Effects of Once Versus Twice Daily Milking Throughout Lactation on Milk Yield and Milk Composition in Dairy Goats

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ABSTRACT

The effects of once (1X) vs. twice (2X) daily milking throughout lactation on milk yield, milk composition, somatic cell count (SCC), and udder health were studied in 32 Murciano-Granadina dairy goats. Goats were assigned at wk 2 of lactation to two treatment groups; once daily milking at 0900 (1X, $n = 17$), or twice daily milking at 0900 and 1700 (2X, $n = 15$). Milk yield was recorded weekly until wk 28, and milk composition and SCC were evaluated for each individual udder half at each milking at wk 2 and 4 of lactation and then, monthly until the end of the experiment. Once daily milking resulted in an 18% reduction in the yield of 4% fat-corrected milk compared to twice daily milking (1.61 vs. 1.95 L/d, respectively). This reduction was more marked from wk 2 to 12 than in mid and late lactation. Response to milking frequency also varied according to parity number where goats of less than four parities suffered more milk yield losses during 1X than older goats. Milk of 1X goats contained higher percentages of total solids (13.6 vs. 12.9%), fat (5.10 vs. 4.62%) and casein (2.57 vs. 2.35%) than milk of 2X goats, but milk protein percentage did not differ between treatments (3.28 vs. 3.20%). Yields of total solids, fat, protein and casein tended to be higher for 2X than 1X. Milk SCC did not differ between treatments. We conclude that application of once daily milking in Murciano-Granadina dairy goats moderately reduced milk yield without negative effects on milk composition and udder health. Losses in milk yield would be reduced if 1X is practiced during mid- or late lactation and in older goats. An increase in labor productivity and a higher farmer's standard of living is also expected.

(**Key words:** once daily milking, milk production, somatic cell count, dairy goat)

Abbreviation key: 1X = once daily milking, 2X = twice daily milking, FIL = feedback inhibitor of lactation, TJ = tight junction.

INTRODUCTION

Number of daily milkings is of great importance in determining milk yield in dairy animals. Once daily milking of dairy cows is practiced in some countries either in early lactation to reduce metabolic stress or in late lactation to improve quality of farming life (Davis et al., 1999). Compared with twice daily milking (2X), once daily milking (1X) reduced milk yield by 7 to 38% in dairy cows (Stelwagen et al., 1994a; Stelwagen and Knight, 1997), 15 to 48% in ewes (Knight et al., 1993; Negrao et al., 2001) and 6 to 35% in dairy goats (Mocquot, 1978; Capote et al., 1999). The wide variation in yield losses during 1X reported by other authors may be due to differences in breed, lactation stage, level of production, duration of 1X milking and individual characteristics.

Bewly et al. (2001) reported that more frequent milking requires more variable costs (labor, utilities, milking supplies, and additional feed costs). In Spain, and other countries where the goat production systems are extensive or semi-extensive, high milking frequency is a major cost for dairy goat farms. Under these conditions, lower milking frequency increases labor productivity and reduces milk storage risks. However, for infrequent milking to be a practical strategy, it should have no long-term deleterious effects on milk yield or milk quality.

Somatic cell count in goat milk has become an important quality index since goat milk was officially defined in the grade A Pasteurized Milk Ordinance in 1989 in the USA (Zeng and Escobar, 1995), and a European regulation (92/46 EEC) to control SCC in goat milk was issued in 1992. Moreover, the relatively low cost and rapidity of SCC determination have resulted in it being widely used as an indicator of milk quality

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and as a management tool to determine the prevalence of IMI in dairy animals. It is well established that SCC in dairy goats is affected by IMI (Zeng and Escobar, 1995), parity number (Sánchez et al., 1999), stage of lactation (Wilson et al., 1995), breed (Sung et al., 1999), level of milk production (Hinckley, 1983), nutritional status and milking method (Salama et al., 2003), and estrus (McDougall and Voermans, 2002). However, there is no information on the effect of milking frequency on SCC in dairy goats.

The objectives of this study were to investigate the effects in lactating Murciano-Granadina goats of 1X vs. 2X throughout lactation on: 1) milk yield and chemical composition, 2) milk SCC and udder health, and 3) secretion of milk and its components at different milking intervals.

MATERIALS AND METHODS

Animals and Management Conditions

Two milking frequencies were studied over 2 consecutive years in a total of 32 Murciano-Granadina dairy goats (17 and 15 goats for the first and second yr, respectively) from the herd of the experimental farm of the S1GCE (Servei de Granges i Camps Experimentals) of the Universitat Autònoma of Barcelona. Goats were divided into two groups and milked from parturition to wk 42 of lactation, when they were dried off. Kids were separated from their dams within 8 h of birth and reared on milk substitutes and all goats were milked twice daily until wk 2. In both years, groups were balanced with respect to parity, milk yield and SCC; baseline measurements were recorded on two consecutive days in wk 2 of lactation. Goat parities were: first, 5; second, 9; third, 7; and, fourth or more, 11. Treatments were randomly applied to the groups from wk 2 to dry-off, and were: goats milked once daily at 0900 (1X; $n = 9$ and 8, for the first and second yr, respectively), and goats milked twice daily at 0900 and 1700 (2X; $n = 8$ and 7, for the first and second yr, respectively). New goats were used for both treatments in the 2nd yr. Both groups grazed on natural pastures for 6 h daily and were supplemented with concentrate in the milking parlor (1.53 Mcal NE_L/kg, 16% CP, as fed) at a flat rate of 0.5 to 1 kg/doe per day according to lactation stage, and with 0.5 kg/doe alfalfa and 0.5 kg/doe alfalfa pellets in the shelter.

Goats were milked in a double-12 stall parallel milking parlor (Westfalia Landtechnik, Granollers, Spain) equipped with recording jars (2 L $\pm$ 5%) and low-line milk pipeline. Milking was performed at a vacuum pressure of 42 kPa, a pulsation rate of 90 pulses/min, and a pulsation ratio of 66% according to the milking parameters used in the breed (Peris et al., 1996). Milking

routine included machine milking, machine stripping before cluster removal, and teat dipping in an iodine solution (P3-cide plus, Henkel Hygiene, Barcelona, Spain).

Sample Collection, Analysis, and Measurements

Milk recording and sampling were done from wk 2 to 28 of lactation. Milk yield of individual goats was recorded weekly at every milking by using the recording jars in the milking parlor. Milk samples were taken from each udder half after each milking for analysis of composition, SCC and bacteriology at wk 2 and 4 of lactation and then monthly until wk 28. Milk yield was also recorded by udder half on the sampling days. Yield of FCM in 300 DIM was estimated according to Thomas et al. (2000).

Milk yield and milk composition recording at each milking (a.m. and p.m.) allowed the study of the secretion of milk and milk components during the different periods of milk accumulation (8 and 16 h for 2X goats, and 24 h for 1X goats).

For analysis of milk composition, a sample of approximately 100 ml was collected and preserved with K₂Cr₂O₇ (0.3 g/L) at 4°C. Unhomogenized milk samples were analyzed with a near infrared spectrometer (Technicon InfraAlyzer- 450, Bran+Luebbe SL, Norderstedt, Germany), using the method of Albanell et al. (1999), for content of TS, fat, CP ($N \times 6.38$), and CN.

For SCC, a sample of approximately 50 ml was placed in a plastic vial, preserved with an anti-microbial tablet (Bronopol, Broad Spectrum Micro-tabs II, D&F Control Systems Inc., San Ramon, CA) and kept at 4°C until analysis. The SCC was determined in the Dairy Herd Improvement laboratory of Catalonia (Allic, Cabrils, Barcelona, Spain) using an automatic cell counter (Fossomatic 250, Foss-Electric, Hillerød, Denmark). Routine bacteriological culture was performed on aseptic milk samples obtained from each udder half before milking. An infection was assumed to have occurred if five or more similar cfu were present in the incubated sample of milk.

Statistical Analysis

Data from one goat in each treatment were excluded from the statistical analysis because of an IMI. Data were analyzed by the PROC MIXED for repeated measurements of SAS (SAS 8.1; SAS Inst. Inc., Cary, NC). The statistical mixed model included the fixed effects of milking frequency, year, parity, prolificacy, and wk of lactation; the random effects of the animal and half udder nested within animal; and the interactions of milking frequency to the factors of year, parity, and wk

of lactation; and the residual effect. Random effect of udder half nested within animal was excluded from the model in the analysis of milk yield. For data analysis of milk secretion during different milking intervals, the fixed effect of milking frequency was replaced by the fixed effect of milking interval (8 and 16 h corresponded to 2X goats and 24h corresponded to 1X goats). Parity number was grouped into three categories corresponding to first and second parities ($n = 14$), third parity ($n = 7$), and fourth or more parities ($n = 9$). Goats of first and second parities were grouped together because they had in many cases the same age. The prolificacy effect corresponded to two levels defined as single or multiple kids. Logarithmic transformations ($\log_{10}$) of SCC values were used in statistical analysis. Data from wk 2 were used as a covariate to correct for differences in initial values when necessary. Significance was declared as $P < 0.05$ unless otherwise indicated.

RESULTS AND DISCUSSION

Milk Yield

Year significantly affected FCM yield throughout lactation and milk yield during midlactation (wk 13 to 28), but interaction between yr and treatment was not significant.

As shown in Table 1 and Figure 1, 1X resulted in a 18% significant reduction in FCM daily yield compared to 2X (-0.34 L/d) during the experimental period. This reduction was greater than the values previously reported in Canarian goats (6%) by Capote et al. (1999) but smaller than in Alpine goats (36%) by Mocquot (1978) for overall lactation. Moreover, Wilde and Knight (1990) reported a loss of 26% in Saanen goats in a short-term experiment in early lactation, while losses ranged between 6 and 7% in Damascus goats during middle and late lactation, respectively (Papachristoforou et al., 1982). The increase in the concentration of the putative feedback inhibitor of lactation (FIL), synthesized by the mammary gland (Wilde et al., 1995) and the intramammary pressure (Peaker, 1980) may cause the decrease in milk synthesis in 1X goats. Also, the loss of tight junction (TJ) integrity after about 20 h of milk accumulation may play a role in the milk yield losses in 1X (Stelwagen et al., 1994b). When less frequent milking is prolonged, the decrease in milk yield is sustained by sequential developmental adaptations, initially as a down-regulation of cellular differentiation (Wilde et al., 1987) and later as a net loss in mammary cell number via apoptosis (Li et al., 1999).

The reduction in 4% FCM yield due to 1X was more marked during the first 3 mo of lactation (19%) than in late lactation (14%; $P < 0.08$). In accordance, Stelwagen and Knight (1997) reported that milk yield losses

Table 1. Effect of milking frequency on milk yield, chemical composition, and somatic cell count in dairy goats.¹

Dependent variable	Milking frequency ²		SED
	1X (n = 16)	2X (n = 14)	
Milk yield			
wk 2 to 12, L/d	1.50 ^b	1.89 ^a	0.16
wk 13 to 28, L/d	1.34 ^b	1.61 ^a	0.20
wk 2 to 28, L/d	1.43 ^b	1.76 ^a	0.19
Estimated 300 DIM, L	460 ^b	531 ^a	31
FCM ³			
wk 2 to 12, L/d	1.70 ^b	2.09 ^a	0.17
wk 13 to 28, L/d	1.55	1.81	0.17
wk 2 to 28, L/d	1.61 ^b	1.95 ^a	0.15
Estimated 300 DIM, L	504 ^b	590 ^a	28
Milk components			
Total solids, %	13.6 ^a	12.9 ^b	0.2
Total solids, g/d	198.0 ^b	225.8 ^a	20.5
Fat, %	5.10 ^a	4.62 ^b	0.21
Fat, g/d	69.1	81.0	7.1
Protein, %	3.28	3.20	0.08
Protein, g/d	45.2	54.4	5.3
Casein, %	2.57 ^a	2.35 ^b	0.07
Casein, g/d	33.8	40.6	4.1
SCC, $\log_{10}/\text{ml}$	5.95	5.86	0.07
SCC, $\log_{10}/\text{d}$	8.77	8.76	0.07

¹Data are least square means and standard errors of the difference ($n = 30$).

²Once (1X) or twice (2X) daily milking.

³4% FCM = 0.4 (L of milk) + 15 (kg of fat).

^{a,b}Means with different superscripts within the same row are different ($P < 0.05$).

Figure 1. Milk production of dairy goats milked once (●; $n = 16$) or twice (○; $n = 14$) daily. Values are means with SEM indicated by vertical bars.

Table 2. Effect of milking frequency according to parity number on fat corrected milk yield, chemical composition, and somatic cell count in dairy goats.¹

Dependent variable	Parity category ³	Milking frequency ²		SED
		1X	2X	
FCM ⁴ , L/d	1	1.52 ^b	2.43 ^a	0.220
	2	1.38 ^b	1.79 ^a	0.210
	3	1.68	1.87	0.172
Milk total solids, %	1	13.46 ^a	12.36 ^b	0.301
	2	14.08 ^a	13.45 ^b	0.311
	3	13.52	13.01	0.264
Milk fat, %	1	5.33 ^a	3.95 ^b	0.286
	2	5.72	5.20	0.282
	3	5.15	4.81	0.243
Milk protein, %	1	3.22	3.14	0.090
	2	3.36	3.27	0.094
	3	3.40 ^a	3.15 ^b	0.078
Milk casein, %	1	2.39	2.40	0.086
	2	2.59 ^a	2.25 ^b	0.084
	3	2.75 ^a	2.38 ^b	0.072
Milk SCC, log ₁₀ /ml	1	5.47	5.31	0.175
	2	5.87	5.86	0.077
	3	6.51	6.38	0.112

¹Data are least square means and standard errors of the difference (n = 30).

²Once (1X) or twice (2X) daily milking.

³Parity number was grouped into 3 categories: 1 (1st and 2nd, n = 14), 2 (3rd, n = 7), and 3 (4th or more, n = 9).

⁴4%-FCM = 0.4 (L of milk) + 15 (kg of fat).

^{a,b}Means with different superscripts within the same row are different ($P < 0.05$).

in dairy cow during 1X in late lactation were lower than in early lactation. McKusick et al. (2002) reported no differences in milk yield between milking every 16 h compared with every 12 h during mid- to late-lactation in dairy ewes, but milk yield was reduced after more than 16 h of milk accumulation in a short term experiment conducted in the same flock.

Mammary gland cisternal capacity appears to be a constraint in cows milked 1X (Knight and Dewhurst, 1994) and cisternal milk proportion increases during the course of a normal lactation in cows (Dewhurst and Knight, 1993) and in dairy ewes (Rovai et al., 2002). Our data also suggest that the cisternal capacity is critical in dairy goats during early lactation when higher levels of milk are produced, while in late lactation (descending phase), the cisterns may have been able to better accommodate the level of milk production, resulting in lesser effect of FIL, and thus lower milk yield losses as previously indicated in Canarian goats that have large cisterns (Capote et al., 1999).

The reduction in FCM yield during 1X varied also according to parity number: 38% in first and second parities, 22% in third parity, and 11% in more than third parity (Table 2). Primiparous cows are reported to have a proportionately greater response to increased milking frequency than multiparous cows (DePeters et al., 1985). As parity number increased, cistern capacity increased in cows (Dewhurst and Knight, 1993) and

dairy ewes (Rovai et al., 2002). Increased cistern capacity might reduce the negative effect of FIL on milk secretion when milk accumulates in the alveoli, thereby decreasing the positive response to 2X in older animals. Positive correlations between milk yield and proportion or volume of cisternal milk in dairy cows milked 1X were reported (Stelwagen and Knight, 1997).

There is no documentation on the effects of 1X on lactation persistency in dairy goats. Both 1X and 2X groups had a maximum yield of 1.75 ± 0.13 and 2.00 ± 0.10 L ($P < 0.01$) during wk 4 and 5 of lactation, respectively (Figure 1). Persistency of lactation as defined recently by Grossman et al. (1999) is the number of days during which the level of peak yield is maintained. Applying this definition, 1X goats persisted for 21 ± 3 d, which was lower ($P < 0.01$) than in 2X goats (40 ± 5 d). By the end of the study (196 DIM), goats were producing approximately 83 and 79% of their peak production for 1X and 2X, respectively, which was higher than the 30% recorded by dairy cows at a similar stage of lactation (Lacy-Hulbert et al., 1999). Milking frequency did not affect lactation length in any of the studied treatments and all goats in this experiment were dried-off routinely for 300 DIM on average. Total 4% FCM for 300 DIM was 14.6% lower for 1X than for 2X (Table 1). Dairy ewes milked every 12 h had similar lactation length and milk yield than did ewes milked every 16 h (McKusick et al., 2002).

We have to take into account that goats used in this study came from a herd initially bred under 2X milking conditions. The same herd is at present managed under 1X milking and the goats yielded more than 2.0 L of 4% FCM daily (González et al., 2002; Salama et al., 2003), which is similar to the production of 2X goats in this experiment. Indeed, the possibility exists that during breeding under 1X milking conditions goats may become more tolerant and adapted to less frequent milking and, consequently, losses in milk yield for 1X would be reduced.

Milk Composition

Year significantly affected yield and percentage of milk components with the exception of protein percentage ($P = 0.619$) and CN percentage ($P = 0.195$). A tendency was also observed for CN yield ($P = 0.096$), but interaction between yr and treatment was not significant.

Milk of 1X goats was more concentrated than milk of 2X goats and had higher concentrations of TS (+6%), fat (+10%) and CN (+9%), as indicated in Table 1. This could be expected as a consequence of the concentration of milk components when milk yield decreased as well as a result of changes occurred in the synthesis of milk components. In dairy cows, concentration of fat, protein and CN increased as a result of 1X for short periods at late lactation (Lacy-Hulbert et al., 1999) or during an entire lactation (Holmes et al., 1992). In contrast, as milking interval increased, milk fat content decreased while milk protein content increased in a short term experiment in dairy ewes in which oxytocin was used to remove alveolar milk (McKusick et al., 2002). The same authors observed that ewes milked every 12 h had similar milk production, milk fat and protein percentages and yields than did ewes milked every 16 h, in a trial conducted during mid-lactation (McKusick et al., 2002). Changes in fat concentration in milk may be related to differing regulatory mechanisms for secretion of milk fat globules relative to the components in the aqueous phase of milk and to the transfer between alveolar and cisternal compartments (Davis et al., 1999; McKusick et al., 2002).

Percentage of milk protein did not vary significantly between treatment groups ($P = 0.260$) in our results, as reported in dairy ewes milked every 12 h vs. 16 h (McKusick et al., 2002). Total protein in milk is the result of the proteins synthesized in the mammary gland and the serum proteins entering the milk when mammary TJ are disrupted. Casein does not move through leaky mammary TJ, presumably because of the large size of their micelles (Stelwagen et al., 1998). Thus, while milk volume was lower with 1X, CN synthe-

sized remained and became more concentrated in the milk. Nevertheless, 1X milking is often associated with increased plasmin and plasminogen activities (Stelwagen et al., 1994c) which may lead to the breakdown of β -CN to γ -CN without changes in total CN. Moreover, mammals have the ability to provide milk that is consistent in protein concentration regardless of the most environmental stresses (Cowie and Tindal, 1971).

Daily yield of TS significantly decreased by 12% in 1X goats, and daily yields of fat ($P = 0.073$), protein ($P = 0.086$) and CN ($P = 0.098$) tended to be reduced by 15, 17 and 16%, respectively, in agreement with the significant reduction in the daily milk volume (19%).

Milk SCC and Udder Health

SCC is an important index for milk quality and in many countries it is used as a criterion for milk payment to producers, penalizing goat milk that contains more than 1×10^6 cells/ml. However, there is no data on the effect of 1X on milk SCC in dairy goats. No significant effects were detected for yr or interaction between yr and treatment on milk SCC. Moreover, SCC did not differ ($P = 0.190$) between treatments (Table 1) and the geometric means of SCC throughout lactation were 979 and 917×10^3 cells/ml for 1X and 2X, respectively. However, these values were greater than previously reported by Salama et al. (2003) in the same conditions.

Available information on SCC in cows during 1X is contradictory. In agreement with our results, both Stelwagen et al. (1994a) and Lacy-Hulbert et al. (1999) indicated no significant effect of 1X on milk SCC at late lactation. In contrast, milking dairy cows 1X throughout lactation (Holmes et al., 1992) or for short periods at early (Stelwagen and Lacy-Hulbert, 1996) or late (Kelly et al., 1998) lactation increased SCC. This increase may be due in part to a concentration effect as milk yield decreased during 1X (Kamote et al., 1994) and in part to the impairment of the TJ barrier facilitating a paracellular influx of somatic cells into the milk without damage to the mammary secretory cells (Stelwagen and Lacy-Hulbert, 1996). Kamote et al. (1994) suggested that if the initial SCC level is low, 1X results in a small increase in SCC. Goats in this experiment started lactation with relatively high SCC but SCC did not increase significantly during 1X. Dairy ewes milked every 12 h had similar SCC in milk than did ewes milked every 16 h (McKusick et al., 2002).

Bacteriological culture revealed that one half udder of one goat in each treatment had an IMI. Clinical mastitis was not observed in any of the studied goats suggesting that 1X had no deleterious effect on udder health. Similarly, udders of dairy cows milked 1X throughout lactation did not suffer any mastitis problems, although milk

Table 3. Secretion rate of milk and its components, and milk composition according to milking interval in dairy goats milked at different milking frequencies.¹

Dependent variable	Milking frequency ²			SEM
	2X		1X	
	8 h	16 h	24 h	
Milk, ml/h	80 ^a	71 ^b	58 ^c	3
Milk fat, g/h	4.34 ^a	2.96 ^b	2.94 ^b	0.14
Milk fat, %	5.43 ^a	4.14 ^b	5.11 ^a	0.21
Milk protein, g/h	2.41 ^a	2.30 ^a	1.89 ^b	0.09
Milk protein, %	3.04 ^b	3.23 ^a	3.29 ^a	0.07
Milk casein, g/h	1.81 ^a	1.64 ^b	1.48 ^b	0.06
Milk casein, %	2.26 ^c	2.33 ^b	2.56 ^a	0.05
Milk SCC, log ₁₀ /ml	6.06 ^a	5.69 ^b	5.98 ^a	0.06

¹Data are least square means and standard error of the mean (n = 30).

²Once (1X) or twice (2X) daily milking.

^{a,b,c}Means with different superscripts within the same row are different ($P < 0.05$).

with higher SCC was produced, when compared to 2X cows (Holmes et al., 1992).

Overall means of milk SCC increased as lactation stage advanced ($P < 0.01$) and milk from the 4th mo of lactation or later exceed the limit of 1×10^6 cells/ml. These results agree with the increase in SCC in goats as lactation advance (Wilson et al., 1995; Salama et al., 2003). The reason for this rise in SCC as lactation progresses may be due to both a concentration effect as less milk is produced and to the presence of chemostatic cytokines that draw polymorphonuclear leukocytes into milk in higher concentrations during late lactation (Manlongat et al., 1998). Also, SCC significantly increased ($P < 0.001$) as parity number increased (Table 2) as previously reported by Sánchez et al. (1999) in dairy goats. This increase could be attributed to the increased prevalence of bacteria in the mammary gland of older animals, or to the cumulative stress of the mammary tissue from several pregnancies and lactations (Boscós et al., 1996).

Secretion of Milk and Its Components

Hourly milk secretion rate had the greatest value for the 8-h milking interval and significantly decreased as time after milking increased (Table 3). The reduction was more marked for the 16 to 24-h interval (–18%) than for the 8 to 16-h interval (–11%) indicating a secretion rate saturation effect with time, as reported in goats (Peaker and Blatchford, 1988), dairy ewes (McKusick et al., 2002) and cows (Knight et al., 1994; Davis et al., 1998; Ayadi et al., 2003). Hourly milk secretion rates in our results were greater than those calculated from data reported (52 to 54 g/h) by McKusick et al. (2002) in dairy ewes milked every 12 h or every 16 h.

Fat secretion rate was greater for the 8-h milking interval, but the values did not differ for the 16 and 24-h milking intervals (Table 3). Alveolar milk is richer in fat content than cisternal milk, which may explain the higher fat content during the 8-h period after milking as compared with 16 and 24 h after milking and confirms the importance of milk ejection during milking for recuperation of alveolar milk that is rich in TS (McKusick et al., 2002). However, fat percentage did not differ between 8 and 24 h after milking. Despite the milk yield and specie differences, hourly fat secretion rates in our results for the 16 and 24-h milking intervals were also similar to those calculated (2.7 to 2.9 g/h) from McKusick et al. (2002) in dairy ewes milked every 12 or 16 h. This may be a result of the plateau observed in the transfer of fat from alveolar milk to cisternal milk during the longer milking intervals, resulting in an accumulation of fat in the alveolar compartment (McKusick et al., 2002).

Protein secretion rate was significantly greater for the 8 h after milking, but the value did not differ for the 16-h milking interval (Table 3). The lowest secretion rate of milk protein was observed at the 24-h milking interval. Hourly milk protein secretion rates in our results were smaller than the value calculated from McKusick et al. (2002) in dairy ewes milked every 12 or 16 h (2.5 g/h). Protein percentage increased as time after milking increased (Table 3), indicating a significant concentration effect in the milk accumulated in the udder after a 16- or 24-h milking interval, as discussed above. Regarding milk CN, secretion rate was decreased as milking interval increased and the concentration effect was clearer when CN percentage increased significantly according to time after milking (Table 3).

Milk at 8 h had the highest SCC (Table 3), which is consistent with reports of lower SCC in fore-stripped milk compared to stripped milk (Gonzalo et al., 1993) and milk SCC according to milking interval (McKusick et al., 2002) in dairy ewes. At 16 h, as cisternal milk percentage increased, milk SCC significantly decreased. However, milk SCC increased at 24 h, which may be associated with leaky TJ between mammary epithelial cells occurred after 20 h in dairy goats (Stelwagen et al., 1994b) facilitating the paracellular influx of somatic cells into milk (Stelwagen and Lacy-Hulbert, 1996). Therefore, if milk quality in dairy goats was based on SCC, the 16-h interval would appear to be the most appropriate interval to produce milk with high quality. Milking 3 times every 48 h (16-h interval between milking) may also be a better alternative to 1X, and McKusick et al. (2002) showed that milking East Friesian ewes every 16 h did not affect milk yield, milk

components, or SCC as compared with twice daily milking at an interval of 12 h.

CONCLUSIONS

Once daily milking in Murciano-Granadina dairy goats moderately reduced milk yield without negative effects on milk composition and udder health. Since milk of 1X goats contained more fat without significant increases in SCC, reduced revenue due to lower milk yield could be partially offset if payment for milk was based on milk quality. Once daily milking for dairy goats in early lactation and for dairy goats of less than four parities may not be a suitable management decision because of higher losses. However, the reduction in total labor when once daily milking is adopted permits farmers more time to devote to other farming practices and/or to other activities off the farm, improving their productivity and standard of life.

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