Machine milking ability and milk composition of some imported dairy goat breeds and some crosses in Greece

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ABSTRACT: A random sample of 40 goats was used to study the partitioning, yield and composition of milk: 8 of Saanen breed (S), 8 of Damascus breed (D), 8 crossbreds Saanen × Local Greek goat (S × L), 8 backcrosses Saanen × Local Greek goat {(S × L) × S} and 8 crossbreds Saanen × Alpine (S × A). Four dams of each genotype were of the first and four of the second parity. Goats were milked twice daily (8:00, 18:00 h) in a 1 × 12 side by side milking parlour with 6 milking units. Milk yield and milk fractions (machine milk, machine stripped milk and hand stripped milk) were recorded twice daily each 14 days (from 7^{th}–8^{th} to 29^{th} week of lactation). Milk composition was examined once a month separately for morning and afternoon samples. The ponderable mean was used for the calculation of milk fat, protein and lactose percentage. The results of the experiment showed that milk partitioning in purebred and crossbred goats ranged on satisfactory levels (machine milk – MM: morning 69.8–81.6%, afternoon 66.2–77.4%; machine stripping milk – MSM: morning 12.2–19.3%, afternoon 19.2–23.4%; hand stripping milk – HSM: morning 6.1–10.9%, afternoon 5.4–11.9%; total machine milk – TMM: morning 89–94.6%, afternoon 88–94.6%). The effect of breed (crossbred) was found to be significant for all milk fractions (ml and %, $P < 0.001$ and $P < 0.05$, respectively). The effect of parity was significant except for MSM (%) and HSM (%). The effect of lactation stage (control day) and the animals was also found to be significant ($P < 0.001$). The fat percentage of S, D, S × L, S × A and (S × L) × L was 3.82, 5.1, 4.8, 3.88 and 3.95%, respectively ($P < 0.001$). Protein percentage ranged from 3.1 to 3.6% in the different genotypes ($P < 0.001$) while lactose percentage was from 4.51 to 4.66%. In conclusion it may be said that imported dairy goat breeds and different crosses with local Greek breed are characterized by good milkability. So the best technique of machine milking is the "routine" milking without applying hand stripping.

Keywords: milking ability; machine milking; milk partitioning; goats; crossbreds

The goat sector has an important position in Greek agriculture contributing 15% to the total output of country's animal production. The total goat population in Greece currently numbers around 5.3 million animals (Faostat, 2003). A major part of this number (above 70%) consists of the local goat breed – Capra Prisca type, ~0.1% are purebred goats of imported dairy breeds (Saanen, Alpine, Damascus) and a considerable portion (above 25%) is crosses between imported breeds and local Greek breed (Zygoyiannis and Katsaounis, 1992).

The traditional technique of milking (hand milking) that is applied on the majority of goat farms of the country is a strongly limiting factor as regards the labour efficiency and the living standard of farmers (Sinapis and Thessalos, 1999). On the other hand, there is a negative impact on the quality of produced milk (higher somatic cells and bacterial colonies) and as a consequence on its products. Machine milking offers a good solution in this respect.

Machine milkability is an important factor that influences the milking efficiency of a dairy breed and consequently the living standard of farmers. It is generally accepted that goats have a good milkability but some of them are harder to be milked having a higher proportion of machine stripped milk and residual milk. Milk partitioning and residual milk are factors that are correlated with milkability (Peris et al., 1996).

Until now the studies have reported different values for milk fractions because the influence of the ease of milking can be considerable (Caja et al., 1999). The machine milking ability of some dairy goat breeds and crosses between high yielding and local breeds have not been studied sufficiently.

The aim of this study was to determine partitioning, yield and composition of milk in some imported dairy goat breeds and some crosses between them and the local Greek goat breed during machine milking.

MATERIAL AND METHODS

The experiment was carried out in the period May – August 2001 on the Thessaloniki TEI farm by random use of 40 goats: 8 of Saanen breed (S), 8 of Damascus breed (D), 8 crossbreds of F_1 Saanen × Local Greek breed (S × L), 8 crossbreds of F_1 Saanen × Alpine (S × A) and 8 crossbreds of F_2 Saanen × Local Greek breed (S × L) × S. Four dams of each genotype were of the first and four of the second parity. The prolificacy of goats ranged from 1.5 to 1.8. During the experimental period 1 dam (of S breed) was removed from the experiment because of mastitis. Thus the experimental results were derived by the data processing of 39 animals. The animals were kept indoors all the year. Their daily ration was composed of 1.5 kg concentrated feed (pellets) given in the milking parlour (0.75 kg on the morning and 0.75 kg on the afternoon milking) and 1.2 kg lucerne hay given in the stable (daily intake of 23.4 MJ ME and 310 g CP). The kidding season was in the period of 1–15 March. The experiment began after the weaning of kids (7–8 weeks).

Goats were milked in a 1 × 12 side by side milking parlour of Casse type, with 6 milking units and a low milk line and air pipeline. The main functional characteristics of milking machine were: vacuum level 44 kPa (33 cm Hg), pulsation rate 90 pulsations/min and pulsation ratio 50 : 50. The experimental period lasted 21 weeks (until the 29th week of lactation period). Milking was carried out twice daily at 8:00 and 18:00 h; it started by the setting of teat cups to udders without any preparation of udders, continued by machine stripping for about 10 s and finished, after the removal of teat cups, by hand stripping of the udder.

Milk recording was applied every two weeks (Wednesday afternoon and Thursday morning) according Fleischmann's method. Milk fractions at morning and afternoon milking were recorded as follows:

– machine milk (MM), which is the quantity of milk that was taken after the setting of teat cups until the cessation of milk flow
– machine stripped milk (MSM), which is the amount of milk that was taken by udder stripping with hands without removing the teat cups
– hand stripped milk (HSM), which is the milk amount that was taken by udder stripping after the removal of teat cups

Based on the above measures we also calculated:

– total machine milk (TMM = MM + MSM)
– milk yield (MY = TMM + HSM)

During the 3rd, 5th, 7th and 9th controls of milk recording (i.e. the 6th, 10th, 14th and 18th week of the experimental period) during both evening and morning milking and by each animal milk samples (~60 ml) were taken for milk fat, protein and lactose determination. Milk composition was studied separately for morning and afternoon milking (separate collection for morning and afternoon milk yiel (MY) after the mixing of all milk fractions). Sample analyses were performed at the Laboratory of Milk Technology, Faculty of Agriculture, Aristotle University of Thessaloniki by using a Milcoscan 104, Foss Electric. The ponderable mean was used for the calculation of morning, afternoon and daily fat, protein and lactose percentage.

All the measured variables were compared by ANOVA using the SAS General Linear Model procedure (SAS, 1995). The following statistical model was used:

$$Y_{ijkl} = \mu + G_i + A_j(G_i) + L_k + P_l + (L \times A)_{kj} + e_{ijkl}$$

where: Y_{ijkl} = $ijkl$ measure
μ = general mean
G_i = genotype effect with i = 1–5
$A_j(G_i)$ = animal inside genotype effect with j = 1–39
L_k = lactation stage (control day) effect with k = 1–11
P_l = parity effect with l = 1–2
$(L \times A)_{ik}$ = lactation stage × animal interaction
e_{ijkl} = residual error

The lactation stage × animal interaction was included in the model because of its significant effect. Multiple mean comparisons were made using Duncan's multiple range test (1955). The calculation of phenotypic correlations between different variables was made using Pearson's simple correlation model.

RESULTS AND DISCUSSION

Milk partitioning

In Table 1 the average values of milk fractions (ml) throughout lactation according to different genotypes are shown.

The daily machine milk (MM) fraction for S, D, S × L, S × A and (S × L) × S was 1 502 ± 82.7, 859 ± 52.4, 956 ± 58.4, 1 439 ± 81.5 and 1 139 ± 72.3 ml, respectively ($P < 0.001$). All these quantities were superior to those found by Sinapis (1991) for the local Greek goat breed (560 ml). In percentage terms, MM accounted for 78.6, 69.8, 78.7, 78.6 and 81.6%, respectively, of the morning MY of goats and for 70.8, 66.2, 68.4, 77.4 and 71.6%, respectively, of the afternoon MY (Table 2). MM (%) for the three crosses was found at the same level with that for S breed. These results show that high yielding breeds simultaneously improve the milk yield and the milkability in crosses. MM (%) in Damascus breed was at a relatively lower level in comparison with the other genotypes. The above percentages are significantly higher than MM (%) found for the local Greek breed (60.5%; Sinapis, 1991). This difference is explained by the fact that high yielding goats and their crosses with local breeds clearly have a better milk availability and give their milk more easily than unimproved goats. Another explanation may be the use of teat cups with silicone. In this regard it was found that the use of silicone increased the MM percentage and simultaneously decreased that of HSM (Le Du, 1982; Sinapis et al., 2000). In similar studies with Saanen and Alpine breeds MM (%) was found to be 87–88% (Buillon and Ricordeau, 1970; Le Mens et al., 1979; Le Mens and Disset, 1984) while for Alpine Chamoise and Poitevine it was 90–93% (Ricodeau and Labussiere, 1970). Peris et al. (1996; 1999) reported for Murciano-Granadina goat breed a mean value of 81.5%. Bruckmaier et al. (1994) found MM 91.2–96.3% for Swiss Saanen. In Canarian dairy goats MM amounted to 78–80% (Caja et al., 1999).

Machine milk (ml) was affected significantly by the dam's genotype, lactation stage, parity and lactation stage × animal interaction. The effect of genotype was also found to be significant for the MM (%). Generally, the crossed animals have a good milkability because the goats that give a high percentage of MM have the ability to be milked easily and after milking the residual milk ranges in low quantities (Buillion and Ricordeau, 1970; Sinapis, 1993). In another experiment with backcrosses (S × L) × S a higher percentage of MM was found in dams of 2nd and 3rd parities and also in those that kidded twins (Skapetas et al., 2003).

The mean daily quantity of MSM was 298, 257, 232, 295 and 228 ml for S, D, S × L, S × A and (S × L) × S, respectively. MSM (ml) accounted for 12.2, 19.3, 14.5, 15.3 and 13%, respectively, of the morning MY of goats and for 19.2, 21.9, 23.4, 17.2 and 20.1%, respectively, of the afternoon MY (Tables 1 and 2). MSM (ml) is almost at the same level for morning and afternoon milking indicating that udder morphology is the reason of this volume. The higher MSM (%) that was observed during afternoon milking is due to the lower milk yield, not to the lower milkability. The above percentages are lower (except that of D) than MSM percentage found for local Greek goat breed (20.3%, Sinapis et al., 1993). In other similar studies MSM (%) ranged from 7 to 13% for Alpine and Saanen breeds (Ricordeau and Labussiere, 1970) while for dairy Canarian goat it was found 20–22% (Caja et al., 1999). The analysis of variance showed that MSM (%) was influenced by the genotype of animals. The influence of lactation stage on MSM (ml) and MSM (%)was also significant.

The mean daily quantity of HSM was 192, 143, 94, 107 and 94 ml, respectively, for S, D, S × L, S × A and (S × L) × S dams (Table 1). As regards HSM (%), its values ranged from 5.4 to 10%. The above percentages are significantly lower than those found for the local Greek goat (19.2%, Sinapis et al., 1993). The lower HSM (%) in imported dairy breeds and their crosses with local breed suggests a better adaptation to machine milking and better milkability of animals. In other studies with Saanen and Alpine Chamoise goats HSM (%) was found to be 11.5% (Le Mens and Disset, 1984).

TMM (%) in different genotypes ranged from 88.0 to 94.6%. This level shows that milking machine can remove a satisfactory quantity of milk from the goat's udder. In these conditions farmers can successfully apply the so-called "routine" milking. The percentage of TMM was lower in Damascus breed ($P < 0.05$).

In Table 3 phenotypic correlations between the variables of milk fractions (ml and %) are shown.

Table 1. Milk fractions (ml) during the machine milking of goats

Variables / Factor		Genotype					Significance					CV (%)
		S ($\bar{x} \pm S_{\bar{x}}$)	D ($\bar{x} \pm S_{\bar{x}}$)	S × L ($\bar{x} \pm S_{\bar{x}}$)	S × A ($\bar{x} \pm S_{\bar{x}}$)	(S × L) × S ($\bar{x} \pm S_{\bar{x}}$)	Genotype	Parity	Lactation stage	Animals	Lact.ation stage × animals	
MM	morning	926 ± 69.1^{a}	499 ± 40.3^{d}	603 ± 46.9^{c}	895 ± 54.7^{ab}	759 ± 60.6^{b}	***	***	***	***	***	22.1
	afternoon	576 ± 47.0^{a}	360 ± 32.5^{bc}	353 ± 49.6^{c}	544 ± 47.2^{a}	380 ± 41.1^{b}	***	**	***	***	***	38.5
	daily	1502 ± 82.7^{a}	859 ± 52.4^{c}	956 ± 58.4^{bc}	1439 ± 81.5^{a}	$1\,139 \pm 72.3^{b}$	***	**	***	***	***	25.3
MSM	morning	142 ± 10.2^{b}	138 ± 8.6^{b}	111 ± 7.5^{c}	174 ± 11.3^{a}	121 ± 9.1^{bc}	**	*	**	***	**	55.6
	afternoon	156 ± 11.4^{a}	119 ± 8.7^{b}	121 ± 8.2^{b}	121 ± 9.7^{b}	107 ± 9.7^{bc}	***	NS	***	***	***	45.4
	daily	298 ± 12.3^{a}	257 ± 21.4^{b}	232 ± 12.3^{c}	295 ± 16.7^{a}	228 ± 15.6^{c}	***	NS	***	***	**	41.4
HSM	morning	111 ± 13.2^{a}	78 ± 10.2^{b}	52 ± 8.6^{c}	69 ± 5.9^{b}	50 ± 6.6^{c}	***	**	***	***	*	60.6
	afternoon	81 ± 8.7^{a}	65 ± 8.2^{ab}	42 ± 6.6^{bc}	38 ± 4.8^{bc}	44 ± 6.6^{bc}	***	*	***	***	**	58.5
	daily	192 ± 19.6^{a}	143 ± 14.7^{b}	94 ± 7.1^{c}	107 ± 8.4^{c}	94 ± 10.7^{c}	***	*	***	***	***	41.4
TMM	morning	$1\,068 \pm 76.6^{a}$	637 ± 32.8^{b}	714 ± 63.3^{b}	$1\,069 \pm 71.5^{a}$	880 ± 70.1^{ab}	*	**	***	***	***	30.5
	afternoon	732 ± 51.1^{a}	479 ± 32.6^{b}	474 ± 50.9^{b}	665 ± 60.2^{ab}	487 ± 53.4^{b}	***	**	***	***	**	31.0
	daily	$1\,800 \pm 96.3^{a}$	$1\,116 \pm 59.8^{b}$	$1\,188 \pm 68.6^{b}$	$1\,734 \pm 84.2^{a}$	$1\,367 \pm 81.4^{ab}$	**	**	***	***	***	41.2
MY	morning	1179 ± 85.2^{a}	715 ± 51.2^{b}	766 ± 67.4^{b}	$1\,138 \pm 71.5^{a}$	930 ± 86.4^{ab}	**	**	***	***	***	30.4
	afternoon	813 ± 53.3^{a}	544 ± 35.6^{b}	516 ± 48.5^{b}	703 ± 48.1^{a}	531 ± 48.2^{b}	**	*	***	***	**	30.6
	daily	$1\,992 \pm 105.1^{a}$	$1\,259 \pm 64.7^{c}$	$1\,282 \pm 69.6^{c}$	$1\,841 \pm 91.2^{a}$	$1\,461 \pm 98.4^{b}$	***	**	***	***	**	17.6

MM = machine milk, MSM = machine stripping milk, HSM = hand stripping milk, TMM = total machine milk, MY = milk yield

[abc]within lines, means not sharing a common superscript differ significantly ($P < 0.05$)

S = Saanen, D = Damascus, S × L = Saanen × Local, S × A = Saanen × Alpine, (S × L) × S = (Saanen × Local) × Saanen

Significance levels: *$P < 0.05$; **$P < 0.01$; ***$P < 0.001$; NS = non significant

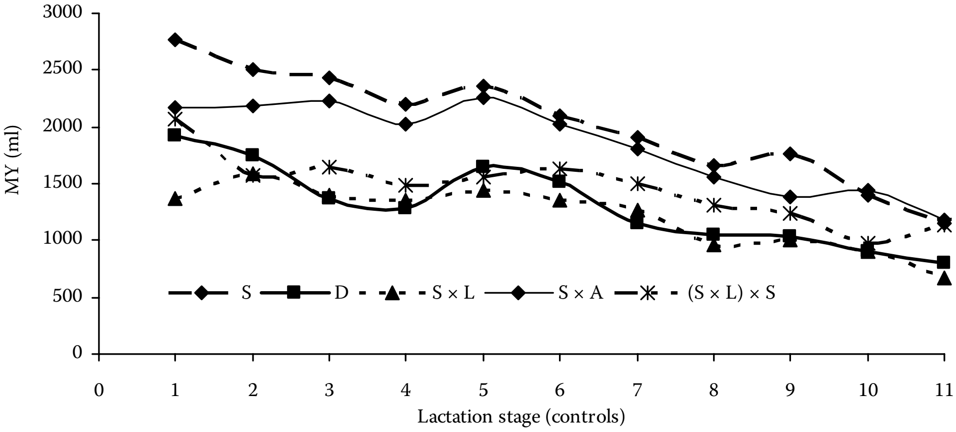

Figure 1. Evolution of milk yield (MY) during the experimental period

High and positive correlations (r = 0.97, r = 0.53, and r = 0.57; P < 0.001) were found between MY (ml) and MM (ml), MSM (ml) and HSM (ml), respectively. The correlations MY (ml)/MSM (%) and MY (ml)/HSM (%) were negative (r = –0.52 and r = –0.22, respectively, P < 0.001) and demonstrate that dams with higher milk yield give a proportionally lower quantity of milk during machine and hand stripping. At the same time, the increase in MM (%) reduces MSM (%) and HSM (%). As a conclusion regarding phenotypic correlations between milk fractions during machine milking of goats it could be said that the higher milk yield is positively correlated with milkability and adaptation of animals to machine milking.

Milk yield

Milk yield patterns and mean daily milk yield during lactation according to different genotypes of dams are shown in Figure 1 and Table 1. A gradual decrease in daily milk yield was observed during the milking period. However, the rate of decrease was different in the particular genotypes. A similar decrease was observed for the quantity of MSM (Figure 2). The average daily milk yield was 1.99 ± 0.11, 1.84 ± 0.09, 1.46 ± 0.10, 1,28 ± 0.07 and 1.26 ± 0.06 l in S, S × A, (S × L) × S, S × L and D dams, respectively (Table 1). The effect of genotype (P < 0.001), lactation stage (P < 0.001) and lactation stage × animal interaction (P < 0.001) was significant. Milk yield was higher in S and S × A dams compared to the backcrosses (S × L) × S (P < 0.05) while that of S × L and D dams was significantly lower than in (S × L) × S (P < 0.05). These results show that S × L crosses have an intermediate milk production between the high yielding breeds (S) and the local breed (L) while dams issued from the backcrosses (S × L) × S showed a clear superiority to S × L animals in the conditions of this experiment. The crosses between two high yielding breeds (S × A) showed a clear superiority to the other crosses. Saanen breed had the highest milk

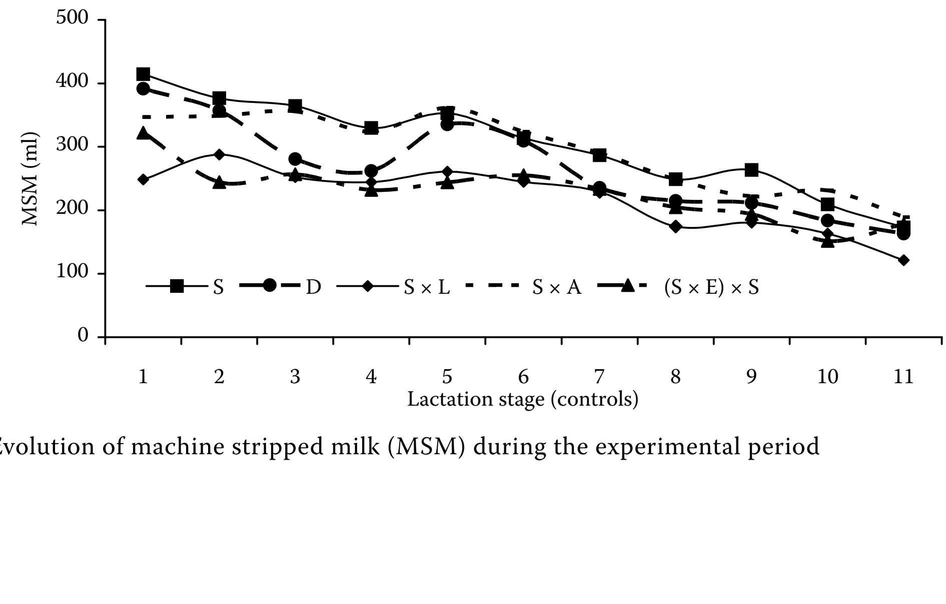

Figure 2. Evolution of machine stripped milk (MSM) during the experimental period

Table 2. Milk fractions (%) during the machine milking of goats

Factor	Variables	S ($x \pm S_{\bar{x}}$)	D ($x \pm S_{\bar{x}}$)	S × L ($x \pm S_{\bar{x}}$)	S × A ($x \pm S_{\bar{x}}$)	(S × L) × S ($x \pm S_{\bar{x}}$)	Genotype	Parity	Lactation stage	Animals	CV (%)
MM	morning	78.56 ± 2.2^a	69.79 ± 2.7^b	78.72 ± 1.4^a	78.65 ± 4.5^a	81.61 ± 2.0^a	**	**	***	***	15.3
	afternoon	70.82 ± 2.3^a	66.17 ± 3.2^b	68.41 ± 2.5^b	77.38 ± 4.3^a	71.56 ± 1.8^a	*	**	***	***	22.5
MSM	morning	12.16 ± 1.6^b	19.30 ± 2.1^a	14.49 ± 1.1^b	15.29 ± 4.5^b	13.01 ± 1.6^b	**	NS	***	***	59.4
	afternoon	19.21 ± 2.0^a	21.87 ± 3.0^a	23.45 ± 2.3^a	17.21 ± 3.7^a	20.15 ± 2.1^a	*	NS	***	***	54.6
HSM	morning	9.41 ± 1.1^a	10.91 ± 2.3^a	6.79 ± 1.0^b	6.06 ± 1.0^b	5.38 ± 0.7^b	*	NS	***	***	70.7
	afternoon	9.96 ± 1.6^a	11.95 ± 1.7^a	8.14 ± 1.1^a	5.41 ± 2.1^b	8.29 ± 0.9^a	*	NS	***	***	71.4
TMM	morning	90.58 ± 1.1^a	89.01 ± 2.3^a	93.21 ± 1.1^a	93.94 ± 1.1^a	94.62 ± 0.7^a	**	***	***	***	8.4
	afternoon	90.10 ± 1.6^a	88.05 ± 1.7^a	91.86 ±1.0^a	94.59 ± 2.2^a	91.71 ± 0.9^a	*	*	***	**	10.5

MM = machine milk, MSM = machine stripping milk, HSM = hand stripping milk, TMM = total machine milk
^{abc}within lines, means not sharing a common superscript differ significantly ($P < 0.05$)
S = Saanen, D = Damascus, S × L = Saanen × Local, S × A = Saanen × Alpine, (S × L) × S = (Saanen × Local) × Saanen
Significance levels: *$P < 0.05$; **$P < 0.01$; ***$P < 0.001$; NS = non significant

yield, but its milk performance was lower than in the region of its origin.

Milk composition

Goat's milk composition is shown in Table 4. The mean percentages of milk fat ranged between 3.82 and 5.06% with higher values in D and S × L dams and lower values in S, S × A and (S × L) × S dams ($P < 0.01$). The milk fat concentration was significantly influenced by lactation stage ($P < 0.01$) and animals ($P < 0.001$). Its values also appear to be higher for evening milk in comparison with morning milk.

In the local Greek breed the milk fat content of 4.5% was found for the first lactation and 5.0% for the second (Sinapis et al., 1993). Other researchers reported a mean value of 5% (Zygoyiannis and Katsaunis, 1992). According to the stage of lactation (May–September) fat content ranged between 4.6 and 7.0% (Hatziminaogiou, 2001). The mean fat content found for S and D breeds was at the same

Table 3. Correlations between the milk fractions during the machine milking of goats

Milk fractions	MM (ml)	MSM (ml)	HSM (ml)	TMM (ml)	MY (ml)	MM (%)	MSM (%)	HSM (%)	TMM (%)
MM (ml)	1	0.35***	0.45***	0.98***	0.97***	0.64***	–0.62***	–0.30***	0.30***
MSM (ml)		1	0.31***	0.52***	0.53***	–0.08*	0.19***	–0.15***	0.15***
HSM (ml)			1	0.47***	0.57***	–0.01^{NS}	–0.23***	0.41***	–0.41***
TMM (ml)				1	0.99***	0.57***	–0.53***	–0.31***	0.24***
MY (ml)					1	0.52***	–0.52***	–0.22***	0,17***
MM (%)						1	–0.88***	–1.0***	0.59***
MSM (%)							1	0.15***	–0.15***
HSM (%)								1	–0.87***

MM = machine milk, MSM = machine stripping milk, HSM = hand stripping milk, TMM = total machine milk, MY = milk yield
Significance levels: *$P < 0.05$; ***$P < 0.001$

Table 4. Milk composition during the machine milking of goats (% and g)

Factor	Variables	S ($x \pm S_{\bar{x}}$)	D ($x \pm S_{\bar{x}}$)	S × L ($x \pm S_{\bar{x}}$)	S × A ($x \pm S_{\bar{x}}$)	(S × L) × S ($x \pm S_{\bar{x}}$)	Significance: Genotype	Significance: Lactation stage	Significance: Animals	CV (%)
Fat (%)	morning	3.77 ± 0.47^{ab}	4.48 ± 0.18^{a}	3.96 ± 0.28^{a}	3.40 ± 0.24^{b}	3.81 ± 0.22^{ab}	*	**	***	25.7
	afternoon	3.89 ± 0.39^{a}	6.39 ± 0.48^{b}	5.47 ± 0.44^{ab}	4.96 ± 0.33^{ab}	4.84 ± 0.37^{ab}	**	**	***	24.5
	daily	3.82 ± 0.41^{a}	5.06 ± 0.19^{b}	4.79 ± 0.29^{b}	3.88 ± 0.25^{a}	3.95 ± 0.27^{a}	**	*	***	23.2
Protein (%)	morning	3.04 ± 0.05^{a}	3.20 ± 0.15^{a}	3.43 ± 0.11^{b}	3.11 ± 0.07^{a}	3.30 ± 0.06^{ab}	***	***	***	11.8
	afternoon	3.33 ± 0.07^{a}	3.55 ± 0.19^{ab}	3.82 ± 0.15^{b}	3.26 ± 0.06^{a}	3.76 ± 0.11^{b}	***	***	***	11.8
	daily	3.14 ± 0.06^{a}	3.25 ± 0.15^{ab}	3.56 ± 0.12^{b}	3.14 ± 0.07^{a}	3.47 ± 0.10^{b}	***	***	***	10.6
Lactose (%)	morning	4.51 ± 0.05^{a}	4.62 ± 0.08^{ab}	4.73 ± 0.05^{b}	4.53 ± 0.07^{a}	4.49 ± 0.14^{a}	***	***	***	4.8
	afternoon	4.40 ± 0.16^{a}	4.67 ± 0.07^{ab}	4.74 ± 0.04^{ab}	4.80 ± 0.07^{b}	4.77 ± 0.06^{ab}	***	***	***	8.4
	daily	4.51 ± 0.05^{a}	4.64 ± 0.07^{a}	4.73 ± 0.05^{ab}	4.66 ± 0.05^{a}	4.63 ± 0.07^{a}	***	***	***	4.5
Fat (g)	daily	76.9 ± 7.3^{a}	63.7 ± 6.9^{a}	61.4 ± 7.4^{ab}	71.4 ± 4.9^{a}	57.7 ± 5.9^{ab}	***	***	***	58.6
Protein (g)	daily	62.5 ± 5.1^{a}	41.7 ± 5.5^{b}	45.6 ± 5.0^{ab}	57.8 ± 3.2^{a}	50.7 ± 5.3^{ab}	***	***	***	55.1
Lactose (g)	daily	89.8 ± 7.6^{a}	58.4 ± 8.1^{b}	60.6 ± 8.4^{b}	85.8 ± 5.1^{a}	67.6 ± 9.6^{ab}	**	***	***	48.9

Significance levels: *$P < 0.05$; **$P < 0.01$; ***$P < 0.001$

[abc]within lines, means not sharing a common superscript differ significantly ($P < 0.05$)

level or relatively higher compared to bibliographic sources (Serradilla, 2001). In crossbred products the milk fat concentration was found to be at an intermediate level. However, in S × L crosses milk fat was similar to that of the local breed (4.79 ± 0.29%) and significantly superior to S, S × A and (S × L) × S genotypes. These results agree with the conclusions of Serradilla (2001).

The daily milk fat yield (g) was found to be higher in S and S × A (76.9 ± 7.3 and 71.4 ± 4.9 g, respectively) compared to the other genotypes ($P < 0.05$). This is explained by the superior milk yield of these two genotypes.

The higher crude protein (CP) percentage was measured in the milk of S × L and (S × L) × S dams which was statistically significant ($P < 0.05$) compared with that of the other genotypes. In the milk of local Greek goats the CP content varies between 3.30 and 3.80% according to the parity (Sinapis et al., 1993). According to the stage of lactation (May to September) a fluctuation of 3.6–4.5% was found (Hatziminaglou, 2001). Zygoyiannis and Katsaunis (1992) reported a CP mean value 3.5%. Generally, the CP concentration was more stable than the fat concentration (CV = 10.6%). However, the effect of lactation stage was significant ($P < 0.001$). In S and D dams the milk CP content (3.14 ± 0.06 and 3.25 ± 0.15) was at the same level that was reported by other authors (Seradilla, 2001). In all the cases higher values were observed for evening milk. The mean daily CP yield (g) was significantly higher in S and S × A dams (62.5 ± 5.10 and 57.80 ± 3.2 g, respectively, $P < 0.05$).

Milk lactose, as usual, was found to be the more stable constituent of goat's milk (CV = 4.52%). A higher value was found for S × L dams ($P < 0.05$). The effect of lactation stage was significant.

CONCLUSIONS

The results of this paper showed that milkability of crossbred goats was at satisfactory levels near to those of high yielding goat breeds for milk production like Saanen and Alpine and significantly better than local Greek breed goats, since ~80% of milk could be removed without applying machine or hand stripping. Machine milk was highly correlated with milk yield of goats. Milk yield of S × L crosses was at an intermediate level between the high yielding breeds (S) and the local breed. The crosses (S × L) × S showed a higher milk yield than that of S × L.

Milk composition (fat, protein and lactose) was found to be better in crossbred goats and Damascus breed.

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