TÜBİTAK

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Monitoring of somatic cell count variations during lactation in primiparous and multiparous Turkish Saanen goats (*Capra hircus*)

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Abstract: In this study, a total of 28 Saanen does were used to evaluate the relationship between somatic cell count (SCC) and milk yield. The study included 14 first-lactation (primiparous) does and 14 does in second lactation or greater (multiparous). Individual milk samples from both morning and evening milkings were taken every 15 days throughout the lactation period of 7 months. While somatic cell counts were higher during the evening milking (840.40 versus 532.30 cells mL^{-1}; 1050.40 versus 759.70 cells mL^{-1}), milk yields were lower during the evening milking (115.40 versus 193.80 kg; 177.40 versus 280.00 kg) for both primiparous and multiparous goats. Parity of the does affected the variables significantly, except for days in milk. Primiparous does had lower milk yields and SCCs than multiparous does. Overall, the mean SCC, logarithmic SCC, days in milk, and milk yield were 686.40×10^6 cells mL^{-1} and 905.10×10^6 cells mL^{-1} ($P < 0.05$), 5.81 and 5.94 ($P < 0.05$), 203.33 and 207.58 days ($P > 0.05$), and 309.20 and 457.40 kg ($P < 0.05$) per doe per lactation, for primiparous and multiparous goats, respectively. Goat milk samples contained high SCCs and exceeded the requirement of 1×10^6 mL^{-1} of the Pasteurized Milk Ordinance (PMO) during most of the late lactation stages; however, the overall SCC mean was under the PMO limit. The SCC was negatively correlated with milk yield, but the correlation coefficient was not found to be significant ($P > 0.05$). As lactation progressed, the SCC increased and milk production decreased in primiparous and multiparous goats. The results of this paper could be useful for the development of acceptable goat milk SCC standards in Turkey.

Key words: Somatic cell count, Saanen, milk yield, correlation

İlk ve daha sonraki laktasyonlarındaki Türk Saanen keçilerinde (*Capra hircus*) laktasyon süresince somatic hücre sayısının değişimi

Özet: Bu çalışmada, 14'ü ilk laktasyonunda (primiparous), 14'ü de 2. ya da daha sonraki laktasyonunda (multiparous) olmak üzere toplam 28 baş Saanen ırkı keçi kullanıldı. Bireysel süt örnekleri, 7 aylık laktasyon süresince 2 haftada bir sabah ve akşam alındı. Her iki grupta da (primiparous, multiparous) somatik hücre sayısı (SHS) akşam sağımında daha yüksek iken (840,40 vs. 532,30 hücre mL^{-1}; 1050,40 vs. 759,70 hücre mL^{-1}), süt verimi daha düşük bulundu (115,40 vs. 193,80 kg; 177,40 vs. 280,00 kg). Laktasyon sırası, laktasyon süresi hariç diğer değişkenleri önemli düzeyde etkiledi. Primiparous keçiler multiparous keçilere göre daha düşük süt verimine ve SHS na sahipti. Primiparous ve multiparous

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keçiler için ortalama SHS, logaritmik SHS, laktasyon süresi ve süt verimi sırasıyla 686,40 × 10^6 hücre mL^{-1}, 905,10 × 10^6 hücre mL^{-1} ($P < 0,05$); 5,81, 5,94 ($P < 0,05$); 203,33, 207,58 gün ($P > 0,05$) ve 309,20, 457,40 kg ($P < 0,05$) dır. Numunlerdeki SHS, özellikle laktasyonun son dönemlerinde PMO (Pasteurized Milk Ordinance) tarafından bildirilen 1 × 10^6 mL^{-1} değerinin üstünde olmasına rağmen, genel SHS ortalaması PMO limitin altındaydı. SHS, süt verimi ile negatif korelasyona sahipti fakat korelasyon katsayısı istatistiksel önemde bulunmadı ($P > 0.05$). Laktasyon ilerledikçe her iki grupta da SHS artarken süt verimi azaldı. Bu çalışmadan elde edilen sonuçlar, Türkiyede kabul edilebilir bir keçi sütü SHS standartının geliştirilmesi için kullanılabilir.

Anahtar sözcükler: Somatic hücre sayısı, Saanen, süt verimi, korelasyon

Introduction

In developed countries, after 100 years of lower production, the position of goat farming has turned positive again. During the last 20 years, the number of goats around the world has increased by about 60%, not only in the countries with low incomes (75%) but also in those with high (20%) and intermediate (25%) incomes. Milk production has increased by nearly 70% during this period, as well. In addition, a new and growing interest in goat milk and goat milk products has occurred around the world, and in recent years, there has been a general increase in the volume of goat milk produced. Urban consumers believe that goat dairy products have a good ecological image, and goat milk and dairy products are not rich in fat, are more digestible, are healthy for many gastrointestinal illnesses, and are less allergenic than cow milk. Consequently, goat milk and goat dairy products have real future economic potentials (1,2).

Milk's somatic cell count (SCC) is the basis for abnormal milk control programs (3). However, high levels of SCC in goat milk are associated with decreased milk yield and changes in milk composition, and they negatively affect cheese production (4). The objective of an abnormal milk control program is to prevent abnormal milk from entering the channels of human consumption (5). Many noninfectious factors cause considerable variation in SCC, especially in goat milk, which must be considered in establishing quality control regulations. There is a great need for further research to determine carefully the threshold at which SCC affects goat milk characteristics, and the quality of related dairy products (4). While SCC is an accepted procedure for evaluating quality in cow and sheep milk, it is not applicable for goat milk. The SCC for uninfected goats appears to be higher than counts for uninfected cows and sheep (5).

In the United States, the legal milk SCC limit as established by the Food and Drug Administration for cows is 750,000 cells mL^{-1}, and for goats and sheep it is 1,000,000 cells mL^{-1} (6). In the European Union, the legal limit for cows is 400,000 cells mL^{-1}, but there is no legal limit for goat or sheep milk (7).

Turkey has the largest goat population in Europe (5,600,000 in 2009) and is fourth in total goat milk production (192,000 t in the year 2009) in the European and Mediterranean region, after France, Spain, and Greece (2). However, there is no legal limit for SCC in goats, nor has there been any information published about SCC variation in Saanen dairy goats in Turkey.

The objective of this study was to investigate the effects of parity and stage of lactation in Turkish Saanen goats throughout lactation on milk yield and milk SCC variations.

Material and methods

Animals and management conditions

A total of 28 Turkish Saanen dairy goats were selected from a Saanen goat flock of Uludağ University's Applied Research Center for Veterinary Faculty and Agricultural Faculty Units, located within the northwestern region of Turkey, 40° N and 29° E, at an altitude of 120 m above sea level. All of the animals underwent parturition in February and were dried off in October. Goats were divided into 2 groups. The first group consisted of 14 primiparous goats and the other group consisted of 14 multiparous goats (the goats were in second or third lactation). All animals were kept under the same management conditions and were fed ad libitum with oats, vetch,

and alfalfa hay, along with 1.5 kg doe^{-1} of concentrate (16% crude protein and 2.54 Mcal kg^{-1} metabolizable energy) per day. Neither group was grazed, but they were always kept in a semiopen yard. Water was offered ad libitum to all goats.

The kids were separated from the goats 3 days after birth and were weaned at 60 days. Kids were not allowed to suckle from the doe on the days that milk sampling took place. Milk yield was assessed by fortnightly controls until the daily yield dropped to below 0.1 kg day^{-1}. Lactation length was calculated from weaning (day 3) until the daily milk yield dropped to below 0.1 kg. All goats were milked twice daily, at 05:00 and 17:00. Goats were milked from parturition to 30 weeks of lactation in a double-8 parallel milking parlor (Uğurkan Ltd. Şti., Turkey), until dry-off. Milking was performed at a vacuum pressure of 42 kPa, a pulsation rate of 90 pulses min^{-1}, and a pulsation ratio of 60:40, in accordance with the recommendations of Peris et al. (8). The milking routine consisted of machine milking, machine stripping before cluster removal, and teat dipping in a benzalkonium chloride (a quaternary ammonium compound) solution.

Collection of milk samples

The first collection occurred after at least 15 days postparturition, in order to avoid collection of colostrum. Each milk sample was collected in a 20-mL plastic vial without any preservative agent. Samples were kept at 4 °C until SCC testing was performed. The test days took place fortnightly, and data included morning and evening milk yields as well as SCC.

Analysis of samples

Milk samples were analyzed within 24 h. The SCC of fresh milk was counted by the method of IDF (9); a 10-µL smear of milk was made in an area of 20 × 5 mm on a glass slide and the somatic cells were stained using methylene blue dye. The somatic cells were counted in 50 fields and were multiplied by the microscopic factor (10).

Statistical analysis

All data were analyzed by the 2-sample t-Test and Pearson correlations with the Minitab (Version 13, 2001) statistical program. Pearson correlation coefficients were determined between milk yield and somatic cell count. Actual and logarithmic transformations ($\log_{10}$) of the SCC values were used in the statistical analysis.

Results

Comparisons of means between primiparous and multiparous Saanen goats are presented in Table 1. Days in milk was calculated to be 203 and 207 days for primiparous and multiparous does, respectively, in the present study ($P > 0.05$).

Table 1. Comparisons of milk yield traits and somatic cell counts (SCC) of primiparous and multiparous Turkish Saanen goats (n = 28).

Traits	Description	Primiparous	Multiparous	SEM	P
DIM	Days in milk (day)	203.33	207.58	6.93	NS
MMY	Morning milk yield (kg)	193.80	280.00	31.30	0.019
EMY	Evening milk yield,(kg)	115.40	177.40	16.40	0.003
LMY	Lactation milk yield (kg)	309.20	457.40	46.10	0.008
MSCC	Morning test day SCC ($\times 10^3$ mL^{-1})	532.30	759.70	107.00	0.050
ESCC	Evening test day SCC ($\times 10^3$ mL^{-1})	840.40	1050.40	88.40	0.037
LSCC	Lactation SCC ($\times 10^3$ mL^{-1})	686.40	905.10	94.20	0.040
MSCCL	Morning test day SCC ($\log_{10}$ mL^{-1})	5.69	5.86	0.08	0.050
ESCCL	Evening test day SCC ($\log_{10}$ mL^{-1})	5.90	6.01	0.05	0.037
LSCCL	Lactation SCC ($\log_{10}$ mL^{-1})	5.81	5.94	0.06	0.040

SEM: standard error of the mean

As shown in Table 1 and Figure 1, morning, evening, and lactation milk yields were higher in multiparous Saanen goats throughout lactation ($P < 0.05$). All does produced more milk during the morning milking ($P < 0.05$).

Results (Table 1 and Figure 2) indicate that the SCC increased with increasing parity for Turkish Saanen goats. Overall means of SCC in the present study were found to be 686.40×10^3 mL^{-1} (log SCC 5.81) and 905.10×10^3 mL^{-1} (log SCC 5.94) for primiparous and multiparous goats, respectively ($P < 0.05$). Evening SCC (primiparous, 840.40; multiparous, 1050.40) was found to be higher than morning SCC (primiparous, 532.30; multiparous, 759.70) for both groups ($P < 0.05$).

The SCCs of primiparous does were lowest, averaging approximately 375,000 mL^{-1} at 6 weeks (45 days) of lactation and reaching a maximum SCC of around 925,000 mL^{-1} at 28 weeks (200 days) of lactation. For multiparous does, counts averaged approximately 475,000 mL^{-1} at 6 weeks (45 days) and increased to a maximum of approximately 1,300,000 mL^{-1} at 28 weeks (200 days) of lactation (Figure 2).

The lowest SCCs were observed during the peak milk stage of lactation, while the highest SCC values were found to occur during the period of lowest milk yields, near the end of lactation for both groups (Figures 1 and 2).

The simple correlation coefficients between milk yield and SCC are shown in Table 2. The SCC curve

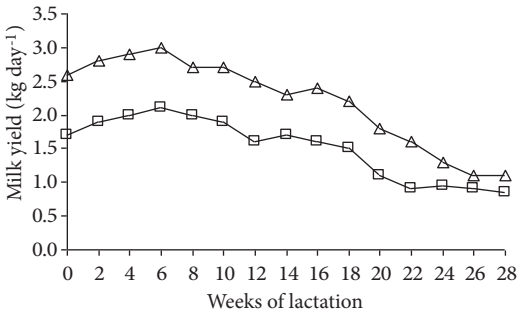

Figure 1. Milk production during lactation of primiparous (⊟) and multiparous (⧋) Turkish Saanen goats.

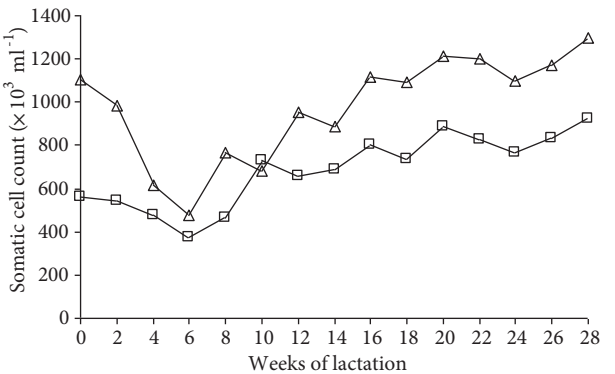

Figure 2. Somatic cell count during lactation of primiparous (⊟) and multiparous (⧋) Turkish Saanen goats.

Table 2. Simple correlation coefficients between milk yield traits and somatic cell count of primiparous (P) and multiparous (M) Turkish Saanen goats (n = 28).

Variable	DIM		LMY		MMY		EMY		MSCC		ESCC		LSCC		MSCCL		ESCCL	
	P	M	P	M	P	M	P	M	P	M	P	M	P	M	P	M	P	M
LMY	0.41	0.39																
MMY	0.46	0.47	0.97***	0.98***														
EMY	0.32	0.19	0.97***	0.94***	0.88***	0.87***												
MSCC	-0.22	-0.08	-0.21	-0.44	-0.16	-0.37	-0.25	-0.54										
ESCC	-0.29	-0.18	-0.26	-0.55	-0.27	-0.49	-0.24	-0.64*	0.88***	0.91***								
LSCC	-0.27	-0.13	-0.25	-0.51	-0.23	-0.44	-0.25	-0.61*	0.96***	0.98***	0.98***	0.98***						
MSCCL	-0.28	0.03	-0.20	-0.39	-0.13	-0.32	-0.26	-0.49	0.97***	0.98***	0.87***	0.89***	0.94***	0.96***				
ESCCL	-0.36	-0.14	-0.25	-0.53	-0.24	-0.46	-0.24	-0.62*	0.85***	0.89***	0.97***	0.99***	0.95***	0.96***	0.90***	0.89***		
LSCCL	-0.34	-0.07	-0.24	-0.47	-0.21	-0.39	-0.26	-0.57	0.93***	0.96***	0.96***	0.97***	0.97***	0.99***	0.96***	0.97***	0.98***	0.97***

* $P < 0.05$, *** $P < 0.001$, Abbreviations as in Table 1.

was the inverted image of the lactation curve (Figures 1 and 2). Correlation coefficients between milk yield and SCC were found to be negative (r ranging from -0.16 to -0.64). The highest correlation was found for multiparous goats (r = -0.32, -0.64). However, there was a significant correlation coefficient only between evening milk yield (EMY) and evening test-day somatic cell count (ESCC), evening test-day logarithmic somatic cell count (ESCCL), and lactation somatic cell count (LSCC) in multiparous goats (r = -0.64, -0.61, and -0.62 respectively; $P < 0.05$). The strength of the negative correlation between milk yield and SCC increased with parity.

In primiparous Turkish Saanen goats, correlation coefficients were found to be low and negative between milk yield (morning, evening, and lactation) and SCC (morning, evening, and lactation), and they ranged between -0.13 and -0.27, respectively ($P > 0.05$).

Discussion

Different values have been reported in different countries for days in milk, ranging between 150 and 288 days in dairy goats (11). Days in milk was calculated at 203 and 207 days for primiparous and multiparous does, respectively, in the present study, and these findings are in agreement with previous studies about days in milk for Saanen dairy goats. It can be concluded that Turkish Saanen goats have a good milk yield potential. If the days in milk were extended, more milk could be produced. Comparing the present findings with previous findings in Turkey (12), it can be said that the breeding of dairy goats in Turkey still follows traditional methods that have been previously used.

Multiparous Saanen goats produced more milk during both morning and evening milkings than primiparous goats, in spite of lactation lengths being similar. Similar results have been reported for relationships between parity and milk yield by several researchers for different breeds. For instance, Zeng and Escobar (13) and Antunac et al. (14) reported that Saanen and Alpine goats produced less milk in their first lactations than in second and third lactations. Significant increases were observed in total milk yield from the first to the fourth lactation in Saanen goats by Moroni et al. (15).

All does produced more milk in the morning milkings (Table 1). This was the expected result, even if the milking interval was equal. This finding was confirmed by Randy et al. (16), who reported the same result for Alpine goats. The differences were significant ($P < 0.05$) between the morning milking and evening milking, although it appears that the morning milking contributed the most to the total daily milk difference. This may be due to increased mammary cell proliferation occurring at night due to the nightly secretion of growth hormone. (17)

SCCs increased with increasing parity for Turkish Saanen goats (Table 1 and Figure 2). Supporting our results, Rota et al. (18) reported that average cell concentration was significantly affected by parity and tended to increase from the first (1.27×10^6 SCC mL^{-1}) to the fourth lactation (2.02×10^6 SCC mL^{-1}). Similarly, Moroni et al. (15) and Wilson et al. (19) reported that parity and stage of lactation affected SCC and that third-lactation goats had higher SCCs than first- and second-lactation goats. Similar results have also been reported for cattle (20).

There is no range yet prescribed for somatic cell counts for goat milk by EU or Turkish regulations, but the overall means of SCC in the present study (686.40×10^3 mL^{-1}, log SCC 5.81 for primiparous goats; 905.10×10^3 mL^{-1}, log SCC 5.94 for multiparous goats) were within the range prescribed by US laws (1,000,000 mL^{-1}) (6). On the other hand, at the International Symposium of Somatic Cells and Milk of Small Ruminants in 1994, it was suggested to the EU authorities that a SCC limit for bulk tank milk for goats and sheep should not be lower than 1.5×10^6 cells mL^{-1} (3). Turkish Saanen goats have acceptable SCCs in respect to this proposed limit.

As expected, the evening SCCs for primiparous and multiparous does were found to be higher than the morning SCCs, because there is an adverse relation between milk yield and SCC and the evening milk yield was lower than the morning milk yield ($P < 0.05$). These results agree with those of Quist et al. (20), who found that the mean SCC was always lower in the morning than the evening milking for cows. Additionally, SCCs were attributed to the time of milking and reported to be higher in the afternoon milking in Alpine goats (16). This is in accord with the findings of the present study.

In this study, SCCs were lowest for primiparous does at the beginning (day 45) of lactation and reached maximum counts of at the end (day 200) of lactation (Figure 2). These results agree with the increase in SCC in goats as lactation advances (19,21). A decrease in milk yield with increasing SCCs was also reported in sheep (22). Additionally, SCCs for uninfected mammary glands have been reported to increase according to the stage of lactation and parity (5,23,24). High SCCs in goat milk appear to be natural, particularly in the later stages of lactation. As lactation progresses, SCC increases and milk production decreases (13).

The lowest SCC values were observed when milk production peaked during lactation, and the highest SCC values were determined to occur during the later stages of lactation, when milk production was at its lowest for both groups (Figures 1 and 2). It can be said that there is a reverse relationship between SCC and milk yield. Negative correlations were reported between milk yield and SCC in a previous study (25). Paape et al. (3) also reported that reduced milk production contributed significantly to increased SCCs. In the present study, SCCs in Saanen does were variable during different periods of lactation. The SCC fluctuation can result from noninfectious factors such as estrus, season, and milk yield (5,26).

Correlation coefficients between milk yield and SCC were clearly negative ($r = -0.16$ to -0.64), but were not significant ($P > 0.05$). Several researchers have reported similar results regarding correlation coefficients between milk yield and SCC in different species. For instance, Zeng et al. (25) reported a nearly zero correlation coefficient between milk yield and SCC ($r = -0.09$; $P < 0.001$) during first lactation in Alpine goats. Similar results ($r = -0.08$; $P < 0.05$) were reported by Serrano et al. (27) during first lactation in Manchega ewes. No research has reported on correlations between morning and evening milk yield and morning and evening SCCs in primiparous and multiparous Saanen goats, and therefore an objective comparison was not possible. The strength of the negative correlation between milk yield and SCC increased with parity. This coincided with the stages in lactation at which SCCs were at their maximum. This is in accord with results presented by other authors (23,28) for Holstein cows and Alpine dairy goats. Additionally, Serrano et al. (27) reported that while parity increased, the correlation between milk yield and SCC increased ($r = -0.08$ and -0.15 in first and third lactations, respectively) in Manchega ewes.

The results of the current investigation indicate that, for Turkish Saanen goats, a progressive increase in SCC is observed with parity and advanced lactation. Milk yield was significantly higher for multiparous goats than primiparous goats. In conclusion, Turkish Saanen goats have greater milk yield potential if the days in milk are extended. The results of the current investigation indicate a progressive increase in SCC observed with parity and advanced lactation. The results of this paper could be useful in the development of acceptable goat milk SCC standards in Turkey.

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References

1. Morand-Fehr, P., Boutonnet, J.P., Devendra, C., Dubeuf, J.P., Haenlein, G.F.W., Holst, P., Mowlem, L., Capote, J.: Strategy for goat farming in the 21st century. Small Rumin. Res., 2004; 51: 175–183.
2. FAOSTAT: Agricultural Statistics (online: http://www.fao.org). FAO, Rome, Italy, 2009.
3. Paape, M.J., Poutrel, B., Contreras, A., Marco, J.C., Capuco, A.V.: Milk somatic cells and lactation in small ruminants. J. Dairy Sci., 2001; 84 (E. Suppl.): 237–244.
4. Raynal-Ljutovac, K., Pirisi, A., De Crémoux, R., Gonzalo, C.: Somatic cells of goat and sheep milk: analytical, sanitary, productive and technological aspects. Small Rumin. Res., 2007; 68: 126–144.
5. Paape, M.J., Wiggans, G.R., Bannerman, D.D., Thomas, D.L., Sanders, A.H., Contreras, A., Moroni, P., Miller, R.H.: Monitoring goat and sheep milk somatic cell counts. Small Rumin. Res., 2007; 68: 114–125.

6. Pasteurized Milk Ordinance (PMO): Grade "A" Pasteurized Milk Ordinance. U.S. Dept. of Health and Human Services, Washington, DC, 1995.

7. Directive 92/46ECC Council: Diario Official de las Comunidades Europeas, vol. L 268. European Council, Brussels, Belgium, 1992; 1–34.

8. Peris, S., Such, X., Caja, G.: Milkability of Murciano-Granadina dairy goats. Milk partitioning and flow rate during machine milking according to parity, prolificacy and mode of suckling. J. Dairy Res., 1996; 63: 1–9.

9. IDF: Recommended methods for somatic cell counts in milk, Doc. No. 168, International Dairy Federation, Belgium, 1984; 15-30.

10. Das, M., Singh, M.: Variation in blood leucocytes, somatic cell count, yield and composition of milk of crossbred goats. Small Rumin. Res., 2000; 35: 169–174.

11. Serradilla, J.M.: Use of high yielding goat breeds for milk production. Livest. Prod. Sci., 2001; 71: 59–73.

12. Sonmez, R., Sengonca, M., Alpbaz, A.G.: An investigation on various characteristics of Saanen goats raised at the Faculty of Agriculture of Aegean University. Ege Uni. Ziraat Fak. Derg., 1970; 8: 115–134.

13. Zeng, S.S., Escobar E.N.: Effect of parity and milk production on somatic cell count, standard plate count and composition of goat milk. Small Rumin. Res., 1995; 17: 269-274.

14. Antunac, N., Kapš, M., Lukač Havranek, J., Samaržija, D.: Effects of breed and parity on some dairy traits of Alpine and Saanen goats in Croatia. In: Milking and Milk Production of Dairy Sheep and Goats. EAAP Publication, 1999; 95: 421–423.

15. Moroni, P., Pisoni, G., Savoini, G., Van Lier, E., Acuna, S., Damiàn, J.P., Meikle, A.: Influence of estrus of dairy goats on somatic cell count, milk traits, and sex steroid receptors in the mammary gland. J. Dairy Sci., 2007; 90: 790–797.

16. Randy, H.A., Wildman, E.E., Caler, W.A., Tulloch, G.L.: Effect of age and time of milking on day-to-day variation in milk yield, milk constituents and somatic cell counts. Small Rumin. Res., 1988; 1: 151–155.

17. Pala, A., Savas, T. Persistency within and between lactations in morning, evening and daily test day milk in dairy goats. Arch. Tierzucht, 2005; 48: 185–193.

18. Rota, A.M., Gonzalo, C., Rodriguez, P.L., Rojas, A.I., Martin, L., Tovar, J.J.: Effects of stage of lactation and parity on somatic cell counts in milk of Verata goats and algebraic models of their lactation curves. Small Rumin. Res., 1993; 12: 211–219.

19. Wilson, D.J., Stewart, K., Sears, P.M. Effects of stage of lactation, production, parity and season on somatic cell counts in infected and uninfected dairy goats. Small Rumin. Res., 1995; 16: 165–169.

20. Quist, M.A., LeBlanc, S.J., Hand, K.J., Lazenby, D., Miglior, F., Kelton, D.F.: Milking-to-milking variability for milk yield, fat and protein percentage, and somatic cell count. J. Dairy Sci., 2008; 91: 3412–3423.

21. Salama, A.A.K., Such, X., Caja, G., Rovai, M., Casals, R., Albanell, E., Marin, M.P., Marti, A.: Effects of once versus twice daily milking throughout lactation on milk yield and milk composition in dairy goats. J. Dairy Sci., 2003; 86: 1673–1680.

22. Gonzalo, C., Carriedo, J.A., Baro, J.A., Primitivo, F.S.: Factors influencing variation of test day milk yield, somatic cell count, fat and protein in dairy sheep. J. Dairy Sci., 1994; 77: 1537–1542.

23. Mariam, M.H., Bowman, P.J., Goddard, M.E.: Genetic and environmental correlations between test-day somatic cell count and milk yield traits. Livest. Prod. Sci., 2001; 73: 1–13.

24. Gomes, V., Libera, A.M.M.P.D., Paiva, M., Madureira, K.M., Araujo, W.P.: Effect of the stage of lactation on somatic cell counts in healthy goats (*Caprae hircus*) breed in Brazil. Small Rumin. Res., 2006; 64: 30–34.

25. Zeng, S.S., Escobar, E.N., Popham, T.: Daily variations in somatic cell count, composition and production of Alpine goat milk. Small Rumin. Res., 1997; 26: 253– 260.

26. McDougall, S., Voermans, M.: Influence of estrus on somatic cell count in dairy goats. J. Dairy Sci., 2002; 85: 378–383.

27. Serrano, M., Perez-Guzman, M.D., Montoro, V., Jurado, J.J.: Genetic analysis of somatic cell count and milk traits in Manchega ewes: mean lactation and test-day approaches. Livest. Prod. Sci., 2003; 84: 1–10.

28. Min, B.R., Tomita, G., Hart, P.S.: Effect of subclinical intramammary infection on somatic cell counts and chemical composition of goats' milk. J. Dairy Res., 2007; 74: 204–210.