Short Communication: Correlations Between Udder Morphology, Milk Yield, and Milking Ability with Different Milking Frequencies in Dairy Goats

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ABSTRACT

Tinerfeña breed goats were assigned to 2 experimental herds and milked once ($n = 28$) or twice ($n = 24$) daily to study correlations between udder morphology, milk yield, and milking ability during the middle stage of the first lactation. Pearson correlation coefficients were significantly higher between yield and measures of udder globulousness (udder volume, $r = 0.79$ and $r = 0.59$; perimeter of insertion of the udder, $r = 0.47$ and $r = 0.37$; distance between teats, $r = 0.77$ and $r = 0.28$, for goats milked once and twice daily, respectively) than for length parameters (cistern floor distance, $r = 0.40$ and $r = -0.29$; udder depth, $r = -0.20$ and $r = 0.20$). The globulousness of the udder was correlated with easier milking ability, as shown by milk fractioning ($r = 0.49$ to 0.70) and milk flow measures ($r = 0.32$ to 0.49). The results showed that the globulousness of the udder is more important than length measurements in assessing milk yield and milking ability.

Key words: udder morphology, milk yield, milk flow, milk fractioning

In zones where high milk producing animals are used for commercial purposes, milking is normally done twice daily; the efficiency of this is corroborated in studies that demonstrate a yield increase when compared with the routine of milking once daily. Once-daily milking reduced milk yield by 6 to 35% when compared with twice-daily milking (Capote et al., 1999; Salama et al., 2003). The reduction in labor when once-daily milking is adopted permits farmers more time to devote to other farm practices or activities, improving their productivity and standard of life (Salama et al., 2003). The frequency of milking also affects udder conformation, milk fractioning, and milk flow

rate (Capote et al., 2000). A relationship between morphological udder measures and milk production has been noted in goats, although diverse criteria exist. Mavrogenis et al. (1989) found a low correlation between production levels and udder measures, whereas others found higher and significant correlations (Linzell, 1966; Peris, 1994). Udder morphology, milk fractioning, and milk flow rate measures affected the milking ability of dairy goats, and there was a high correlation between cisternal milk volume and the cisternal area (Salama et al., 2004). On the other hand, an adequate milk flow reduced the operation time, and the rate of milk release was correlated with morphological udder measures in the Murciano-Granadina goat (Peris et al., 1996). The economic indications of these measures in farm production justify the undertaking of studies to assess the correlation between udder morphology, milk production, and milking ability measures.

During the first lactation in 52 Tinerfeña dairy goats, 2 milking frequencies were studied. The herd was located at the experimental farm of the ICIA (Instituto Canario de Investigaciones Agrarias, Tenerife, Spain). Goats were randomly allotted to 2 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. Treatments were as follows: goats milked once daily at 0900 h ($n = 28$), and goats milked twice daily at 0900 and 1700 h ($n = 24$). The animals were fed according to Institute National de la Recherche Agronomique (Paris, France) recommendations (Jarrige, 1990). Goats were milked in a double 12-stall parallel milking parlor (Alfa-Laval, Madrid, Spain) equipped with recording jars ($4 \text{ L} \pm 5\%$) and a 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% in accordance with Capote et al. (2000). The milking routine included machine milking, machine stripping before cluster removal, and teat dipping in an iodine solution (P3-cide plus; Henkel Hygiene, Barcelona, Spain). Milk yield, udder morphology measurements, milk fractioning,

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Table 1. Descriptive statistics (mean $\pm$ SD) for udder morphology measures, milk yield, milk fractioning, and milk flow in Tinerfeña dairy goats milked once or twice daily

	Milking frequency	
	Once daily	Twice daily
Milk yield (L/d)	1.88 $\pm$ 0.49	2.00 $\pm$ 0.40
Machine milk (L/d)	1.51 $\pm$ 0.38	1.44 $\pm$ 0.40
Machine stripping milk (L/d)	0.37 $\pm$ 0.15	0.58 $\pm$ 0.12
Residual milk (L/d)	0.29 $\pm$ 0.11	0.11 $\pm$ 0.08
Milking time (s)	102 $\pm$ 36	70 $\pm$ 25
Average flow rate (L/min)	1.00 $\pm$ 0.32	0.88 $\pm$ 0.24
Maximum flow rate during first minute (L/min)	2.34 $\pm$ 0.57	2.54 $\pm$ 0.76
Time at maximum flow rate (s)	19 $\pm$ 12	16 $\pm$ 10
Volume during first minute (L)	1.06 $\pm$ 0.32	0.82 $\pm$ 0.23
Udder volume (L)	3.97 $\pm$ 0.12	3.35 $\pm$ 0.11
Perimeter of insertion of the udder (cm)	43.10 $\pm$ 0.90	42.20 $\pm$ 1.00
Distance between teats (cm)	23.30 $\pm$ 0.50	21.50 $\pm$ 0.40
Udder depth (cm)	21.40 $\pm$ 0.40	18.20 $\pm$ 0.50
Cistern-floor distance (cm)	23.00 $\pm$ 0.50	24.30 $\pm$ 0.50

and kinetic data were recorded during 5 d in midlactation (21 wk). The milk yield was measured by using recording jars in the milking parlor. Milk fractioning was measured according to the method used by Le Mens (1978), recording machine milk, machine stripping milk, and residual milk. Milk emission (flow rate, volume, milking time) was evaluated according to Ricordeau et al. (1963), measuring the time needed for the maximum flow per minute, the volume of milk in the first minute, mean flow rate, and maximum flow in the first minute. The following udder morphology measures were taken just before milking: udder volume (measured by water displacement), perimeter of insertion of the udder (measured with a flexible tape), cistern-floor distance (measured with a rigid tape), distance between sphincters of the teats (measured with a rigid tape), and udder depth, as the difference in distance between the udder floor and the cistern floor (measured with a rigid tape; López et al., 1999).

Pearson correlation coefficients between measures were calculated using the SPSS statistics package (v.11.0, SPSS, Inc., Chicago, IL).

Table 1 shows descriptive statistics for all measures. Milk yield, udder volume, perimeter of insertion of the udder, and distance between teats had positive and significant correlations with once-daily milking (Table 2), but only the udder volume was significant for twice-daily milking (Table 3). The correlation for distance between teats with milk yield was reported previously (Peris, 1994; Capote et al., 2000). These results indicated that milk yield was more related to udder morphology in once-daily milking than in twice-daily milking. Thus, udder morphology must be taken more into account in once- than in twice-daily milking. No correlation was found between cistern-floor distance and milk yield for either milking frequency, which may indicate a greater importance of the globulosity of the udder (the balance between the horizontal and

Table 2. Correlations among udder morphology measures and milk yield, milk fractioning, and milk flow parameters in Tinerfeña dairy goats milked once daily

	Udder volume	Perimeter of insertion of the udder	Distance between teats	Udder depth	Cistern-floor distance
Milk yield	0.79***	0.47*	0.77***	0.40*	-0.20
Machine milk	0.62**	0.49*	0.08	-0.03	0.24
Machine stripping milk	0.32	0.15	0.42*	0.16	-0.01
Residual milk	0.18	0.26	0.68***	0.16	0.07
Milking time	0.39	0.49	0.26	0.17	0.06
Average flow rate	-0.05	0.02	-0.16	0.10	0.01
Maximum flow rate during first minute	0.14	0.28	-0.18	0.19	0.03
Time at maximum flow rate	-0.07	-0.01	0.07	0.13	-0.29
Volume during first minute	0.06	0.13	-0.01	0.16	-0.08

* $P < 0.05$; ** $P < 0.01$; *** $P < 0.001$.

Table 3. Correlations between udder morphology measures and milk yield, milk fractioning, and milk flow parameters in Tinerfeña dairy goats milked twice daily

	Udder volume	Perimeter of insertion of the udder	Distance between teats	Udder depth	Cistern-floor distance
Milk yield	0.59**	0.37	0.28	-0.29	0.20
Machine milk	0.70***	0.58**	0.47*	-0.25	0.24
Machine stripping milk	0.36	0.03	0.41*	0.12	-0.27
Residual milk	-0.07	-0.26	0.28	0.12	-0.54**
Milking time	0.36	0.32	0.25	0.21	0.23
Average flow rate	0.10	0.05	-0.06	-0.12	-0.10
Maximum flow rate during first minute	-0.02	0.23	-0.07	0.17	-0.13
Time at maximum flow rate	-0.02	0.01	0.08	-0.26	0.07
Volume during first minute	0.52*	0.46*	0.27	0.15	0.01

* $P < 0.05$; ** $P < 0.01$; *** $P < 0.001$.

vertical diameters) compared with length parameters. In contrast, Peris (1994) observed a negative correlation between milk production and teat-floor distance in Murciano-Granadina dairy goats. The teats of this breed are located in the ventral portion of the udder, but teat placement is more variable in Tinerfeña goats (Capote et al., 2000); thus, cistern-floor distance measurement is more adequate for measuring the drop of the udder.

Udder volume and the perimeter of insertion of the udder were significantly correlated with machine milk, and no significant correlation was observed in machine stripping milk for either milking frequency (Tables 2 and 3). High correlation between milk yield and machine milk has been reported (Peris, 1994; Capote et al., 2000). No significant correlation was detected between udder depth and cistern-floor distance with machine milk, and this may indicate a greater importance of the globulousness of the udder compared with length parameters. The only significant residual milk correlations found were a positive one between the distance between the teats of the goats milked once a day ($r = 0.68$, Table 2) and a negative one with the cistern floor distance in goats milked twice daily ($r = -0.54$, Table 3). The absence of significant correlations between residual milk and other udder measures, together with those of milk yield, as already observed by Capote et al. (2000), impedes the establishment of a solid relationship between the residual milk and morphological parameters of the udder.

No correlations were observed in kinetic parameters except between volume of milk during first minute with udder volume and with perimeter of insertion of the udder in goats milked twice daily (Table 3). This could be explained by the fact that the udder volume of the goats milked once daily was greater than those milked twice daily (Table 1), supporting the results of Caja et al. (1999) and Capote et al. (1999).

In conclusion, milk yield in Tinerfeña goats was more correlated to udder morphology in once-daily milking than with twice-daily milking. Milk kinetic parameters were poorly correlated with udder morphology measurements. The results showed greater importance of the globulousness of the udder than udder length measures with regard to milk yield and milking ability.

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