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Research Article

Non-Genetic Factors Affecting Milk Yield, Composition and Somatic Cell Count in Hungarian Holstein Cows

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Abstract

The purpose of this study was to determine effects of non-genetic factors on milk yield, milk composition and somatic cell count (SCC) of dairy cows. A total of 4891 records of Hungarian Holstein cows raised in a private dairy farm in South Hungary, between 2007 and 2008 were investigated. Fat, protein and lactose were assessed as milk composition parameters. To evaluate milking cows by effective factors; three different stage of lactation (SL) (SL 1= 90d<, SL 2= 91-150d and SL 3=151≤d), five parity, four calving season (CS) and three body condition score (BCS) groups (group1=<3 points; group2=3-3.50 points and group3=>3.50 points) were designed. While fat, protein and lactose decreased, daily milk yield (DMY), 305 daily milk yield (305 DMY) and SCC increased with advanced parity. Fat, protein and SCC increased, but lactose and DMY tended to drop with later SL and BCS. These parameters were highest in cows calved in winter-autumn, summer, winter-spring and winter-autumn, respectively. DMY negatively correlated with investigated parameters except for lactose and 305 DMY. The study revealed that non-genetic factors are associated with milk composition, yield and SCC of milk. Therefore, it is suggested that these factors should primarily be considered to obtain more quality and quantity milk from dairy cows.

Keywords: *Environmental factor, Cow, Body condition score, Milk quality, Somatic cell count*

Macar Siyah Alaca İneklerinde Süt Verimi, Bileşimi ve Somatik Hücre Sayısını Etkileyen Genetik Olmayan Faktörler

Özet

Bu çalışmada süt sığırlarında süt verimi, süt bileşimi ve somatik hücre sayısı (SHS)'nı etkileyen genetik olmayan faktörlerin belirlenmesi amaçlanmıştır. Güney Macaristan'daki özel bir süt sığırı işletmesindeki Macar Siyah Alacaları'nın 2007-2008 yıllarına ait toplam 4891 verim kaydı incelenmiştir. Yağ, protein ve laktoz; süt bileşimine ait parametreler olarak değerlendirilmiştir. Sağmal inekleri etkili faktörler bakımından değerlendirmek üzere; üç farklı laktasyon dönemi (LD) (LD 1= 90<, LD 2= 91-150 ve LD 3=151≤gün), beş laktasyon sırası (LS), dört buzağılama mevsimi (BM) ve üç vücut kondüsyon puanı (VKP) grubu (grup1=<3 VKP; grup2=3-3.50 VKP ve grup3=>3.50 VKP) oluşturulmuştur. İlerleyen LS'na bağlı olarak yağ, protein ve laktoz azalırken, günlük ortalama süt verimi (GOSV), 305 günlük süt verimi (305 GSV) ve SHS yükselmiştir. İleri LS ve VKP gruplarında yağ, protein ve SHS'nda artış, laktoz ve GOSV'nde ise azalış gözlenmiştir. Bu parametreler sırasıyla kış-sonbahar, yaz, kış-ilkbahar ve kış-sonbahar BM'nde buzağılayan ineklerde en yüksek bulunmuştur. GOSV; laktoz ve 305 GSVdışındaki parametrelerle negatif korelasyona sahiptir. Bu araştırma, genetik olmayan faktörlerin süt bileşimi, süt verimi ve SHS ile ilişkili olduğunu ortaya koymuştur. Bu nedenle, süt ineklerinden daha kaliteli ve yüksek miktarda süt elde etmek için bu faktörlerin öncelikli olarak dikkate alınması önerilmektedir.

Anahtar sözcükler: *Çevre faktörü, Inek, Vücut kondüsyon puanı, Süt kalitesi, Somatik hücre sayısı*

INTRODUCTION

Elevating quality and quantity of milk is crucial to achieve more income by dairy herd owners. In addition to genetic factors, multiple factors such as parity, season, stage of lactation, milking interval or feeding management markedly affect milk yield and composition [1,2]. Generally, variation in milk yield is associated with milk composition [3]. Water, fat, protein, ash, lactose and minerals can be classified as the major components of bovine raw milk [4]. Highly wide ranged genetic correlations between milk fat and persistence of lactation have been estimated [5-7]. Plasma proteins migrate to the inflammation site for dealing with the infection, and thus, percentage of protein may increase during this time. A decrease in lactose percentage of milk leads to reduce in milk yield due to

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lactose plays an active role for transmission of water to the mammary gland [8]. On the other hand, some milk components can be used as reflectors of reproductive performance. Moderate heritabilities for milk yield, fat and protein have been estimated [7,9]. This cases show the importance of non-genetic factors on milk production markers. In addition to reaching high quantity, determination of somatic cell count (SCC) is regarded as the principal process for monitoring quality of cow milk [10-12]. Somatic cells are responsible for natural defence system and contain lymphocytes, macrophages, epithelium cells and polymorphonuclear cells [13]. Studies revealed that high SCC adversely affects milk composition and processing level [8,14]. It has been indicated that elevation of SCC from $50x10^3$ cells/ml to $800x10^3$ cells/ml caused to reduction in milk yield by 6.3% in primiparous cows and 9.6% in cows in the third or later parities [10]. Today, modern dairy industry encourages producers to obtain milk with low SCC via additional payments [8]. In milk production cycle, energy demands are generally higher than their intake in early lactation especially for high-yielding cows [15]. Due to hardness of controlling this balance, an indirect parameter, body condition score (BCS), is commonly used in dairy operations. It has been revealed that BCS losses post-calving are correlated with milk yield, fertility and animal health [16]. That's why; investigating factors affecting the production parameters would highly be useful to dairy owners to take critical decisions for animal selection, husbandry and feeding management of the herds. Information on this subject in dairy cows may also lead for gaining more quality and quantity raw milk. In spite of many environmental factors can be effective on yield and components of milk, of these, parity, lactation period, calving season and body condition score may be classified as the main non-genetic factors. Eliminating the effects of these factors may be seen a gold step to manage an elite herd for dairy breeders.

The present study aims to determine the influence of stage of lactation, calving season and body condition score those referred to non-genetic factors on composition, milk yield and SCC in Hungarian Holstein cows.

MATERIAL and METHODS

The study was conducted in a private dairy farm in Szegvár, South- Hungary. A total of 4891 records of Hungarian Holstein cows, clinically *healthy and* in the lactation, between 2007 and 2008 were evaluated. The *cows were kept* in similar feeding and management conditions: in loose housing stable with deep litter and by means of feeding mainly forage supplemented with concentrated feeds during the experiment period. All cows were kept indoors all the study period. The daily rations were formulated with a ration-optimizing program. The data of measurements was recorded by dairy farm management software and milk recording data including daily milk yield (DMY), 305 daily milk yield (305 DMY), calving time and parity information was collected from the Association of Milk Recording. Milk composition traits (fat, protein, lactose) and SCC analysis were performed by the Fourier Transform Spectrometer and Infrared *Milk Analyzer* (Bentley Instrument Inc., Chaska, MN, USA). To ensure homogeneity of variance, SCC values were transformed into log scale (log10) for statistical analysis.

The cows were monthly recorded by BCS using a 5-grade scoring system, which describes 1 point is emaciated and 5 points refer to an obese cow, and to achieve more sensitivity, 0.50 points were also used.

To evaluate cows by effective factors; periods of milk production (early, middle and late lactation) of milking cows was considered and thus, three different stage of lactation (SL) (*SL 1 = 90 d<, SL 2 = 91-150 d and SL 3 = 151≤d*) were designed. Cows were evaluated in five parity (*cows with parity ≥5 were assessed into 5th group*) and four calving season groups. Besides, milk components, DMY, 305 DMY and SCC data were assessed in three BCS subgroups (*group 1 = <3 points; group 2 = 3-3.50 points and group 3 = >3.50 points*).

The data were tested by analysis of variance (One-Way ANOVA) and effects of the non-genetic factors on fat, protein, lactose, DMY, 305 DMY and logSCC were analyzed using the following linear model:

$$Y_{ijklm} = \mu + a_i + b_j + c_k + d_l + e_{ijklm}$$

where: Y_{ijklm}: is dependent variable *(parameters)*

μ: population mean,

a_i: effect of parity *(i = 1,2,3,4 and 5th lactation)*

b_j: effect of stage of lactation *(j = 90<, 91-150 and 151≤d in lactation)*

c_k: effect of calving season *(k = winter, spring, summer and autumn)*

d_l: effect of BCS (*l = 1,2,3; 1 = <3 points; 2 = 3-3.50 points; 3 = >3.50 points)*

e_{ijklm}: random residual effect.

Relations among investigated traits were estimated by Pearson's correlation coefficients. The means were compared by Duncan's multiple range test based on the 0.05 level of probability and all statistical analyses were performed using SPSS 17.0 for Windows.

RESULTS

Effects of environmental factors on investigated parameters are given in *Table 1*. As seen that all components were significantly (P<0.01) affected by parity. Fat percentage mean of the 2nd parity was found to be different from that calculated for the 4th also 5th parity. Protein percentage means for the advanced parities (4th and 5th) were lower

Table 1. *Means (±SD) of traits by non-genetic factors*
Tablo 1. *Özelliklerin genetik olmayan faktörlere göre ortalamaları (±S)*

Factors	n	Fat (%)	Protein (%)	Lactose (%)	Daily Milk Yield (kg)	logSCC	n	305 Daily Milk Yield (kg)
Parity								
1	1028	4.04±0.77^{ab}	3.38±0.32^{ab}	4.85±0.23^{a}	21.34±6.93^{a}	5.12±0.57^{a}	1000	7156.88 ±1367.43^{A}
2	1038	4.06 ±0.84^{a}	3.41 ±0.37^{b}	4.73±0.25^{b}	24.60±9.33^{b}	5.10±0.57^{a}	1006	8543.07±1619.29^{B}
3	1370	3.98 ±0.85^{abc}	3.36±0.36^{a}	4.67±0.32^{bc}	25.92±10.58^{b}	5.29±0.67^{b}	1319	9315.23±1646.35^{C}
4	923	3.95±0.81^{b}	3.23±0.36^{c}	4.64±0.31^{c}	28.04±10.37^{c}	5.42±0.76^{c}	840	9139.43±1765.26^{CD}
5	534	3.96±0.78^{bc}	3.30±0.36^{c}	4.58±0.32^{d}	27.10±10.48^{c}	5.71±67^{d}	480	8945.02±1740.71^{D}
Total	4893	4.00±0.92	3.36 ±0.36	4.716±0.30	25.21±9.87	5.28±0.66	4645	8613.29±1809.32
Stage of lactation								
1 *(0-90d)*	1013	3.77±0.85^{a}	3.04±0.27^{a}	4.760±0.25^{a}	32.31±8.65^{a}	5.103±0.71^{a}		
2 *(91-150d)*	828	3.86 ±0.85^{b}	3.24±0.27^{b}	4.770±0.28^{a}	30.37±8.17^{b}	5.166±0.69^{a}		
3 *(≥151d)*	3047	4.11±0.79^{c}	3.49±0.33^{c}	4.671±0.31^{b}	21.46 ±8.66^{c}	5.38±0.63^{b}		
Total	4888	4.00±0.82	3.35±0.36	4.706±0.30	25.22±9.86	5.28±0.67		
Calving season								
1 *(winter)*	1160	4.03±0.85^{a}	3.36±0.35^{ab}	4.73±0.29^{a}	26.05±10.22^{a}	5.27±0.68	1083	8749.18±1873.06^{A}
2 *(spring)*	891	3.95±0.84^{b}	3.35±0.39^{a}	4.72±0.33^{a}	23.27±10.14^{b}	5.27±0.64	853	8259.56±1899.24^{B}
3 *(summer)*	1456	3.96±0.81^{b}	3.38±0.37^{b}	4.69±0.29^{b}	24.48±8.81^{c}	5.31±0.64	1393	8352.02±1639.37^{B}
4 *(autumn)*	1384	4.05±0.77^{a}	3.33±0.32^{a}	4.69±0.31^{b}	26.52±10.18^{a}	5.26±0.70	1314	9008.39±1780.90^{C}
Total	4891	4.00±0.82	3.36±0.36	4.71±0.30	25.21±9.87	5.28±0.67	4643	8613.59±1809.65
Body condition score								
1 *(<3points)*	2425	3.91±0.81^{a}	3.30±0.34^{a}	4.71±0.29^{a}	26.44±9.00^{a}	5.27±0.68^{a}	2278	8706.59±1826.10^{A}
2 *(3-3.50 points)*	1762	4.05±0.79^{b}	3.37±0.35^{b}	4.72±0.31^{a}	25.43±10.15^{b}	5.26±0.67^{a}	1680	8649.14±1807.53^{A}
3 *(>3.50 points)*	702	4.16±0.84^{c}	3.50±0.39^{c}	4.68±0.31^{b}	20.38±10.53^{c}	5.37±0.61^{b}	683	8215.71±1692.35^{B}
Total	4889	4.00±0.82	3.36±0.36	4.71±0.30	25.20±9.86	5.28±0.67	4641	8613.55±1807.66

Different superscript letters in the same column indicate statistically significant differences (a,b: P<0.05; A,B: P<0.01); ***logSCC:*** *logarithmic somatic cell count,* ***305 dMY:*** *305 daily milk yield*

than the means for the other parity groups. Besides, protein means between 2nd and 3rd parities was different from each other. For lactose, a clear dropping with later parities was also observed. In contrast, distinctly increase was obtained with advanced parities for DMY and 305 DMY. The overall DMY and 305 DMY means were calculated to be 25.21±9.87 kg and 8613.29±1809.32 kg, respectively. Similarly, while the lowest logSCC mean was calculated in first and second parity, a linear increase was obtained for logSCC means by advanced parity.

When parameters were evaluated by SL, significant differences (P<0.05) were found among all groups *(Table 1)*. For fat and protein, a distinct increase was observed by advancing parity. The means (%) for these parameters were calculated to be 4.00±0.82 and 3.36±0.36, respectively. In lactose evaluation, relatively lower percentage (4.67±0.31) was obtained in the 3rd SL group. Cows in the first SL had highest DMY and 305 DMY when compared to other groups. In the 3rd SL group, DMY or 305 DMY means were calculated to be fairly lower than those calculated in the other SL groups. Also, a linear increment might be observed in logSCC means by SL groups.

In the study, fat percentages obtained in the winter and autumn CS was statistically different (P<0.05) from those estimated in the other CS groups *(Table 1)*. For protein, mean calculated in spring CS was lower (P<0.05) than the other means. Also, lactose means of winter and spring CS were different (P<0.05) from the means of other CS groups. While cows calved in winter and autumn had the highest DMY, the highest 305 DMY mean was obtained from cows calved in autumn season. In this study, no significant effect of CS on logSCC was determined. The overall untransformed SCC was calculated to be 663x10^3 cells/ml.

In BCS evaluation, significant (P<0.05) increase was determined according to elevated BCS for fat and protein means. Besides, cows with highest BCS had lowest lactose percentage (4.678±0.314) but highest logSCC (5.37±0.61) in this investigation. Also, a severe dropping in DMY was observed in cows with BCS >3.50.

Associations of investigated markers are given in *Table 2*. DMY had negative correlations with all parameters except for lactose and 305 DMY. While fat positively correlated

Table 2. *Pearson's phenotypic correlation coefficients between traits*
Tablo 2. *Özellikler arasındaki Pearson fenotipik korelasyon katsayıları*

Trait	F	P	Lac	BCS	logSCC	305dMY
dMY	-0.281	-0.485	0.308	-0.190	-0.280	0.466
F		0.452	-0.089	0.109	0.098	-0.136
P			-0.122	0.196	0.217	-0.132
Lac				-0.013	-0.412	-0.140
BCS					0.019	-0.060
logSCC						-0.013

dMY: *daily milk yield,* **F:** *fat,* **P:** *protein,* **Lac:** *lactose,* **BCS:** *body condition score,* **logSCC:** *logarithmic somatic cell count,* **305dMY:** *305 daily milk yield*

with protein, BCS and logSCC, negative correlations were calculated between lactose and other components except for DMY. Besides, a positive correlation coefficient *(r= 0.019)* was also estimated between BCS and logSCC. Estimated all correlation coefficients were found to be non-significant, statistically.

DISCUSSION

In the present study, fat percentage was found as relatively lower in cows with later parities. Similarly, protein percentages were decreased in advanced parity groups. In an earlier investigation [17], changeable fat and protein percentages in different parities have also been determined. However, our findings disagree with the report of results obtained in previously investigation [18]. Relatively low lactose content of milk collected from cows with later parities was determined in this study. However, obtained higher milk production (DMY and 305 DMY) in advanced parity groups might also assumed as unsurprised case. Undoubtedly, enhancement in body weight and udder size and new gestations might be referred as the main reasons for this fact. Thus, this result was parallel with the findings of some studies [19,20]. Similar to DMY results, logSCC means increased with advanced parities. Such that, relatively more milk production and eroding the tissues in udder gland with advanced age might be assumed as the normal reason of this case.

The study revealed that fat and protein percentages were lower in milk samples collected from cows in lower than 150th d of lactation. This result can be evaluated as a normal case due to new calving. In contrast, lactose ratio decreased in the latest SL group. This finding was inline with the results of the some researchers [21], who found that the lactose curve showed a progressive decrease as stage of lactation advanced. A general concept that milk production reaches to peak level in lactating cows at the beginning phase of the lactation. In this view, our finding is agreement with the results of some studies [17,22]. However, the linear dropping in DMY with later SL might be seen the reason for elevation in fat and protein percentages by SL. Obtained results for logSCC contrast with some earlier investigation results by an earlier work [23]. At this point, it can be advised to dairy owners that cows in higher than 150 d of lactation should be finically managed to obtain more milk quality.

In this study, cows calved in winter and autumn had more fat in milk (P<0.05). Effect of nutrition program and feeds presented to milking cows in these seasons might be seen the major reasons for this case. In other words, elevated the fat level of milk might be determined due to feeding cows with high energy included feeds in winter and autumn, where the herd kept indoors all year. In protein evaluation, an unsteady trend might be observed. Similarly, a group of researchers [17] reported an altered protein levels by season in their study. In a study [24], it was determined the lowest protein percentage in the summer and the highest percentage in the winter. However, while lactose in milk was higher in winter and spring CS groups, this result was found as harmonic with the indication of some researchers [21], who explained this case by inadequate forage supplementation of diet in these months.

Cows calved in winter and autumn had more DMY when compared to others. This finding is parallel to fat evaluation results. Similarly, cows calved in winter had higher 305 DMY. As mentioned earlier, feeding applications and adjustments in nutrition programs in herds in these seasons might be assumed the marked reason for this case. Actually, it was reported that cooler months positively affected milk production in dairy herds [25]. CS had no significant effect on SCC. In spite of calculated SCC mean of this study was found as similar to level obtained by a group of researchers [26], who conducted a study on this subject in Poland conditions, the mean was higher than SCC limits (400x10^3 cells/ml) by EU directives [27]. In this context, recording and closely observing SCC data may be seen a major stage to ensure high quality raw milk from dairy herds.

In BCS evaluation, similar results were found for fat and protein means in the study. As seen that cows with BCS<4 (group 1 and 2) had lower fat and protein percentage when compared to cows with BCS>3.50. In other words, low BCS caused to low fat and protein percentage in milk. Feeding regime of the farm might be caused to this case. However, lactose mean dropped in the highest BCS group. Actually, this finding was inline with obtained results *(Table 1)* on lactose percentages by SL groups. An attractive result was obtained in DMY means by BCS and cows with BCS<3 had highest milk production. Such that, loss in milk production between cows with BCS<3 and cows BCS>3.50 was estimated to be 22.91%. Actually, this result is harmonic with DMY evaluation by SL. Namely, high producing cows might be referred as cows in the first SL group, and exposing to negative energy balance [28], BCS seems as relatively low in this group. Similarly, in highest BCS groups, cows had higher SCC. Concisely, keeping cows under 4 BCS points might be considered to achieve more quantity and quality milk yield from Hungarian Holstein cows.

In correlation assessment, DMY had negative correlations with all parameters except for lactose and 305 dMY. In a normal lactation cycle, this finding might be assumed to be an expected result. As mentioned earlier, cows should not be allowed to gain high BCS to take more milk production from herds. Actually, a negative relationship between SCC and milk yield have been reported by many authors [29-31]. Also, positive correlations could be regarded between fat, protein, BCS and SCC. Besides, both fat and protein had negative correlations with lactose percentage. This finding agrees with the report of a study [32] that indicated negative associations of lactose with fat and protein contents. Also, lactose negatively correlated with BCS and SCC. Similarly, it was estimated a negative relationship between lactose and SCC of milk in an earlier work [21]. It was emphasized in a previous study [32] that elevated SCC of milk is highly associated with relatively low lactose, moreover udder health of milking cows adversely affected by this case.

In other words, findings obtained here are agreement with literature, and thus, combining all milk markers may be seen a more beneficial process in the farms for milk quality assessment. And last, a positive but non-significant correlation (*r=0.019*) was also estimated between BCS and SCC. A general hypothesis that negative energy balance in cows exposed to early lactation may be seen a major reason of udder inflammation [33]. In a study [23] that conducted in Turkey conditions, it was determined a negative but non-significant correlation coefficient (*-0.030*) between two parameters.

Finally, the present research indicated that non-genetic factors are associated with milk composition, production level and SCC in milk. Keeping records on milk parameters and observing cows are important steps to obtain an elite dairy herd. Therefore, it is suggested that environmental factors should primarily be considered to achieve more quality and quantity milk from milking cows.

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