyses had no visible abnormality nor came from an abnormal udder. The milk samples were stored in an icebox until analyzed. The Direct Microscopic Somatic Cell Count (DMSCC) procedure as outlined in Form FDA-2400d was used to determine the SCC in milk samples. NFDM% was determined by a 32 brix refrectometer. For statistical analyses, 1,415 sets of test day data were used for each trait. Based-10-logarithmic transformation was applied to the SCC to create a normal distribution (Shook, 1982). Each trait was analyzed separately and the linear mixed model was applied for all traits. The statistical model for the traits is as follows.

$$DMY_{ijklmn} = \mu + \alpha_i + \beta_j + \gamma_k + \omega_l + \delta_m + (\alpha\omega)_{il} + (\alpha\delta)_{im} + (\beta\omega)_{jl} + (\gamma\omega)_{kl} + b(X_{ijklmn} - \bar{X}) + c(Z_{ijklmn} - \bar{Z}) + \varepsilon_{ijklmn}$$

Where, μ: overall mean, α_i: i[th] herd effect (1,2,3), β_j: j[th] breed effect (BS and HF), γ_k: k[th] parity effect (1,2,3), ω_l: l[th] lactation month effect (1,2,…,11), δ_m: m[th] milking time effect (morning and evening), $(\alpha\omega)_{il}$: interaction between herd and lactation month, $(\alpha\delta)_{im}$: interaction between herd and milking time, $(\beta\omega)_{jl}$: interaction between breed and lactation month, $(\gamma\omega)_{kl}$: interaction between parity and lactation month, b: regression coefficient of NFDM%, $\bar{X}$: average NFDM%, X_{ijklmn}: NFDM%, c: regression coefficient of $Log_{10}SCC$, $\bar{Z}$: average $Log_{10}SCC$, Z_{ijklmn}: $Log_{10}SCC$ and ε_{ijklmn}: residual random error. In the NFDM% and $Log_{10}SCC$ calculation formulae, b represents the regression coefficient of DMY, X_{ijklmn} is DMY and $\bar{X}$ is the average DMY. In the NFDM% calculation, c represents the regression coefficient of $Log_{10}SCC$, however for $Log_{10}SCC$ analyses, c is the regression coefficient of NFDM%. In the NFDM% calculation, $\bar{Z}$ is used as the average $Log_{10}SCC$, but for $Log_{10}SCC$ calculation, $\bar{Z}$ is the average %NFDM. In the NFDM% calculation Z_{ijklmn} is the $Log_{10}SCC$, but for $Log_{10}SCC$, Z_{ijklmn} is the NFDM%.

The SAS mixed procedure (SAS Inst. 1999) was used to fit the linear mixed model with the corresponding R matrix, which is a block diagonal with blocks corresponding to the individuals and with each block having the *compound-symmetry* (CS) structure for each trait. The form of the R matrix is as follows:

$$R = \begin{bmatrix} R_1 & 0 & 0 \\ 0 & \ddots & 0 \\ 0 & 0 & R_{83} \end{bmatrix}, \text{ where } R_i = \begin{bmatrix} \sigma^2+\sigma_1 & \sigma_1 & \cdots & \sigma_1 \\ \sigma_1 & \sigma^2+\sigma_1 & \cdots & \sigma_1 \\ \vdots & \vdots & \ddots & \vdots \\ \sigma_1 & \sigma_1 & \cdots & \sigma^2+\sigma_1 \end{bmatrix} \text{ where I = 1, 2, ..., 83 animals}$$

Individual observations at each time interval (lac. month) were treated as repeated measurements of the corresponding experimental unit (cow within herd and breed) for each trait. The *compound-symmetry* covariance structure, which was optimal for the DMY, NFDM% or $Log_{10}SCC$ data set, was determined using Schwarz's Bayesian Criterion (Littell *et al*., 1997). Two unknown parameters, one modelling a common covariance (σ_1) and the other a residual variance (σ^2) of R matrix and the common correlation

$$\frac{\sigma_1}{\sigma_1+\sigma^2}$$

were estimated in SAS for each trait. After significant effects of fixed factors were identified, differences between LS means of fixed factor levels were considered significant at P<0.05 (2-tailed) based on the Tukey adjustment type I error rate.

RESULTS AND DISCUSSION

The effects of breed, lactation month, milking time and the interaction between herd and lactation month were found to be statistically significant (P<0.05) for all traits (Table 1). Herd had significant effects on DMY and NFDM% (P<0.01), but its effect was insignificant for $Log_{10}SCC$ (P>0.05). Parity had statistically significant effects on DMY and $Log_{10}SCC$ (P<0.01), but its effect was insignificant for NFDM% (P>0.05). The means of DMY, NFDM% and SCC for each breed, herd, parity, lactation month and milking time are given in Table 1. HF cows produced 1.83 kg more milk but had 5.04% less NFDM content and

Table 1. DMY, NFDM% and SCC LSMEANS and Std. Errors for breed, herd, parity, milking time and lactation month

Factor	$\bar{X} \pm S_{\bar{X}}$ (DMY, kg)		Log₁₀ Somatic Cell Count, cell/mL	
			$\bar{X} \pm S_{\bar{X}}$ (Log_{10}SCC, cell/mL)	Back-transformed values(cell/mL)
Breed	**	**	**	
HF (67)	8.92 ± 0.188^{Aa}	9.61 ± 0.048^{Aa}	5.6918 ± 0.02947^{Aa}	491,813
BS (16)	7.09 ± 0.367^{Bb}	10.12 ± 0.093^{Bb}	5.4948 ± 0.05719^{Bb}	312,464
Herd	**	**	NS	–
Herd1	7.32 ± 0.302^{Aa}	10.05 ± 0.076^{Aa}	5.5952 ± 0.04711^{Aa}	393,731
Herd2	8.22 ± 0.302^{ABb}	9.81 ± 0.078^{ABb}	5.6373 ± 0.04763^{Aa}	433,810
Herd3	8.48 ± 0.309^{Bb}	9.73 ± 0.080^{Bb}	5.5475 ± 0.04879^{Aa}	352,777
Parity	**	NS	**	–
Parity1	7.29 ± 0.233^{Aa}	9.93 ± 0.059^{Aa}	5.4717 ± 0.03654^{Aa}	296,278
Parity2	8.21 ± 0.351^{ABb}	9.88 ± 0.090^{Aa}	$5.6043 \pm 0.05523^{ABab}$	402,069
Parity3	8.52 ± 0.359^{Bb}	9.77 ± 0.092^{Aa}	5.7040 ± 0.05655^{Bb}	505,825
M.Time	**	**	*	–
Morning	8.87 ± 0.216^{Aa}	9.82 ± 0.054^{Aa}	5.5771 ± 0.03364^{Aa}	377,708
Evening	7.15 ± 0.216^{Bb}	9.90 ± 0.055^{Bb}	5.6096 ± 0.03408^{Ab}	407,005
L. Month	**	**	**	–
1	10.93 ± 0.296^{Aa}	9.79 ± 0.067^{Aa}	5.8439 ± 0.04420^{Aa}	698,072
2	10.31 ± 0.292^{ABa}	9.51 ± 0.066^{Bb}	5.6937 ± 0.04379^{Bb}	493,969

Cont Table 1.

Factor	$\bar{X} \pm S_{\bar{X}}$ (DMY, kg)		Log_{10} Somatic Cell Count, cell/mL	
			$\bar{X} \pm S_{\bar{X}}$ (Log_{10}SCC, cell/mL)	Back-transformed values(cell/mL)
3	9.34 ± 0.291^{BCb}	9.55 ± 0.065^{BCbc}	$5.6150 \pm 0.04319^{BCbc}$	412,098
4	8.68 ± 0.290^{CDbc}	9.70 ± 0.065^{BCDcd}	$5.5664 \pm 0.04310^{BCbc}$	368,468
5	8.12 ± 0.290^{DEcd}	9.76 ± 0.065^{CDEde}	$5.5915 \pm 0.04315^{BCbc}$	390,391
6	7.73 ± 0.284^{DEFde}	9.87 ± 0.064^{DEFdef}	5.5198 ± 0.04220^{BCc}	330,979
7	7.04 ± 0.287^{EFGe}	9.88 ± 0.065^{DEFef}	5.5148 ± 0.04289^{BCc}	327,190
8	6.81 ± 0.288^{FGf}	9.94 ± 0.065^{EFGfh}	5.4845 ± 0.04296^{Cc}	305,141
9	6.67 ± 0.305^{FGf}	10.04 ± 0.068^{FGfgh}	$5.5264 \pm 0.04510^{BCbc}$	336,047
10	6.05 ± 0.415^{Gf}	10.22 ± 0.085^{Gg}	$5.5746 \pm 0.05963^{BCbc}$	375,491
11	6.39 ± 0.548^{EFGdef}	10.22 ± 0.108^{FGgh}	$5.5961 \pm 0.07663^{ABCabc}$	394,458
DMY	–	NS ($-.006 \pm 0.005$)	** (-0.028 ± 0.004)	–
NFDM	* (-0.306 ± 0.141)	–	NS (-0.029 ± 0.020)	–
Log_{10}SCC	** (-1.583 ± 0.191)	NS (-0.047 ± 0.037)	–	–
HerdxM.Time	**	**	NS	–
BreedxL.Month	NS	**	*	–
ParityxL.Month	NS	**	**	–
HerdxL.Month	**	**	**	–

*: $P<0.05$; **: $P<0.01$. NS: Not significant, a,b,c,d,e,f,g,h: Significance level for P.05; A,B,C,D,E,F,G: Significance level for $P<0.01$.
DMY: Daily milk yield, NFDM%:Nof-fat dry matter percentage, M.Time: Milking time, L. Month: Lactation month

179,349 cells/mL higher SCC than BS cows. All of these differences between the breeds were found to be significant (P<0.01).

The significant differences between BS and HF cows for DMY, NFDM% and SCC means agree with the studies of Busato *et al*. (2000), Rupp and Boichard (2003), Koç (2006a) and Bulot (2006). The NFDM% mean estimated for HF cows was higher than the results of Chongkasikit *et al*. (2002) in Thailand. The lower SCC mean found for BS cows than for HF cows in this study agrees with the results of Bulot (2006). Busato *et al.* (2000) and Bulot (2006) reported that different morphological conformations of udders and different milking characteristics between the breeds could cause varying milk yield, milk composition and mammary gland infection risks. Detilleux (2005) also reported an association between udder conformation with SCC and the occurrence of mastitis. On the other hand, the SCC level for BS cows found in this study was higher than reported by Busato *et al*. (2000) and Bulot (2006).

Uzmay *et al.* (2001), Eyduran (2002) and Göncü & Özkütük (2002) reported relatively higher SCC levels for dairy farms in Turkey compared to this study. Omore *et al*. (1999) in Kenya and Fernandes *et al*. (2004) in Brazil reported similar values for HF cows. However, the average herd SCC levels found in this study were higher than those found in some researches conducted in European countries (Busato *et al*. 2000, Toledo *et al*. 2002, Skrzypek *et al*. 2004, Remond *et al*. 2004; Bulot 2006) and in the USA (Klei *et al*. 1997).

The effect of milking time on DMY (P<0.01), NFDM% (P<0.01) and Log_{10}SCC (P<0.05) was significant. Our results agree with Barkema *et al*. (1999), Ahn *et al*. (2005), Nielsen *et al*. (2005) and Green *et al*. (2006a). The statistically significant difference between the SCC means at varying milking times found in this study could result mainly from different milking intervals and different milk yields. Green *et al*. (2006b) reported a potential dilution in SCC in milk due to the increase in milk yield. Similarly, Baltay & Janosi (2003) in HF cows found that less than 2h difference in milking time did not affect SCC in milk.

Co-variable NFDM% (P<0.05) and Log_{10}SCC (P<0.01) effects on DMY were significant. The regression coefficients of NFDM% and Log_{10}SCC were found to be -0.306±0.141 and -1.583±0.191, respectively. However, neither DMY nor Log_{10}SCC co-variable effects on NFDM% were statistically significant. The co-variable effect of DMY on Log_{10}SCC was significant (P<0.01) and the coefficient was -0.028±0.004, but co-variable effects of NFDM% on Log_{10}SCC were insignificant (P>0.05). An important negative association between SCC and DMY found in this study agrees with Omore *et al*. (1999), Bielfeldt *et al*. (2004) and Magalhaes *et al*. (2006), but disagrees with Stenzel *et al*. (2002).

The results of this study indicated that the DMY, NFDM% and SCC level between HF and BS cows managed in the same nutritional, managerial and barn conditions are different. HF cows had higher DMY but lower NFDM% and higher SCC than BS cows. A lower SCC mean for BS in comparison to HF in all lactation months could be due to breed differences in milk yield, resistance mechanisms against mastitis and udder conformation.

The interaction between herd and milking time was statistically significant for DMY (P<0.01) and NFDM% (P<0.01), but it was insignificant for SCC

(P>0.05). As seen in Figure 1, for DMY, the differences between milking times were statistically significant (P<0.01) for all herds, but for NFDM% the same difference was significant only for Herd1 (P<0.01).

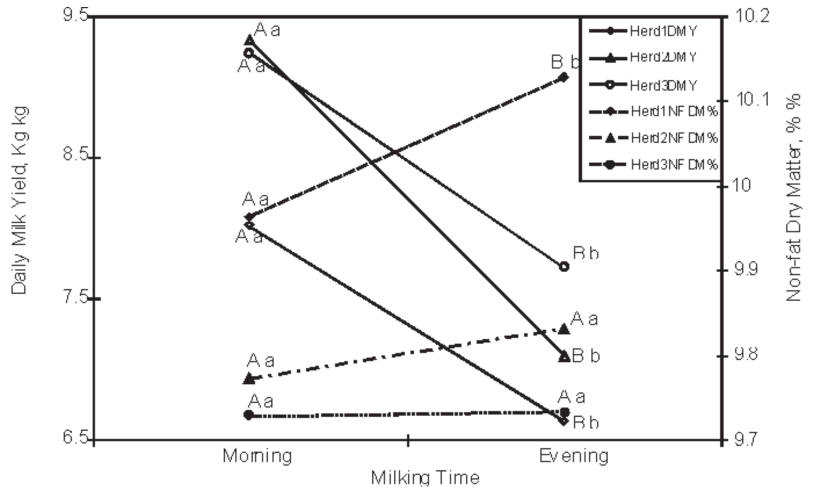

Figure 1. DMY and NFDM% differences between milking times for all herds

The interaction between breed and lactation month was found to be significant for NFDM (P<0.01) and Log_{10}SCC (P<0.05), but it was insignificant for DMY (P>0.05). The lactation curves for NFDM% and SCC were similar for both breeds (Figure 2). For every lactation month, the NFDM% was higher but SCC was lower for BS cows than for HF cows.

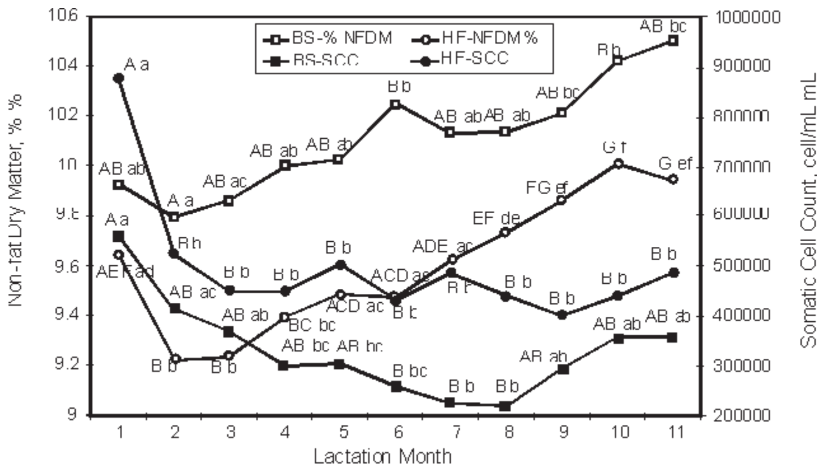

Figure 2. SCC and NFDM% means for HF and BS cows and differences between months

For the BS breed, the NFDM% mean for months six and ten of lactation was similar and these months were statistically different from the second month ($P<0.01$). For the HF breed, the lowest NFDM% was found for the second and third months and these months were similar to month four. However, they were statistically different from all other months ($P<0.01$). On the other hand, the highest NFDM% was found in month ten for the HF breed and it was similar to months nine and eleven, but was different from all other months ($P<0.01$).

For both breeds, the SCC levels decreased sharply in the second and third months. In the middle of lactation, the SCC level of the HF breed remained nearly the same until increasing at the end of lactation. However, SCC levels in the BS breed continued to decrease up to month eight and then gradually increased until the end of lactation. The smallest and largest SCC differences between the breeds were found in the third month (80,000 cells/mL) and first month (316,000 cells/mL). The SCC mean of the HF breed in the first month was different ($P<0.01$) from other months, and other differences between the months were not significant ($P>0.05$). For BS cows, months six, seven and eight were statistically different from month one ($P<0.01$), but other differences between the months were insignificant.

The interaction between parity and lactation month had a significant effect on NFDM% ($P<0.01$) and $Log_{10}SCC$ ($P<0.01$), but its effect was insignificant on DMY ($P>0.05$). As shown in Figure 3, the NFDM% level for all parities decreased in month two, and then increased gradually until the end of lactation. The SCC level for the first six months of lactation at Parity 3 was higher than the same months at Parity 1 and Parity 2. In the later months, the differences between the parities decreased and the SCC levels had closer values for all parities. For all lactation months, the SCC mean for Parity1 had the lowest values for every lactation month of all parities.

The highest SCC level was calculated for the first month of lactation for Parity 3 and this level decreased below 400,000 cells/mL level at month seven. The SCC level in the first month for Parity 1 was about 100,000 cells/mL and about 500,000 cells/mL lower than Parity 2 and Parity 3, respectively. For Parity 1, the SCC level decreased below 400,000 cells/mL at the second month of lactation but, for Parity 2, the SCC decreased the same level at the third month of lactation and remained at this low level until the end of lactation for both parities (Figure 3).

The SCC level for Parity1 in month one was found to be different from months three to eight ($P<0.01$) but was similar to the other months. For Parity 2, the SCC level in month one was different from months six and nine ($P<0.05$), but was similar to the other months. For Parity 3, on the other hand, the SCC level in the first month was different from months six to nine ($P<0.01$) and months ten and eleven ($P<0.05$).

The interaction between herd and lactation month was found to be statistically significant for all traits ($P<0.01$). As shown in Figure 4, the highest DMY for the first month of lactation was calculated for all herds and the level decreased gradually until the end of lactation. In contrast to DMY, the NFDM% decreased in the second month of lactation, then increased to the end of lactation. For DMY, the first lactation months for all herds were different from the middle or later lactation months (P<0.01). For all herds, DMY and NFDM% in the first few lactation months were statistically different from the middle or later lactation months (P<0.01).

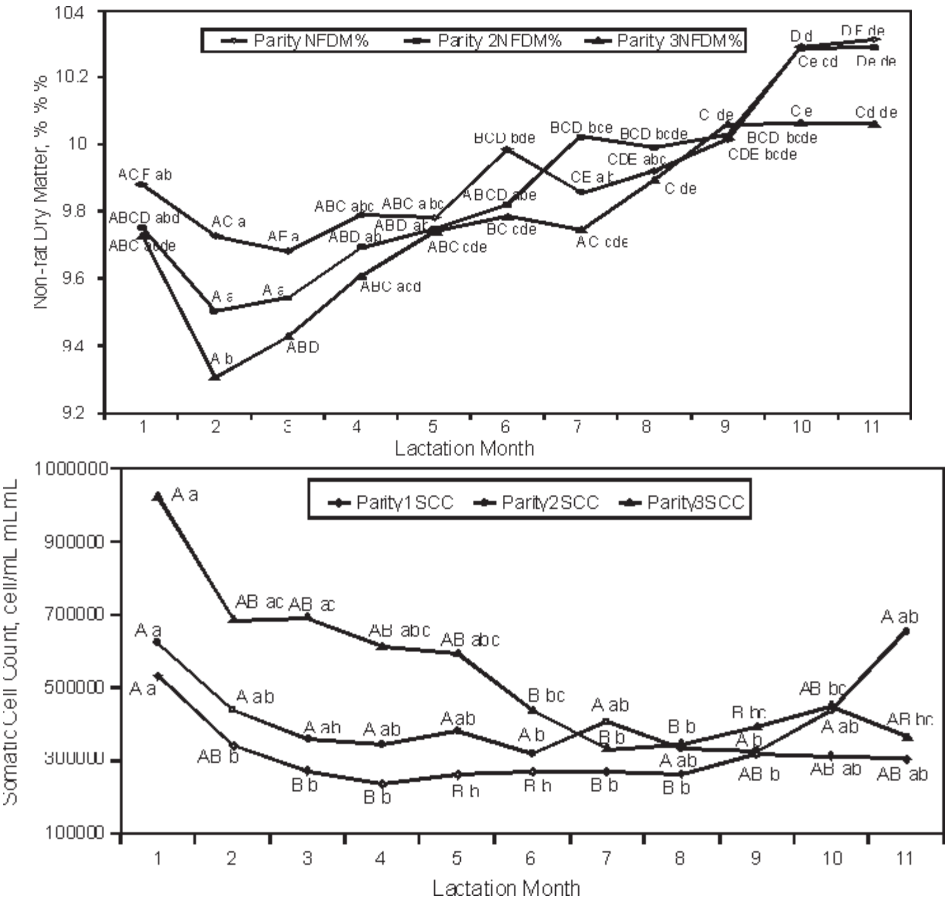

Figure 3. NFDM% and SCC means for parities and differences between lactation months

As shown in Figure 4, the SCC means at the first month of lactation decreased sharply in the second month and continued to decrease until month eight in Herd 1, month four in Herd 2 and month seven in Herd 3, then increased gradually to the end of lactation for all herds. Although the highest SCC mean was found for Herd 3 in month one, it decreased sharply in later months and the lowest SCC means were found for the same herd in the middle and later months. On the other hand, the first lactation month was statistically different from months six to eight for Herd 1 (P<0.01), month four for Herd 2 (P<0.01) and months three to ten for Herd 3 (P<0.01).

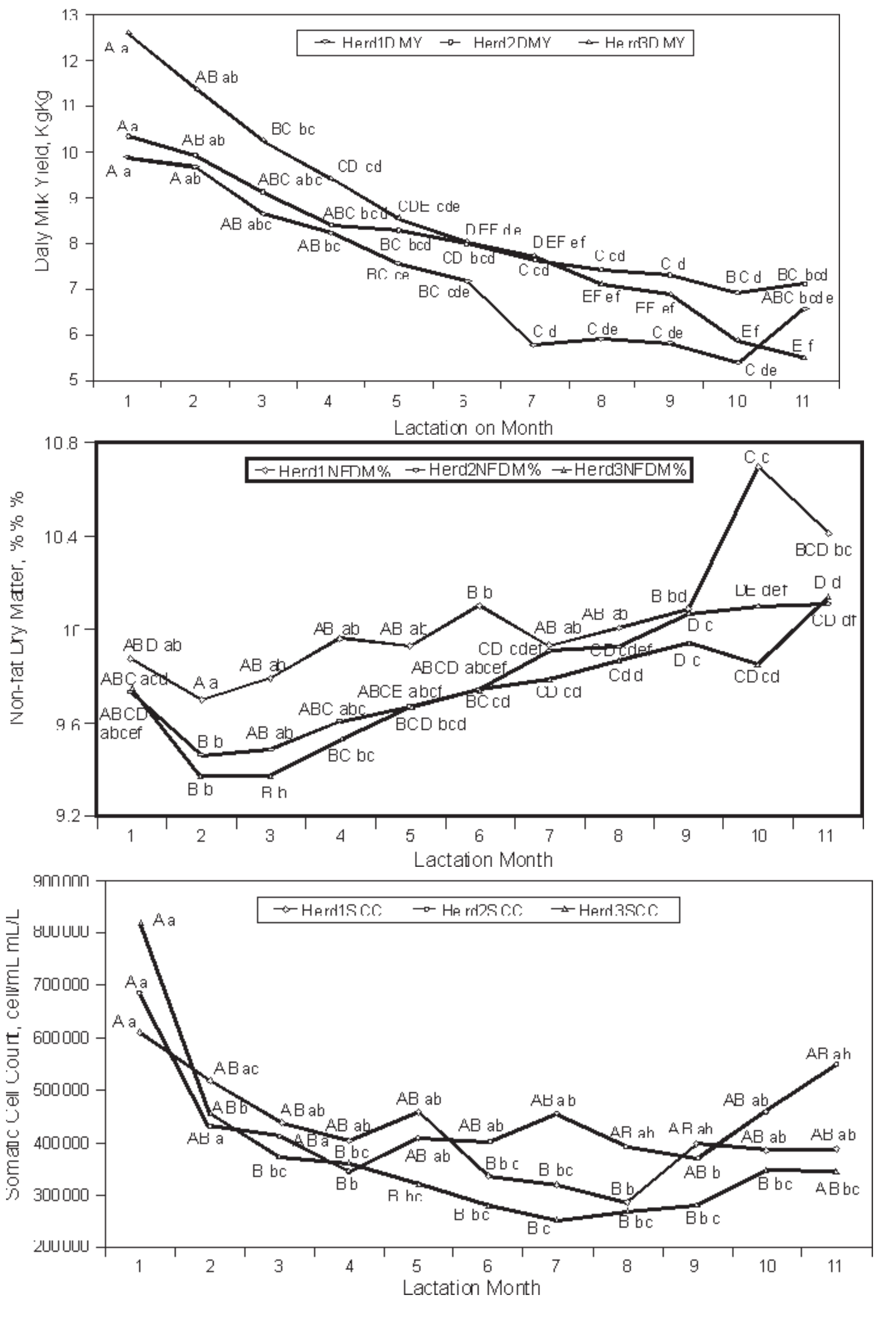

Figure 4. DMY, NFDM% and SCC means for herd and differences between lactation months

CONCUSIONS

The lower SCC mean found in this study in comparison to other studies in Turkey could be the result of an increasing effort by Turkish officials and farmers to produce quality milk by improving managerial factors, barn conditions and hygiene, as part of the process to meet EU criteria. However, the means for both breeds are still high and some extra measures need to be taken in the managerial practices, barn conditions, nutrition and milking hygiene on the farms. The data used in this study came from three middle-scale BS and HF family farms and this may limit the generalization of the conclusions. However, by monthly observation over two years, some important findings between BS and HF breeds for DMY, NFDM% and SCC in milk were obtained, particularly for the managerial factors and hygienic conditions of HF and BS rearing dairy farms in Mediterranean climatic conditions in Turkey.

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DNEVNA MLEČNOST, SADRŽAJ SUVE MATERIJE BEZ MASTI I BROJ SOMATSKIH ĆELIJA KOD HOLŠTAJN FRIZIJSKIH I MRKIH ŠVAJCARSKIH KRAVA

KOC A

SADRŽAJ

U ovom radu su proučavani faktori koji utiču na dnevnu mlečnost (po muži), sadržaj suve materije bez masti i broj somatskih ćelija kod holštajn frizijskih (HF) i mrkih švajcarskih krava (BS) držanih u uslovima mediteranske klime u Turskoj. Uzorci su prikupljani jednom mesečno u periodu od dve godine i ukupno je analizirano 1 415 uzoraka od 67 HF i 16 BS krava. Srednje vrednosti ispitivanih parametara su iznosile 8,92 kg, 9,61 % I 491 813 ćelija/ml za HF i 7,09 kg, 10,12 % I 312 464 ćelija/ml kod BS krava. Autor smatra da postoje značajne rasne razlike u pogledu ispitivanih vrednosti.