The first observation of milkability of the sheep breeds Tsigai, Improved Valachian and their crosses with Lacaune

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ABSTRACT: The aim of this study was to evaluate the milkability of two purebred breeds Tsigai (TS, n = 14) and Improved Valachian (IV, n = 15), their crosses with Lacaune 50% TS × 50% LC (n = 13), 50% IV × 50% LC (n = 9) and purebred Lacaune (LC, n = 19). The measurements of the milk flow were performed on day 90 ± 10 of lactation during evening machine milking. The recording of milk flow was carried out by the equipment for graduated electronic recording of milk level in a jar in one-second intervals. The milk flow curves were classified into four types: 1 peak (1P), 2 peaks (2P), plateau I (maximal milk flow over 0.4 l/min (PLI)), plateau II (maximal milk flow less than 0.4 l/min (PLII)). The last two types refer to ewes with steady milk flow during milking. Udder morphology traits were measured (cisternal depth, teat angle) and subjectively assessed by the use of linear scores (cistern depth, teat position). The average total milk yield was 0.335 ± 0.043, 0.392 ± 0.042, 0.407 ± 0.042 l in purebred TS, IV, LC resp. and 0.397 ± 0.046, 0.434 ± 0.056 l in crosses TS × LC and IV × LC, resp. The frequency of occurrence of different types of milk flow /1P:2P: PLI:PLII/ was 27, 47, 22, 4%, resp. The highest milk yield was observed in ewes with PLI (0.481 ± 0.045 l), followed by 2P (0.401 ± 0.029 l) and 1P (0.293 ± 0.036 l) type of milk flow curve (P = 0.0112). An opposite effect was observed in the percentage of machine stripping yield where 1P had 41.94 ± 3.83%, 2P 21.29 ± 3.04% and PLI 15.90 ± 4.70% (P < 0.0001). LC and TS × LC, IV × LC had the more horizontal teat position than TS and IV. It can be supposed that at least during around 69% milkings the sheep released oxytocin in response to machine milking and that TS, IV and their crosses with LC also have a suitable potential for machine milking.

Keywords: dairy sheep; milk flow curves; udder morphology; machine milking

Tsigai (TS) and Improved Valachian (IV) are sheep breeds with high endurance and adaptability to walking and natural conditions. They are very similar in milk production (Oravcová et al., 2002). They are often crossed with Lacaune (LC) or purebred selection through the genetic evaluation is done with the purpose to improve their milk production and milkability (Oravcová and Peškovičová, 2008). However, there is limited information about the physiological response (milkability) of TS and IV to machine milking in literature.

Milkability can be evaluated by the analysis of milk flow curves (Mayer et al., 1989; Bruckmaier et al., 1997; Mačuhová et al., 2007; Tančin et al., 2007), milking characteristic and udder morphology (Rovai et al., 1999; Milerski et al., 2006).

The milk flow pattern depends on the storage of milk in the udder before milking and milk ejection (Labussičre, 1988; Bruckmaier et al., 1997). Milk within the udder of dairy sheep can be divided into two fractions: the cisternal fraction, which has already been transferred from alveoli to the cistern during the interval between milkings and is immediately obtainable by the machine without milk ejection. The second is the alveolar fraction (milk stored in the alveoli), which can be removed from the udder only when milk ejection occurs during milking (Marnet and McKusick, 2001). The cisternal milk represents approximately 20% in dairy cows after a 12-hour milking interval (Pfleilsticker et al., 1996) and above 40% of the total milk in dairy sheep (Marnet and McKusick, 2001). One part of the cisternal milk can be located below the orifice of the teat canal and therefore cannot be reached directly by the milking machine without additional handling (Bruckmaier et al., 1997).

With increased milk production increased storage capacity of the udder was observed (Rovai et al., 1999; Marnet and McKusick, 2001). However, concurrently with increased milk production a tendency of udders to have more horizontally placed teats was observed (Rovai et al., 1999; Marnet and McKusick, 2001). Therefore, the mammary gland morphology is the second factor that determines aptitude for the machine milking of sheep. The ideal dairy sheep should have the large capacity of cisterns and vertical teat position that will enable the milk removal without any functional inhibitions (Labussičre, 1988).

The aim of this study was to evaluate the milkability and udder morphology of Lacaune and two purebred breeds Tsigai and Improved Valachian and as well as their crosses with Lacaune.

MATERIAL AND METHODS

Animals

A total of 70 dairy sheep of three breeds and their crossbreds (14 heads TS, 13 heads 50% TS × 50% LC, 15 heads IV, 9 heads 50% IV × 50% LC, 19 heads LC) were randomly selected for an experiment from the flock of 400 dairy sheep. Average milk production of the flock calculated for 150 days of lactation was 105.6 l, 146.4 l, 99.7 l, 135.9 l and 148.9 l for TS, TS × LC, IV, IV × LC and LC, resp. The experimental dairy sheep were in their first to fourth lactation. They were in day 90 ± 10 of lactation. The animals were kept on the pasture and only at milking time they were brought into the stable. During milking each dairy sheep received 0.1 kg concentrate.

Milking routine

Ewes were routinely milked twice daily at 7:30 a.m. and 7:30 p.m. in a milking parlour, designed for 24 animals and equipped with 12 standard milking

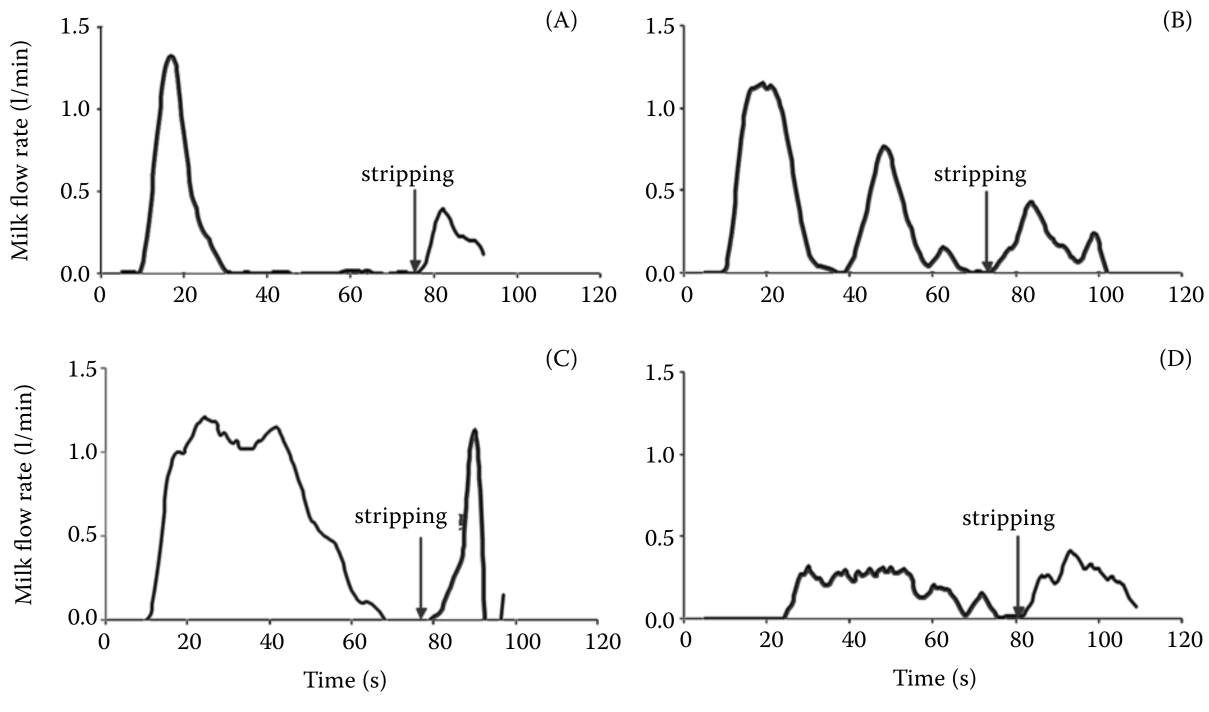

Figure 1. Different milk flow patterns during the machine milking of TS, IV, LC, TS × LC, IV × LC; (A) 1 peak; (B) 2 peaks, (C) plateau I, (D) plateau II

units. Milking vacuum was 40 kPa, pulsation rate 180 cycles/min at a ratio of 50:50. Clusters were attached without udder preparation. The machine stripping was performed after the milk flow had ceased but not earlier than 70 s from the attachment of clusters to be able to detect the second emission of milk in the case of milk ejection.

Udder morphology and milk flow curves

The morphology of mammary gland was measured and evaluated before evening milking in the milking parlour one day before the first experimental milking with milk flow measurements. The measurements were performed as follows.

The evaluation of cistern depth and teat position was based on a nine-point linear scale as previously described by Milerski et al. (2006). Moreover, the cistern depth (CD – mm) was measured with a measuring tape and the teat angle (TA – degree) with a protractor (Milerski et al., 2006).

The milk flow was continuously recorded by a graduated electronic milk collection jar for ewe milking placed between the claw and the milk line. Milk flow curves were evaluated according to Bruckmaier et al. (1997) and Rovai et al. (2002) into four types: 1 peak (1P), 2 peaks (2P), plateau I (PLI), plateau II (PLII)). 1P represents milk flow curves with one peak of milk flow before stripping. 2P type of milk flow has two clearly separated milk flow peaks, i.e. transiently decreasing milk flow followed by increasing milk flow before stripping was performed. PLI represents the milk flow of ewes with larger emission curves and maximal milk flow rate > 0.4 l/min without clear differences between peak 1 and 2. Plateau II (PLII) also represents the milk flow curves with steady milk flow during milking, but at a very low milk flow level (maximal milk flow rate ≤ 0.4 l/min). This type of milk flow occurred only during three milkings, therefore this data were not included in the statistical evaluation of the effect of milk flow on milkability. Examples of individual ewes' milk flow curves are shown in Figure 1.

The following milking characteristics were evaluated: machine milk yield and milking time (the amount of milk obtained by the machine from time 0 to time when the milk flow ceased), machine stripping (the amount of milk obtained by the milker during machine stripping), total milk yield (machine milk yield + machine stripping), maximal milk flow rate (the maximum flow rate recorded during machine milking), milk flow latency (the lag time between the attachment of teat cups and reaching of 0.03 l in jar), milk yield in 30 s and 60 s (the amount of milk obtained in 30 and 60 s). Milk yield in 30 s and 60 s was the same as machine milk yield if the time of milking was less than 30 or 60 s. In bimodal curves the time of bimodality beginning also was recorded, i.e. the time when the second emission started.

The milk flow kinetics was calculated according the following model:

$$Yt = (\text{yield in time } (t) - \text{yield in time } (t-4)) \times 15$$

$$t > 3$$

Statistical analysis

The data set consisted of 70 measurements belonging to 70 ewes. A mixed model (mixed procedure; SAS/STAT 9.1, 2002–2003) was applied to study the influence of the sources of variation in studied traits (milk production and milk emission/milkability).

The model equation was as follows:

$$y_{ikl} = \mu + T_i + L_k + G_l + e_{ikl}$$

where:

y_{ikl} = individual observations of studied traits: total milk yield (l), machine milk yield (l), machine stripping (l), milking time (s), milk flow latency (s), maximal milk flow rate (l/min), milk yield in 30 s (l), milk yield in 60 s (l), milk yield in 30 s from machine milk yield (%), milk yield in 60 s from machine milk yield (%), machine stripping from total milk yield (%), time of bimodality beginning, milk yield of first emission (l), milk yield of first emission from machine milk yield (%), cistern depth (points and mm), teat angle (°), teat position (points)

μ = intercept

T_i = fixed effect of milk flow type (2P, PLI, 1P); $\sum_i T_i = 0$

L_k = fixed effect of lactation numbers (1, 2 , 3 and 4); $\sum_k L_k = 0$

G_l = fixed effect of breeds and crossbreds, TS, IV, LC and TS 50 × LC 50, IV 50 × LC 50); $\sum_l G_l = 0$

e_{ikl} = random error; $e_{ilk} \sim N(0.1\ \sigma_e^2)$

Because of no effect of lactation the results are not shown in the paper. Fixed effects included in the model were estimated using the LSM (Least Squares Means) method. Statistical significance was tested by Fischer's *F*-test and differences between the estimated levels of fixed effects were tested by Scheffe's multiple range tests. Residual error variances were estimated using the REML (Restricted Maximum Likelihood) method.

RESULTS AND DISCUSSION

Milk flow curves and correlations

Altogether 70 milk flow curves were evaluated. The ratio of four types of milk flow curves (1P:2P: PLI:PLII) evaluated in this study was 27:47:22:4%. The least frequency of occurrence was observed in PLII type of milk flow. This type of milk flow curve was observed seldom also in other breeds (Dzidic et al., 2004). Extremely weak or totally absent oxytocin release during milking is typical of the dairy sheep with PLII type of milk flow curves (Bruckmaier et al., 1997).

Cisternal, alveolar and stripping milk yield represented 59.8 ± 5.3, 0, 40.2 ± 5.3% and 54.2 ± 3.0, 26.5 ± 2.6, 19.3 ± 1.9% of total milk yield in 1P and 2P type of milk flow curves. The percentage of machine milk fraction (cisternal plus alveolar fraction) was clearly higher during milkings with 2P type of milk flow (~ 79%) than with 1P type of milk flow (~ 60%). Moreover, the percentage of cisternal milk fraction was quite similar in these types of milk flow curves. It confirms that the 1P type of milk flow curves in this study is without alveolar milk ejection and only the cisternal milk fraction was removed in response to machine milking as observed previously in another study (Bruckmaier et al., 1997). On the other hand, the milk flow curves with two separated peaks (so-called bimodal) are showing alveolar milk ejection after the cisternal milk was removed. The percentage of alveolar milk observed in our ewes with 2P type of milk flow was lower than that reported by Marnet et al. (1998) in Lacaune ewes (34%). The percentage of cisternal milk in 1P type of milk flow was also lower in our ewes than in those tested in the above-mentioned study. The bimodality (the start of the second increase of milk flow) during milkings with 2P type of milk flow curves was observed at around 39 ± 2 s in our study. Similar results were observed also by McKusick (2000) in Lacaune breed. In PLI type of milk flow it is not possible to distinguish the cisternal and alveolar fraction. The second peak is masked because at the time of milk ejection, i.e. when the alveolar fraction descends into the cistern for removal, the cisternal fraction has not yet been completely removed from the udder as it was already reported by Marnet et al. (1998). Therefore, in this type of milk flow curves the cisternal and alveolar milk fraction could be evaluated only together and yielded 84% of total milk yield. Stripping milk yield represented 16% from total milk yield (Table 1). The 2P and PLI types of milk

Table 1. The effect of milk flow types on milkability of ewes

Traits	Milk flow curve type			
	1P	2P	PLI	*P*
Total milk yield (TMY), (l)	0.293 ± 0.036[a]	0.401 ± 0.029[a,b]	0.481 ± 0.045[b]	0.0112
Machine milk yield (MMY), (l)	0.175 ± 0.035[a]	0.320 ± 0.028[b]	0.427 ± 0.250[b]	0.0003
Machine stripping (MS), (l)	0.119 ± 0.016	0.082 ± 0.013	0.055 ± 0.019	0.0534
MS/TMY (%)	41.94 ± 3.83[a]	21.29 ± 3.04[b]	15.90 ± 4.70[b]	< 0.0001
Milking time (s)	45 ± 4[a]	64 ± 3[b]	67 ± 5[b]	0.0005
Milk flow latency (s)	15 ± 1	13 ± 1	16 ± 2	0.0572
Maximal milk flow rate (l/min)	0.883 ± 0.168	1.207 ± 0.132	0.953 ± 0.206	0.2324
Milk yield in 30 s (MY30s), (l)	0.145 ± 0.025	0.214 ± 0.020	0.176 ± 0.031	0.0925
Milk yield in 60 s (MY60s), (l)	0.169 ± 0.035[a]	0.302 ± 0.028[b]	0.388 ± 0.043[b]	0.0012
MY30s/MMY (%)	80.83 ± 4.31[a]	66.07 ± 3.44[b]	46.95 ± 5.30[c]	< 0.0001
MY60s/MMY (%)	94.78 ± 1.95	93.16 ± 1.56	92.57 ± 2.40	0.7547
Cistern depth (points)	4.1 ± 0.3	4.6 ± 0.3	4.9 ± 0.4	0.2804
Cistern depth (mm)	19.5 ± 2.1	21.1 ± 1.7	25.8 ± 2.6	0.1610
Teat angle (ş)	42.9 ± 2.7	42.6 ± 2.2	44.5 ± 3.4	0.8642
Teat position (points)	4.3 ± 0.3	5.3 ± 0.3	5.8 ± 0.3	0.0525

[a,b,c]means in the same line without a common superscript letter were significantly different ($P < 0.05$)

flow occurred during 69% of tested milkings. It can be assumed at least during these milkings (which is not a negligible proportion) that the sheep released oxytocin during machine milking. Therefore it can be supposed that TS, IV and their crosses with LC also have a suitable potential for machine milking (at least as concerns milk ejection).

The effect of the type of milk flow on milkability is shown in Table 1. The type of milk flow has a significant effect on total milk yield, machine milk yield, percentage of machine stripping from total milk yield, milk yield in 60 s and the percentage of milk yield in 30 s from machine milk yield. The other parameters were not affected by the type of milk flow. The highest total and machine milk yields were observed in PLI, followed by 2P and the lowest in 1P. The same effect of the same milk flow curve type on milk production was observed also in Manchega and Lacaune ewes (Rovai et al., 2002). The results of milk yield support the already mentioned suggestions by which type of milk flow curves the milk ejection occurred during machine milking. The fact that the ewes with PLI type of milk flow had the highest total milk yield and the lowest machine stripping yield from the tested types of milk flow curves supports the assumption that by this type of milk flow the milk ejection reflex really occurred, though the cisternal and alveolar fractions were not so clearly visible as by the 2P type of milk flow. Whereas the machine milk yield was significantly lower by 1P than by 2P and PLI type of milk flow, the total milk yield differed only between 1P and PLI type of milk flow and stripping milk yield was numerically higher (0.119 vs. 0.055 l) between these two types of milk flow. It can be concluded that some ewes with 1P type of milk flow release oxytocin during milking, however, alveolar milk was removed only in the time of stripping. This could be caused either by delayed oxytocin release or by delayed reaction to oxytocin (by the very small alveolar fraction).

Once more, we would like to mention the ewes with PLII type of milk flow even though they are not included in the results. Surprisingly, the total milk yield of these ewes (0.376 ± 0.091 l) was numerically higher than the milk yield of ewes with 1P type of milk flow (the ewes in whom no release of oxytocin is presumed) and comparable with the milk yield of ewes with 2P type of milk flow in our study. Therefore, it can be possible that these ewes released oxytocin during the machine milking. However, the (very low) milk flow and in consequence also the milking time (85 ± 9 s, i.e. significantly longer than by milking with the other types of milk flow) could be affected by some health problems or deformity of the teat canal. This suggestion is also supported by the highest stripping milk yield (0.126 ± 0.039 l), which was observed just in these ewes. Stripping could help to remove milk from the udder more easily.

The milking time was shortest during milkings with 1P type of milk flow (45 s) and similarly during milking with 2P and PLI types of milk flow (64 and 67 s, resp.). This is not surprising when it is supposed that during milkings with 1P type of milk flow no milk ejection occurred and only cisternal milk was removed in contrast to the other types of milk flow. Moreover, although the milking time was 45 s in 1P, 81% of machine milk yield was obtained already during the first 30 s of milking. Within this time only 66% (2P) and 47% (PLI) of machine milk yield were removed in the other types of milk flow.

Marnet et al. (1998) found out that the majority of very high-producing ewes had the PLI type of milk flow. Our observation in this study was similar. However, some ewes with this type of milk flow had a horizontal teat position, restricting the milk flow (Marnet et al., 1998). The animals in our study with this type of milk flow had the most horizontal teat position, however only numerically higher than the animals with 1P and 2P type of milk flow. Moreover, the recorded values in ewes with PLI type of milk flow were not so high (5.8 ± 0.3 points for the teat position and 44.5 ± 3.4° for the teat angle) and the most of milk could be removed without stripping (the milk yield of machine stripping accounted for only around 16% of total milk yield) in our study. Most ewes with this type of milk flow belonged to LC breed.

Correlation coefficients between the parameters of udder traits and milking characteristics are shown in Table 2. Total milk yield and machine milk yield were significantly correlated with all parameters of udder traits and milking characteristics except machine stripping and milk flow latency. Milk flow latency showed positive correlations with milking time and negative correlations with maximal peak flow rate. Besides the relation of milk flow latency with milking time and maximal peak flow rate Marnet et al. (1999) found out that milk flow latency had a clear relation with the high mean flow and low vacuum needed for the teat sphincter opening (parameters not observed in our study).

Table 2. Correlations between observed parameters

	MMY	MS	MT	MFL	MMFR	TP	CD	CD (mm)	TA
TMY	0.9134	0.1851	0.3681	–0.1060	0.5159	0.3445	0.4656	0.5253	0.3561
	< 0.0001	0.1250	0.0017	0.3826	< 0.0001	0.0035	< 0.0001	< 0.0001	0.0060
MMY		–0.2310	0.3958	–0.1782	0.5453	0.2631	0.3517	0.4254	0.2828
		0.0543	0.0007	0.1398	< 0.0001	0.0276	0.0028	0.0002	0.0177
MS			–0.0745	0.1799	–0.0849	0.1887	0.2653	0.2301	0.0963
			0.5397	0.1362	0.4843	0.1178	0.0265	0.0554	0.4277
MT				0.4149	–0.1233	0.2861	0.1838	0.2134	0.1031
				0.0004	0.3088	0.0163	0.1277	0.0761	0.3959
MFL					– 0.3939	0.0784	0.0169	0.2038	0.1241
					0.0070	0.5189	0.8895	0.0905	0.3061
MMFR						–0.0767	0.04592	0.1306	0.0055
						0.5284	0.7058	0.2813	0.9441
TP							0.7526	0.6014	0.5557
							< 0.0001	< 0.0001	< 0.0001
CD								0.7741	0.6145
								< 0.0001	< 0.0001
CD (mm)									0.6674
									< 0.0001

TMY = total milk yield; MMY = machine milk yield; MS = machine stripping; MT = milking time; MFL = milk flow latency; MMFR = maximal milk flow rate; TP = teat position; CD = cistern depth (points), CD (mm) = cistern depth (mm); TA = teat angle

The positive and significant correlation was also found between the teat position and cistern depth (points). The same effect was also observed between the teat angle and cistern depth (mm) in our flock and also in Manchega (Rovai et al., 1999) and East Friesian ewes (McKusick et al., 2000). The latter authors used an opposite scale for the teat position evaluation, therefore the correlation was negative. However, the udders with deeper cisterns and larger teat angle can have a problem with the falling off of the cups during milking (Labussiere, 1988) and increasing of stripping milk yield by a part of the cisternal milk which is located below the orifice into the teat canal and cannot be reached without machine stripping (Bruckmaier et al., 1997; Carta et al., 1999). This can, however, prolong the milking time and thereby reduce the efficiency of machine milking. The ewes in our study did not belong to really high-producing ewes, however, positive correlations of total milk yield with cisternal depth and teat position could already be observed in these sheep. This could indicate that further breeding for higher milk production could lead to the worsening of udder morphology (as it is observed in high-producing ewes in other studies).

Effect of breeds and crossbreds

The factor breeds and crossbreds did not influence the evaluated parameters except for milk flow latency, milking time, percentage of milk yield in 60 s from machine milk yield and teat position (Table 3). The milk flow latency and milking time were shortest in TS × LC, with very similar milk yield to LC. In contrast, LC had the numerically longest milking time. TS × LC had shorter milking time ($P < 0.0647$), higher percentage of milk yield in 60 s than LC ($P < 0.0562$) and higher teat position than TS ($P < 0.0678$). The animals of TS × LC also had the numerically highest maximal milk flow rate and percentage of milk removal in 30 s, 60 s during machine milking compared with other breeds and/or crossbreds tested in this study. Moreover, around 99% of milk from machine milking was removed in 60 s in TS × LC crossbreds and the proportion of stripping milk yield from total milk yield

Table 3. Parameters of milkability of different breeds and crossbreds

Traits	Breed					F-test
	TS	LC	IV	TS × LC	IV × LC	*P*
Total milk yield (TMY), (l)	0.335 ± 0.043	0.407 ± 0.042	0.392 ± 0.042	0.397 ± 0.046	0.434 ± 0.056	0.6757
Machine milk yield (MMY), (l)	0.258 ± 0.042	0.300 ± 0.040	0.312 ± 0.041	0.324 ± 0.044	0.344 ± 0.055	0.7209
Machine stripping (MS), (l)	0.077 ± 0.018	0.107 ± 0.018	0.081 ± 0.018	0.073 ± 0.020	0.091 ± 0.024	0.6738
MS/TMY (%)	28.09 ± 4.43	31.68 ± 4.30	23.28 ± 4.34	18.70 ± 4.75	30.12 ± 5.8	0.2025
Milking time (s)	57 ± 4	67 ± 5	56 ± 4	50 ± 4	65 ± 6	0.0415
Milk flow latency (s)	$14 \pm 1^{a,b}$	17 ± 1^{a}	$16 \pm 1^{a,b}$	11 ± 1^{b}	$15\pm 2^{a,b}$	0.0053
Maximal milk flow rate (l/min)	0.797 ± 0.194	0.735 ± 0.189	1.198 ± 0.191	1.272 ± 0.028	1.070 ± 0.256	0.1468
Milk yield in 30 s (MY30s), (l)	0.138 ± 0.029	0.140 ± 0.029	0.171 ± 0.029	0.240 ± 0.031	0.203 ± 0.039	0.0688
Milk yield in 60 s (MY60s), (l)	0.234 ± 0.041	0.280 ± 0.040	0.288 ± 0.040	0.327 ± 0.044	0.303± 0.054	0.6120
MY30s/MMY (%)	68.53 ± 4.99	57.14 ± 4.85	60.59 ± 4.90	75.27 ± 5.35	61.53 ± 6.57	0.0584
MY60s/MMY (%)	93.50 ± 2.26	90.93 ± 2.20	93.31 ± 2.22	98.96 ± 2.42	89.66 ± 2.98	0.0212
Cistern depth (points)	4.2 ± 0.4	4.3 ± 0.4	4.3 ± 0.4	5.1 ± 0.4	4.8 ± 0.5	0.3747
Cistern depth (mm)	20.4 ± 2.4	24.0 ± 2.3	20.4 ± 2.4	21.9 ± 2.6	24.1 ± 3.2	0.7819
Teat angle (ş)	43.1 ± 3.2	43.8 ± 3.0	40.2 ± 3.1	42.6 ± 3.4	46.5 ± 4.2	0.8089
Teat position (points)	4.5 ± 0.4	5.6 ± 0.3	4.9 ± 0.4	6.0 ± 0.4	5.3 ± 0.3	0.0405
Bimodality (2P)						
Time of bimodality beginning (s)	41 ± 3	44 ± 4	40 ± 3	34 ± 4	38 ± 3	0.2886
Milk yield of the first emission (l)	0.204 ± 0.058	0.234 ± 0.061	0.195 ± 0.057	0.263 ± 0.067	0.267 ± 0.057	0.9015
Milk yield of the first emission/MMY (%)	$69.28 \pm 8.29^{a,b}$	81.43 ± 8.81^{a}	47.15 ± 8.99^{b}	$73.32 \pm 9.58^{a,b}$	$73.32 \pm 9.09^{a,b}$	0.2026

^{a,b}means in the same line without a common superscript letter were significantly different ($P < 0.05$)

was the lowest, at least numerically. The crossing of TS seems to be an acceptable way to increase their milkability although certain concern should be given to the teat position.

The milking time of breeds could be influenced by the frequency of occurrence of the particular types of milk flow patterns. The frequency of occurrence of different milk flow patterns /1P:2P:PLI:PLII/ was 43:50:7:0% for TS, 30.5:39:30.5:0% for TS × LC, 10.5:42:37:10.5% for LC, 47:47:6:0% for IV, 0:67:22:11% for IV × LC. This would mean that more than 50% of the ewes of all tested breeds and crossbreds showed a clear ejection reflex during the machine milking. Marnet et al. (1998) reported 56% of ewes with two separate peaks in LC, we only 47%. Crossing with LC influenced the milk flow of crossbred ewes because they had a higher occurrence of PLI due to higher milk yield than purebred TS and IV animals. TS and IV had lower production than crossbreed ewes. The percentage of milk yield of the first emission at bimodality (2P) was 81.43, 69.28 and 47.15 in LC, TS and IV, resp. (Table 3). We can conclude from these results that LC and TS with 2P stored most of milk that is removed by machine milking in cistern space and IV in alveolar space before milking. A positive effect of crossing TS and IV with LC was proved in the cistern depth. They stored more than 73% of milk from machine milking in cisterns before milk ejection occurred. The cistern size was related to the autocrine inhibition of milk secretion in the mammary gland. Animals with large cisterns are more efficient producers of milk and more tolerant to long milking intervals in general (Wilde and Peaker, 1990).

The udder morphology traits are described in Table 3. LC had the more horizontally positioned teats than the purebred breeds TS and IV. The same results were also reported by Milerski et al. (2006). The crossing with LC negatively influenced the teat position in TS × LC /6.0/ and IV × LC /5.3/ (Table 3). This should be taken in consideration for future breeding programmes.

CONCLUSION

The relatively high occurrence of bimodal and plateau I milk flow curves was observed in our study. These types of milk flow patterns are very important. They characterize better-adapted animals to machine milking, because it is assumed that they achieve milk ejection during milking. Therefore it can be supposed that at least during around 69% milkings the sheep released oxytocin during machine milking and that the breeds Tsigai, Improved Valachian and their crosses with Lacaune also have a suitable potential for machine milking (at least the milk ejection reflex). However, further research in physiological responses of the above-mentioned breeds and crossbreds to machine milking conditions is required.

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