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ORIGINAL ARTICLE

Effects of short period frequent milking on milk yield and udder health in Turkish Saanen goats

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ABSTRACT

The major purpose of this study was to investigate whether increasing milking frequency for a short period (21 days) increases milk yield and milk components and improves udder health throughout lactation in Turkish Saanen goats. Two groups were formed (control, $n = 14$, treatment, $n = 14$); balanced by parity, bodyweight and birth type to make them homogenous. Feeding and management practices were the same for both groups. The treatment group was milked four times a day (4×) for 21 days after weaning whereas the control group was milked twice a day (2×). All the animals were milked twice daily thereafter. The pyronin methyl green stain method was used to estimate the somatic cell count (SCC), which is an indication of udder health. This method provided a count that excluded RNA and background noise while including cells with DNA. Repeated measures analyses indicated that overall differences between the 2× and 4× groups were significant for the morning, evening and total test day milk yields, in that values for the 4× group were increased 14.7, 8.8 and 12.1%, respectively. Differences between the groups for SCC were not significant. The results of this study indicate that increasing milking frequency to 4×, even for a short time (21 days), increases overall milk yield throughout lactation in dairy goats.

Key words: *frequent milking, goats, milk yield and milk composition, somatic cell count.*

INTRODUCTION

Increasing milking frequency has been studied in many species and has been shown to increase milk yield and udder health (Dahl *et al*. 2004). However, one major disadvantage of this application is the increase in labor costs (Bewley *et al*. 2001). Recent evidence in dairy cattle suggests that increasing milk frequency for a short period could help increase milk yield throughout lactation (Dahl *et al*. 2004) because suckling is better simulated and mammary cells can be kept alive longer.

Dairy goats have been shown to have an increase in milk yield either by milking one or two udders, or by milking once versus twice throughout lactation. Milking goats once a day throughout lactation resulted in a 6–35% drop in milk yield compared to milking them twice a day (2×) (Salama *et al*. 2003).

Knight (1992) milked goats thrice daily for 6 weeks and reported a 10.4% increase in milk yield, but the increase reported was for the treatment period of 6 weeks only. All other studies using goats reported overall increases in milk yield with increased milking frequency that continued for a long period, such as throughout lactation, thereby increasing labor costs. Wilde and Knight (1989) reported that milking thrice daily (3×) long-term increased milk yield in the later stages of lactation by preventing the decline in secretory cell numbers after peak. Stefanon *et al*. (2002) suggested that frequent milking, timed appropriately, could improve persistency by maintaining milk secretion during the declining phase of lactation. In this study, Turkish Saanen dairy goats were milked four times (4×) a day for 3 weeks after weaning to prevent the drop in milk yield.

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In dairy animals udder health and milk quality problems can cause large losses. Increased milk yield is usually associated with an increased risk of clinical mastitis (Hillerton *et al*. 1995; Waage *et al*. 1998). However, more frequent milking increases the migration of neutrophils from the blood into the mammary gland to provide a more efficient defense against pathogen infections (Paape *et al*. 1992).

The objective of this study was to investigate the effects of a 21-day period of frequent milking on milk yield, milk composition and udder health, as measured by a somatic cell count (SCC).

MATERIALS AND METHODS

Two milking frequencies, 2× (throughout lactation) and 4× (21 days only) were studied in a total of 28 Turkish Saanen dairy goats. The test days took place monthly and data included morning and evening milk yields, milk yield per day, milk component percentages and SCC.

The kids were separated from the goats after 3 days. They were reunited with the goats only after their dams had been milked in the evening. The weights of the kids were monitored and those reaching 10 kg were weaned. The treatment of 4× milking was started after all the kids had been weaned.

Two groups of goats were formed and balanced by parity, bodyweight and birth type to make them homogenous. The treatment group was milked 4× at 07.00, 10.00, 16.00 and 19.00 hours and the control group was milked 2× at 07.00 and 19.00 hours for 21 days after weaning. All the goats were milked an equal number of times per day (2×) outside the specified 21 days. The management and feeding were always the same for both groups.

In dairy cattle, the SCC, an indication of udder health, is approximately equal to the number of leukocytes (Crist *et al*. 1997). In goat milk, however, there are cytoplasmic particles due to the apocrine milk secretory system, which makes it necessary to use a dichromal stain. Pyronin-Y methyl green method (New York modification) was used for the direct microscopic somatic cell count (DMSCC/mL). This method provided a count that included only the cells that had DNA and excluded RNA and background noise (Pachard *et al*. 1992).

The model and analyses were similar to the second approach reported by Pala and Savas (2005) and the analyses of Pala and Savas (2006). The repeated statement in proc MIXED of SAS V8.2 (SAS 1999) was used to fit a lactation curve model and a variance–covariance model was used to account for the correlations of all the observations from individual goats (Jennrich & Schluchter 1986; Everitt 1995). Akaike's information criteria (Akaike 1974) and Schwarz's Bayesian criteria (Schwarz 1978) were computed (SAS 1999) and both of these fitness measures indicated that the first order autoregressive moving-average had the highest fit.

The statistical model was:

$$Y_{ijklmno} = \mu + A_i + B_j + C_k + D_l + \sum_{m=1}^{4} b_{mn} X_m + F_o(B_j) + e_{ijklmno}$$

where:

Y_{iklmno} = test day record for morning, evening, daily, or fat corrected daily milk yield,
μ = overall mean
A_i = effects due to milking frequency (2×, 4×)
B_j = effects due to parity (1, . . . , 5),
C_k = effects due to birth type (single, multiple)
D_l = effects due to test day (1, . . . , 7),
X_m = covariates:
C1 = DIM/c where c is constant, set to 300 days,
C2 = $(DIM/c)^2$
C_3 = ln(c/DIM)
C_4 = $([\ln(c/DIM))^2$. The subscript n denotes that regression were nested within parity
F_o = effects of the subject within parity,
$e_{ijklmno}$ = random error.

DMSCC/mL was analyzed using χ^2 and continuity-adjusted χ^2 by using a 200 000-cell/mL cutoff to categorize the SCC values. In addition, DMSCC/mL was log transformed to somatic cell score (SCS) using SCS = $\log_2$ (SCC/100) + 3 (Ali & Shook 1980) and was analyzed using the same covariance structure as in the milk yield analyses.

RESULTS AND DISCUSSION

Compared with 2× goats, 4× goats had a similar peak milk yield ($P > 0.05$) and achieved peak during the same test day (Table 1). The overall differences between the 2× (control) and 4× (treatment) groups were significant for the total test day milk, fat-corrected test day milk and morning milk yields (Table 1).

For the test day milk yield, the difference between the groups was 222 g, constituting a 12.11% increase over the 2× value. The test day milk yield increased 16.87% during the treatment (2930.4 vs 2507.3 g). Test day milk yield and fat-corrected milk yield were

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Table 1 Repeated measures analyses, including least squares means (LS) comparisons of production traits of goats milked twice/day (2×) or four times/day (4×) for 21 days of lactation after weaning

Trait	2×	4×	SEM†	*P*
Peak milk, g	2556.24	2824.10	159.80	0.237
DIM at peak	24.88	25.67	1.35	0.677
Test day milk, g	1829.27	2050.87	83.58	0.004
Fat corrected test day milk, g	1571.04	1701.09	70.13	0.048
Morning test day milk, g	1032.56	1183.92	50.76	0.002
Evening test day milk, g	796.61	866.92	39.12	0.053
Milk fat, %	3.08	2.95	0.06	0.039
Milk protein, %	3.19	3.20	0.02	0.497
Non-fat solids, %	9.53	9.46	0.04	0.075

†Pooled standard error of the mean based on most conservative number in a group.

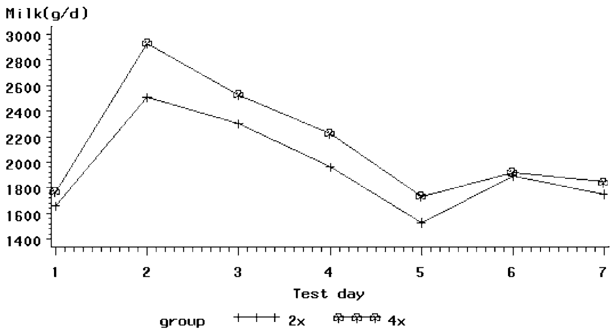

Figure 1 Test day average (least squares mean) milk yield of goats milked four times/d (4×; $n = 14$) for the initial 21 days after weaning the kids or milked twice/day (2×; $n = 14$) for the initial 21 days after weaning the kids. All the goats were milked 2× for the remainder of the lactation. Standard error of the mean ranged from 131 to 134 g/day. The 4× treatment falls into the second interval.

both significant, indicating that the treatment of 4× had large effects on both (Table 1). These results indicate that increasing milking frequency to 4× for a short time increases milk yield for the whole lactation period, as calculated by the test day data. Studies in the literature show that goats milked more frequently throughout lactation have increased milk yield (Salama *et al*. 2003) while our study shows that increasing milking frequency for a short period had similar effects.

The milk yield of both groups started out very close as the groups had been balanced to remove any bias (Fig. 1). The 21-days period of 4× milking resulted in significant differences between the treatment and the control group. In dairy goats, increased activity per cell and mammary growth increases the milk yield during early lactation. Milk yield declines after peak lactation because the epithelial tissue regresses due to apoptotic cell death (Knight & Wilde 1987). During late lactation, the milk yield decreases because the cell numbers keep declining and the secretory activity by the cells starts to diminish (Capuco *et al*. 2003; Pala & Savas 2005).

Stefanon *et al*. (2002) suggested that mammary cell apoptosis occurs after peak and the frequency of milking may affect the rate of apoptosis. If milking frequency is increased for a certain period of time, the milk yield increases during treatment and for the rest of the lactation (Dahl *et al*. 2004) because of increased mammary cell proliferation (Hale *et al*. 2003) or due to increased stimulation of the mammary gland, which increases blood flow and oxygen tension (Capuco *et al*. 2003). Since milk yield is determined by a number of factors, these parameters would have to be combined during and after the 21-day period of increased milking frequency in order to explain the observed milk yield responses. A sustained elevation in milk yield in the 4× group would require that the number and/or activity of differentiated mammary epithelial cells to remain increased after the cessation of 4× milking or that the rate of apoptosis had dropped. It is likely that the cause is a combination of these factors, along with increased blood flow and oxygen.

The number of differentiated mammary epithelial cells in the 4× group would have to remain elevated and the rate of apoptotic death would have to decrease in order for the 4× group to have a sustained increase in milk yield. However, the decline in milk production that occurred in both groups as lactation progressed is likely to have involved increased apoptotic cell death, as reported in the literature (Knight & Wilde 1987; Capuco *et al*. 2003). This means that 4× treatment prevented cell death for a while, but then this group also experienced apoptosis. The difference is that the animals in the 4× group probably started experiencing apoptotic cell death later than the 2× group did, thus

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having an elevated milk yield during most of the lactation period.

Increasing milking frequency to 4× increased morning milk by 14.66% and the evening milk by 8.83%. The differences were significant in both morning milk and evening milk though it appears that the morning milk contributed to most of the total daily milk difference. This may be because the increased mammary cell proliferation occurs at night due to the nightly secretion of the growth hormone (Pala & Savas 2005) and thus, the morning milk is increased mostly due to the 4× milking.

The goat milk in 2× group had a significantly higher fat percentage than that of the 4× group, but the differences between the groups for protein and nonfat solids were not significant (Table 1). Salama *et al.* (2003) compared goats milked once daily (1×) with those milked twice daily (2×) day throughout lactation and reported that 1× group had a significantly higher milk fat percentage than 2× group and the differences for protein and total solids were not significant. Similar results are also reported in cows (Lacy-Hulbert *et al.* 1999) and sheep (McKusick *et al.* 2002). The difference for the percentage of fat could be due to the increased fat concentration as milk yield decreases and differences in milk component synthesis (Salama *et al.* 2003).

The repeated measures analyses of SCS indicated that overall group effects were small ($P > 0.05$) and analyses of the differences between the groups on different test days resulted in similar answers to the χ^2 analyses using a 200 000 SCC/mL cutoff (Table 2). The DMSCC was significant during the 4th and 5th test days and was larger in the 4× group. Milk yield in these test days was also larger for the 4× group than the 2× group. Though the 4× group also produced a larger volume of milk in the previous test days, the 21 days of extra milk removal apparently prevented the increased SCC and the effect persisted through 3rd test day. Increasing milk yield can increase SCC because of the increased risk of infection (Hillerton *et al.* 1995), which in turn decreases milk yield (De Vliegher *et al.* 2005). The milk yield decreased after the high SCC count in the 4× group, and thus, both group milk yields were almost identical during the 6th test day.

Salama *et al.* (2003) reported that application of once daily milking in Murciano–Granadina dairy goats did not have negative effects on udder health compared to milking them twice a day. Dahl *et al.* (2004) used 10 test days and reported significant differences only on the 1st and 3rd test days for SCC when comparing thrice daily (3×) and six times daily (6×) groups of dairy cattle, in favor of the more frequently milked group. Dahl *et al.* (2004) suggested that more frequent milking increases the expression of the prolactin (PRL) hormone and sensitivity to PRL, which increases the number of mammary cells and enhances the immune function. Some reports in dairy cows indicated that milking frequency is inversely related to SCS (Stelwagen & Lacy-Hulbert 1996; Kelly *et al.* 1998; Smith *et al.* 2002). Other studies (Stelwagen *et al.* 1994; Lacy-Hulbert *et al.* 1999; McKusick *et al.* 2002) reported no significant effects of decreased milking frequency on milk SCC. These reports indicate that there is no definite answer for the effects of milking frequency on SCC as they vary greatly.

Increasing milking frequency throughout lactation can increase milk yield dramatically, but the increased labor costs hamper producers' enthusiasm. Milking dairy goats 4× for 21 days increases milk yield throughout lactation without an increase in SCC.

Table 2 χ^2 analysis of DMSCC/mL of goats milked twice/day (2×; $n = 14$) or 4 times/day (4×; $n = 14$) for 21 days of lactation after weaning

Test day	2×		4×		χ^2	Continuity adjusted χ^2	Repeated analysis of SCS
	SCC <200 000	SCC >200 000	SCC <200 000	SCC >200 000			
1	9	5	10	4	0.686	1.000	0.561
2	10	4	11	3	0.662	1.000	0.981
3	7	7	8	6	0.705	1.000	0.894
4	9	5	3	11	0.022	0.056	0.050
5	11	3	5	9	0.022	0.056	0.060
6	8	6	5	9	0.256	0.449	0.160
7	9	5	7	7	0.445	0.703	0.525

The columns represent the number of goats in each treatment that had SCC > or < 200 000 cells/mL of milk on that test day. *P*-values regarding SCC χ^2, continuity adjusted SCC χ^2 and SCS repeated analyses are presented.

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REFERENCES

Akaike H. 1974. A new look at the statistical model identification. *IEEE Transaction on Automatic Control, AC* **19,** 716–723.

Ali AKA, Shook GE. 1980. An optimum transformation for somatic cell concentration in milk. *Journal of Dairy Science* **63,** 487–490.

Bewley J, Palmer RW, Jackson-Smith DB. 2001. Modeling milk production and labor efficiency in modernized Wisconsin dairy herds. *Journal of Dairy Science* **84,** 705–716.

Capuco AV, Ellis SE, Hale SA, Long E, Erdman RA, Zhao X, Paape MJ. 2003. Lactation persistency: insights from mammary cell proliferation studies. *Journal of Animal Science* **81,** 18–31.

Crist WL, Harmon RJ, McAlister AJ. 1997. *Mastitis and its Control.* Cooperative Extension Service, University of Kentucky College of Agriculture, ASC-140, Lexington, KY.

Dahl GE, Wallace RL, Shanks RD, Lueking D. 2004. Hot topic: effects of frequent milking in early lactation on milk yield and udder health. *Journal of Dairy Science* **87,** 882–885.

De Vliegher S, Barkema HW, Stryhn H, Opsomer G, De Kruif A. 2005. Impact of early lactation somatic cell count in heifers on milk yield over the first lactation. *Journal of Dairy Science* **88,** 938–947.

Everitt BS. 1995. The analysis of repeated measures: a practical review with examples. *Statistician* **44,** 113–135.

Hale SA, Capuco AV, Erdman RA. 2003. Milk yield and mammary growth effects due to increased milking frequency during early lactation. *Journal of Dairy Science* **86,** 2061–2070.

Hillerton JE, Shearn MFH, West JGH. 1995. Risk factors for summer mastitis. In: *Proceedings, 3rd International Dairy Federation International Mastitis Seminar, Tel Aviv, Israel*, pp. 88–89. International Dairy Federation, Brussels.

Jennrich RI, Schluchter MD. 1986. Unbalanced repeated-measures models with structured covariance matrices. *Biometrics* **42,** 805–820.

Kelly AL, Reid S, Joyce P, Meaney WJ, Foley J. 1998. Effect of decreased milking frequency of cows in late lactation on milk somatic cell count, polymorphonuclear leucocyte numbers, composition and proteolytic activity. *Journal of Dairy Research* **65,** 365–373.

Knight CH. 1992. Milk yield responses to sequential treatments with recombinant bovine somatotropin and frequent milking in lactating goats. *Journal of Dairy Research* **59,** 115–122.

Knight CH, Wilde CJ. 1987. Mammary growth during lactation: implications for increasing milk yield. *Journal of Dairy Science* **70,** 1991–2000.

Lacy-Hulbert SJ, Woolford MW, Nicholas GD, Prosser CG, Stelwagen K. 1999. Effect of milking frequency and pasture intake on milk yield and composition of late lactation cows. *Journal of Dairy Science* **82,** 1232–1239.

McKusick BC, Thomas DL, Berger YM, Marnet PG. 2002. Effect of milking interval on alveolar versus cisternal milk accumulation and milk production and composition in dairy ewes. *Journal of Dairy Science* **85,** 2197–2206.

Paape MJ, Capuco AV, Lefcourt A, Burvenich C, Miller RH. 1992. Physiological response of dairy cows to milking. In: *Proceedings International Symposium on Prospects for Automatic Milking*, pp. 93–105. EAAP Publications No. 65. PUDOC Scientific Publications, Wageningen.

Pachard VS, Tanni S, Fugun R, Heady J, Gilman C. 1992. Direct microscopic methods for bacterial or somatic cells. In: *Standards Methods for the Examination of Dairy Products*, p. 309. Association of Public Health Observatories, Washington, DC.

Pala A, Savas T. 2005. Persistency within and between lactations in morning, evening and daily test day milk in dairy goats. *Archiv Fur Tierzucht* **48,** 185–193.

Pala A, Savas T. 2006. Relationship between daily, morning, evening and peak yield and persistency in Turkish Saanen goats. *Animal Science Journal* **77,** 532–537.

Salama AAK, Such X, Caja G, Rovai M, Casals R, Albanell E, Marin MP, Marti A. 2003. Effects of once versus twice daily milking throughout lactation on milk yield and milk composition in dairy goats. *Journal of Dairy Science* **86,** 1673–1680.

Schwarz G. 1978. Estimating the dimension of a model. *Annals of Statistics* **6,** 461–464.

Smith JW, Ely LO, Graves WM, Gilson WD. 2002. Effect of milking frequency on DHI performance measures. *Journal of Dairy Science* **85,** 3526–3533.

Statistical Analysis Systems (SAS). 1999. *SAS Onlinedoc*, Version 8. SAS Institute, Cary, NC.

Stefanon B, Colitti M, Gabai G, Knight CH, Wilde CJ. 2002. Mammary apoptosis and lactation persistency in dairy animals. *Journal of Dairy Research* **69,** 37–52.

Stelwagen K, Davis SR, Farr VC, Eichler SJ, Politis I. 1994. Effect of once daily milking and concurrent somatotropin on mammary tight junction permeability and yield of cows. *Journal of Dairy Science* **77,** 2974–3001.

Stelwagen K, Lacy-Hulbert J. 1996. Effect of milking frequency on milk somatic cell count characteristics and mammary secretory cell damage in cows. *American Journal of Veterinary Research* **57,** 902–905.

Waage S, Sviland S, Ødegaard SA. 1998. Identification of risk factors for clinical mastitis in dairy heifers. *Journal of Dairy Science* **81,** 1275–1284.

Wilde CJ, Knight CH. 1989. Metabolic adaptations in mammary gland during the declining phase of lactation. *Journal of Dairy Science* **72,** 1679–1692.

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