Study on milkability traits in different dairy ewe breeds

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Abstract

Milkability of dairy ewes is a complex functional trait that can be characterised by milk yield, milk flow traits and the efficiency of milk removal during machine milking. The aim of this study was to evaluate selected milkability indicators in 151 ewes of three purebred breeds, Tsigai, Lacaune and Improved Valachian, from the first to the third lactation. The animals were monitored under machine-milking conditions during four control milk measurements representing different stages of lactation. The evaluated traits were total milk yield, machine milk yield, machine stripping ratio and maximum milk flow. Breed had a highly significant effect on total milk yield, machine milk yield and maximum milk flow ($P < 0.001$). The mean total milk yield was 0.412 L/ewe/milking, machine milk yield was 0.306 L/ewe/milking, machine stripping ratio was 15.907%, and maximum milk flow was 25.804 mL/s. Lactation number significantly affected total milk yield, and pairwise comparison also indicated a difference in machine milk yield between the second and third lactations. Control milk measurement significantly affected all evaluated traits. With advancing lactation, total milk yield and machine milk yield decreased, whereas the machine stripping ratio increased. These results indicate that breed and stage of lactation are important factors influencing machine milkability in dairy ewes.

Keywords: dairy ewes, machine milking, milkability, milk flow, breed

Introduction

Machine milking is an important component of modern dairy ewe production, because it influences labour efficiency, udder emptying, milking time and the practical suitability of animals for intensive or semi-intensive dairy systems. In dairy ewes, milkability is a complex functional trait that can be characterised by total milk yield, machine milk yield, milk flow traits, machine stripping, udder morphology and the proportion of milk obtained during different phases of milking. Recent studies on dairy sheep and small ruminants have shown that these traits are affected by breed, udder conformation, stage of lactation, milk flow curve type, milking routine and individual animal response to machine milking (Tančin et al., 2011; Olechnowicz, 2012; Margetín et al., 2013; Džidić et al., 2019; Costa et al., 2022; Kaskous, 2022).

In Central European sheep production, Tsigai and Improved Valachian represent traditional local breeds, whereas Lacaune is a specialised dairy breed frequently used to improve milk production and machine milkability. Previous research on these breeds and their crosses demonstrated that genotype is an important source of variation in milkability traits (Milchevskiy et al., 2020). Tančin et al. (2011) reported that genotype significantly influenced most milkability parameters in Tsigai, Improved Valachian, Lacaune and their F1 crosses during machine milking throughout lactation. Similarly, Margetín et al. (2013) found that genotype, parity and stage of lactation affected several milk yield and milk flow traits in Improved Valachian, Tsigai and Lacaune purebred and crossbred ewes. Additional studies on the same or related dairy ewe populations confirmed that udder traits and milkability differ between genotypes and should be considered in breeding and management decisions (Makovický et al., 2013; Makovický et al., 2017; Makovický et al., 2019a; Makovický et al., 2019b; Makovický et al., 2022).

Udder morphology is closely related to the suitability of ewes for machine milking. The position and size of teats, udder depth, cistern characteristics and udder attachment can influence milk flow, the need for machine stripping and the completeness of udder emptying. Studies in dairy ewes have reported relationships among udder morphology, milk production, somatic cell count and udder health, supporting the inclusion of udder and milkability traits in selection programmes (de la Fuente et al., 2011; Prpić et al., 2016; Vrdoljak et al., 2020; Makovický et al., 2024). Therefore, milkability should not be interpreted only as a production trait, but as a functional trait linking milk yield, udder conformation, machine-milking efficiency and mammary gland health.

Milk flow curve type is also relevant for evaluating the suitability of ewes for machine milking. Ewes may show different milk emission patterns, including one-peak, two-peak or plateau-shaped curves, and these patterns are associated with differences in machine milk yield, stripping percentage and udder emptying. In Tsigai, Improved Valachian and Lacaune ewes, Mačuhová et al. (2012) found that milk flow type was related to residual milk, and that Lacaune ewes had lower residual milk than Tsigai and Improved Valachian ewes. More recent studies in crossbred and Sarda dairy ewes also confirmed that milk flow type affects milk production and milkability traits, and that monitoring milk emission curves may help to adapt milking management to the individual milkability of ewes (Mačuhová et al., 2019; Costa et al., 2022). Besides breed and udder morphology, lactation-related factors are also important in the evaluation of dairy ewe milkability. Stage of lactation may influence total milk yield, machine milk yield, milk flow and the proportion of milk obtained by machine stripping. Therefore, repeated control milk measurements during lactation can provide useful information on changes in milkability traits and on the suitability of different breeds for machine milking under practical farming conditions.

The objective of this study was to evaluate the influence of breed, lactation number and control milk measurement, representing the stage of lactation, on selected indicators characterising the milkability of Tsigai, Improved Valachian and Lacaune dairy ewes under machine-milking conditions.

Methodology

The study was carried out in the experimental flock of the Animal Production Research Centre Nitra, located in Trenčianska Teplá, Slovak Republic (48.92535780758216° N, 18.13504919438285° E). The measurements were performed during the milking season under machine-milking conditions.

A total of 151 dairy ewes of three purebred breeds (Tsigai, Improved Valachian and Lacaune) were included in the study. The animals were in their first to third lactation. Ewes of all three breeds were housed and fed under the same conditions throughout the entire monitoring period.

Machine milking was performed in a 1 × 24 row milking parlour. The milking machine was operated at a pulsation frequency of 160 cycles per minute, a pulsation ratio of 50:50 and a vacuum level of 43 kPa.

Four control milk measurements were carried out during the milking period. At the first control measurement, the experimental ewes were, on average, at 75 days of lactation. At the second, third and fourth control milk measurements, the ewes were, on average, at 103, 139 and 167 days of lactation, respectively. The control milk measurement, therefore, represented the stage of lactation.

The following indicators characterising milk production and milkability were evaluated: total milk yield (TMY), machine milk yield (MMY), machine stripping ratio (MS/TMY, %) and maximum milk flow. Total milk yield was defined as the total amount of milk obtained during machine milking, including machine milk yield and machine stripping. The amount of milk was determined using a measuring device consisting of a measuring cylinder equipped with an electromagnetic rod for sensing the milk level. The device was connected to a computer, which registered the milk level in the cylinder at one-second intervals.

Statistical analysis was performed using the restricted maximum likelihood (REML) methodology and the MIXED procedure of the SAS statistical package. The following statistical model with fixed and random effects was applied:

$y_{ijklm} = \mu + Y_i + LS_j + GEN_k + Pl + anm + a \times DIM_{ijklm} + e_{ijklm}$

where:

y_{ijklm} is the observed trait;

Y_i is the fixed effect of year, with 4 to 7 levels;

LS_j is the fixed effect of control milk measurement (lactation stage), with 4 levels: 40th to 99th lactation day, 100th to 129th lactation day, 130th to 159th lactation day and 160th to 210th lactation day;

GEN_k is the fixed effect of genotype/breed group;

Pl is the fixed effect of parity, with 3 levels: first, second and third lactation; anm is the random effect of animal;

DIM_{ijklm} is days in milk, included as a covariate; a is the regression coefficient for days in milk;

e_{ijklm} is the random residual error.

Differences were considered statistically significant at $P < 0.05$.

Results and Discussion

Table 1 summarises the mean values and variability of the evaluated milkability indicators in the analysed population of 151 dairy ewes. The least squares mean (LSM) for total milk yield was 0.412 L/ewe/milking, while machine milk yield averaged 0.306 L/ewe/milking. The mean machine stripping ratio (MS/TMY) was 15.907%, and maximum milk flow averaged 25.804 mL/s. The greatest variability was observed for maximum milk flow (CV = 54.33%; range 0 to 84.786 mL/s), followed by the machine stripping ratio (CV = 41.78%; range 3.267 to 48.333%). High variability in milk flow and machine stripping traits is common in dairy ewes because these indicators reflect both milk production level and individual response to machine milking (Tančin et al., 2011; Mačuhová et al., 2012; Costa et al., 2022).

The analysis of variance is presented in Table 2. Breed had a highly significant effect ($P < 0.001$) on total milk yield, machine milk yield and maximum milk flow, whereas its effect on the machine stripping ratio was not significant. Lactation number significantly affected only total milk yield ($P < 0.05$). Control milk measurement, which represented the stage of lactation, significantly affected all evaluated traits: total milk yield and maximum milk flow at $P < 0.05$, and machine milk yield and machine stripping ratio at $P < 0.001$. The interaction between breed and control milk measurement was significant for total milk yield and machine milk yield ($P < 0.01$). Days in milk significantly affected the machine stripping ratio ($P < 0.001$) and maximum milk flow ($P < 0.05$).

The least squares means according to the analysed factors are shown in Table 3. Among breeds, Lacaune ewes had the highest total milk yield (0.558 L/ewe/milking), machine milk yield (0.376 L/ewe/milking) and maximum milk flow (34.87 mL/s). Tsigai and Improved Valachian ewes had lower values for these indicators. The machine stripping ratio did not differ significantly among breeds. These results confirm the importance of breed-specific evaluation of machine milkability in dairy ewes, particularly when local breeds are compared with specialised dairy breeds such as Lacaune (Tančin et al., 2011; Margetín et al., 2013; Makovický et al., 2019a).

Lactation number had a significant overall effect on total milk yield. Although the overall effect of lactation number on machine milk yield was not significant in the analysis of variance, the pairwise comparison of least squares means indicated a significant difference between the second and third lactations for machine milk yield. No significant differences among lactation numbers were observed for the machine stripping ratio or maximum milk flow. The limited effect of lactation number suggests that, under the conditions of this study, breed and control milk measurement were more important determinants of the evaluated milkability traits than parity. However, parity effects may differ according to flock structure, breed composition and the traits evaluated, as shown by previous studies on dairy ewes (Margetín et al., 2013; Libis-Márta et al., 2021). Similarly, Meraï et al. (2014) reported that milk production in Sicilo-Sarde dairy sheep was affected by several non-genetic factors, including flock, year and month of lambing, parity, suckling length, litter size and milking-only length, confirming that production traits in dairy ewes are strongly influenced by management and lactation-related factors. During the successive control milk measurements, total milk yield decreased from 0.559 to 0.286 L/ewe/milking, and machine milk yield decreased from 0.512 to 0.135 L/ewe/milking. At the same time, the machine stripping ratio increased from 4.984% at the first control measurement

to 45.152% at the fourth control measurement, while maximum milk flow decreased from 31.794 to 1.147 mL/s. These results indicate a marked change in milkability traits with advancing stage of lactation. Similar effects of control milk measurement or month of lactation on milkability traits have been reported in Tsigai, Improved Valachian, Lacaune and crossbred ewes (Tančin et al., 2011; Margetín et al., 2013; Mačuhová et al., 2019).

Table 1: Mean values and variability of selected milkability indicators of the analysed population

Indicators	n*[2]	LSM	Standard error	v (%)	min.	max.
Total milk yield (L/ewe/milking)	151	0.412	0.114	27.57	0.087	1.339
Machine milk yield (L/ewe/milking)	151	0.306	0.124	40.47	0.044	1.060
Machine stripping ratio MS/TMY (%)	151	15.907	6.647	41.78	3.267	48.333
Maximum milk flow (mL/s)	151	25.804	14.018	54.33	0	84.786

Table 2: Analysis of variance of selected milkability indicators

Indicators	R*[2]	Breed	Lactation numbers	Control milk measurement	Interaction Breed x Lactation number	Interaction Breed x control milk measurement	Days in milk
Total milk yield (L/ewe/milking)	0.751	57.00+++	3.72+	3.86+	0.86	3.07++	0.42
Machine milk yield (L/ewe/milking)	0.598	14.88+++	2.60	6.17+++	0.16	3.01++	0.55
Machine stripping ratio MS/TMY (%)	0.350	2.01	0.97	9.15+++	6.80+++	0.36	16.09+++
Maximum milk flow (mL/s)	0.269	11.98+++	0.57	3.81+	1.27	1.27	6.60+

+ P < 0.05; ++ P < 0.01; +++ P < 0.001

Table 3: Least squares means (LSM) of selected milkability indicators according to the analysed factors

Source of variation	Total milk yield (L/ewe/milking)	Machine milk yield (L/ewe/milking)	Machine stripping ratio MS/TMY (%)	Maximum milk flow (mL/s)
Genotype				
Tsigai (1)	0.327	0.234	15.735	28.59
Lacaune (2)	0.558	0.376	13.249	34.87
Improved Valachian(3)	0.319	0.273	15.945	17.26
Significant differences	1:2+++ 2:3+++	1:2+++ 2:3++		2:3+++ 1:3++ 1:2+
Lactation number				
1.	0.405	0.298	15.334	27.071
2.	0.369	0.265	13.896	28.261
3.	0.430	0.320	15.699	25.388
Significant differences	2:3++	2:3+		
Control milk measurement				
1.	0.559	0.512	4.984	31.794
2.	0.435	0.339	21.157	21.522
3.	0.325	0.191	36.335	7.736
4.	0.286	0.135	45.152	1.147
Significant differences	1:2,3++ 1:4+ 2:3+	1:2,3+++ 1:4++ 2:3++ 2:4+	1:2,3,4++ 2:3,4+	1:2,3,4+++ 2:3,4+++ 3:4+++

+ P < 0.05; ++ P < 0.01; +++ P < 0.001

The breed effect observed in the present study is consistent with earlier ewe-specific studies showing that genotype influences milk yield, machine milk yield, milk flow traits and udder characteristics. In particular, studies on Tsigai, Improved Valachian, Lacaune and their crosses showed that Lacaune and Lacaune-crossbred ewes generally express more favourable milk production or milkability parameters than local purebred ewes (Tančin et al., 2011; Margetín et al., 2013). Morphological studies in the same breed groups also demonstrated genotype differences in udder and teat characteristics, which may partly explain differences in milk flow and machine milkability (Makovický et al., 2013; Makovický et al., 2017; Makovický et al., 2019b).

The decrease in maximum milk flow and the simultaneous increase in machine stripping ratio may be interpreted as signs of reduced efficiency of milk removal during the later control measurements. Mačuhová et al. (2012) showed that milk flow type was related to the amount of residual milk in Tsigai, Improved Valachian and Lacaune ewes, and that Lacaune ewes had lower residual milk than Tsigai and Improved Valachian ewes. In Sarda sheep, Costa et al. (2022) also demonstrated that milkability traits differ among milk flow curve types, with practical implications for avoiding overmilking and adapting milking management. These findings support the interpretation that milk flow traits and stripping ratio are useful indicators of the efficiency of machine milk removal.

The relationship between udder morphology and milkability should also be considered when interpreting differences among breeds. Udder conformation traits have been associated with milk yield, somatic cell count and udder health in dairy ewes (de la Fuente et al., 2011; Prpić et al., 2016). Recent reviews and breed-specific studies also emphasise that udder and teat morphology influence the suitability of small ruminants for machine milking and should be included in selection or management programmes (Vrdoljak et al., 2020; Makovický et al., 2024). Therefore, the differences observed in the present study may be related not only to production potential but also to breed-related differences in udder structure and milk emission pattern.

From a practical perspective, the increase in the machine stripping ratio during the milking period is significant because higher stripping requirements can increase labour input and may indicate less efficient machine milking. Recent studies and reviews on small ruminant machine milking emphasise that milking routines, machine settings, cluster removal and the adaptation of management to milk flow characteristics are important for efficient milk removal and for reducing overmilking and mammary gland stress (Olechnowicz, 2012; Džidić et al., 2019; Vrdoljak et al., 2020; Kaskous, 2022).

Although entrance order was not evaluated in the present study, previous studies suggest that behavioural and management factors may also contribute to variation in milkability. Jackuliaková et al. (2014) showed that relocation and changed milking conditions may affect milk flow kinetics in ewes. Mačuhová et al. (2017) found that ewes entering the milking parlour earlier had more favourable milkability parameters than those milked later. Similarly, Libis-Márta et al. (2021) reported an association between entrance order and milk production in Lacaune ewes. These findings indicate that milkability should be evaluated not only as a production trait, but also as a trait affected by animal behaviour and the stability of milking routines.

Overall, the present results confirm that breed and stage of lactation are key factors affecting milkability traits in dairy ewes. The higher total and machine milk yield of Lacaune ewes, together with the marked decrease in milk yield and maximum milk flow during later control measurements, indicates that breed- and lactation-stage-specific evaluation is needed when optimising machine-milking management in mixed dairy ewe flocks.

Conclusions

Breed and stage of lactation were the main factors affecting milkability traits in the evaluated dairy ewes. Lacaune ewes showed the highest total milk yield, machine milk yield and maximum milk flow. During successive control milk measurements, total and machine milk yield decreased, while the machine stripping ratio increased, indicating a decline in the efficiency of machine milk removal with advancing lactation. These findings support the importance of breed- and lactation-stage-specific evaluation when optimising machine milking in dairy ewe flocks.

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