Milkability of Improved Valachian, Tsigai and Their Crosses With Lacaune and East Friesian

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Keywords: *dairy sheep, machine milking, milkability, systematic effects.*

Abstract. *Milkability is defined as the ability of an animal to give a regular, complete, and rapid milk secretion by the mammary gland in response to a proper milking technique. Indicators of milk production and milkability of ewes were determined in 359–370 ewes of 9 genotypes. For each ewe, the milk flow was recorded during the individual control measurements. The amount of milked milk was measured in individual time intervals after the attachment of milking cups to teats on udder of the ewe (10 indicators). We processed the obtained data using the REML methodology, with the MIXED procedure of the SAS statistical package. All indicators characterizing milk production and milkability of ewes were statistically significantly influenced by the genotype and the control year factors ($p < 0.001$). The order and stage of lactation were also significant factors in some cases. The machine milk yield of the monitored population of ewes was 318.26 mL on average. The total milk yield was 436.58 mL and the machine stripping ratio was 27.73% on average, ranging from 0 to 95%. The highest machine stripping ratio was determined in the Lacaune breed (37.69%), which had the highest total milk yield (524.69 mL) and one of the highest machine milk yield (332.70 mL). Compared with purebred Tsigai ewes and ewes of the Improved Valachian breed, crossbreeds with specialized dairy breeds (Lacaune and East Friesian) had better milk production and, in some indicators, also better milkability.*

Introduction

The machine milking of Improved Valachian and Tsigai in Slovakia already started during 1960s. Introduction of milking machines required information related to the milkability of ewes and search for the best milking parameters. Therefore, many experiments were carried out concerning milkability of the mentioned breeds in Slovakia between 1960s and 1980s (Mikuš, 1973), in cooperation with France (Labussiere, 1988). However, machine technology did not spread to farms in a larger scale since that time in Slovakia.

Genetic improvement of the milkability is the main tool to improve cheese production, and consequently the income of the producers. Many factors, such as breed, feeding or parity, have an influence on the quantity and the composition of sheep milk (Libis-Márta, 2021).

Milk, a product that is consumed by newborns to develop and grow, is one of the most important products of livestock. It is the main source of nutrition in feeding a human and animal offspring. Increasing demand for cheese made from processed ewe milk indicates that dairy sheep are becoming an interesting economic alternative for farmers. Farms with high-producing dairy sheep usually milk large flocks automatically (by machine milking) and conduct milking twice-daily throughout the lactation period. As a result, more than half of the total daily labor on dairy sheep farms is spent on milking (Marnet and McKusick, 2001), and therefore milking is one of the main reasons that deters people from dairy sheep production.

Milking characteristics and udder morphology are important factors determining milkability in dairy ewes. Machine milking benefits are maximal milk yield with better hygienic properties than hand-milked milk and easier stripping.

Milk flow kinetics is related to milk production (Mioč et al., 2009; Kremer et al., 2015; Kremer and Roses, 2016; Turkyilmaz et al., 2018; Salamon et al., 2019; Panayotov et al., 2018; Dhaoui et al., 2019; Pourlis, 2020; Prpic et al., 2020; Sevov et al., 2018; Vrdoljak et al., 2020; Devi et al., 2022), especially in non-well genetically selected breeds (Mačuhová et al., 2020; Costa et al., 2022). It can indicate the occurrence of a milk ejection reflex, which is crucial for complete milk extraction and, thus, for milk production. Milk within the udder of dairy ruminants can be divided into two fractions: the cisternal fraction, which has already been transferred from the alveoli to the cistern during the intermilking interval (immediately obtainable without prior milk ejection),

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and the alveolar fraction, which can be induced from the udder only if milk ejection occurs during machine milking (Tancin and Bruckmaier, 2001). A ide range of differences between dairy species exists with respect to the proportion of total milk that can be stored within a cistern. For example, following a normal milking interval of 12 to 14 h, the dairy ewe and goat can store up to 75% of the total milk volume within a cistern (Marnet and McKusick, 2001).

Improving milkability is a major issue to consider in breeding dairy species. Milking is the most time-consuming task in dairy farming. The constant increase in the average flock size and its productivity has been contributing to the extension of the milking time. In Slovakia, Lacaune ewes are selected for milk production traits, because of somatic cell count and udder morphology. On the one hand, selection of udder morphology aims to improve milking ability indirectly. Direct assessment of the milk flow can be assessed with automatic milking jars (Marie-Etancelin et al., 2006).

Milk production and milk flow profiles are important parameters to be recorded and evaluated, as being informative about milking management.

Monitoring the milkability of animals allows improving efficiency of milking procedures and reducing farm production costs. It is noted that udder traits like depth, udder attachment or teat placement are correlated with milk production, machine milking extraction or mastitis incidence.

The aim of the presented work was to determine the milk production and milkability of ewes in the breed Improved Valachian (IV), Tsigai (T), Lacaune (LC) and their crossbreeds with a 25%, 50% and 75% genetic share of specialized dairy breeds (SDB) Lacaune and East Frisian. At the same time, we analyzed genetic and non-genetic factors which influence selected indicators qualifying the milkability of ewes during the milking period under machine milking conditions.

Materials and methods

The breed Improved Valachian originated from a coarse wool Valachian breed in Slovakia, where intensive cross-breeding programme started in 1950. To improve wool, meat and milk production, the crossing with a wide range of breeds (Leicester, Lincoln, Texel, Cheviot, Kent and East Friesian sheep) was attempted. The Improved Valachian was recognized as an independent dual-purpose breed (wool-meat and meat-milk, respectively) in 1982. Tsigai and Improved Valachian are very similar in production potential. At present, Tsigai and Improved Valachian are crossed with the purpose to improve their milk production, milkability and prolificacy with specialized dairy breeds as Lacaune and East Friesian. We included biological material from the Center of Animal Production Research Nitra of Institute of Sheep and Goat Breeding Trencianska Tepla in our experiments. In this farming, during the milking period, under machine milking conditions, we determined the milk production and milkability of ewes of various breeding groups over a period of 7 years. The kinetics of milk ejection was monitored during the milking period. The animals were bred and managed within one dairy flock.

The ewes were milked twice a day during the lactation period, in each of the monitored years. Machine milking was performed in a row milking parlor 1 x 24 stalls, with a sliding fixing device (vacuum 38 kPa; number of pulses 140-160 / min pulsation ratio 1:1). The included ewes represented purebred individuals of the Valachian, Tsigai and Lacaune breeds. In addition to the purebred ewes of the breeds Improved Valachian, Tsigai and Lacaune, the experiment also included ewes crossbred with different genetic proportions of improved breeds Lacaune and East Frisian. The crosses created on the basis of the Improved Valachian breed and on the basis of the Tsigai breed were divided into six genotypic groups, with a 25%, 50% and 75% genetic share of Lacaune and East Friesian dairy breeds (IV x SDB 25%, IV x SDB 50%, IV x SDB 75%, T x SDB 25%, T x SDB 50%, T x SDB 75%). We compared the functional and morphological properties of the udder of selected ewes of 9 genotypes (3 purebred breeds, 6 genotype groups of hybrids). Most crosses created on the basis of a breed of Tsigai or the Improved Valachian formed two-breed crossbreeds with a 25%, 50% and 75% genetic share of the Lacaune breed. Three-breed crossbreeds with a 25%, 50% and 75% genetic share of both Lacaune and East Frisian dairy breeds represented a significantly smaller part of the evaluated population (17 ewes, i.e. about 5% of the evaluated population). In the experimental ewes of all 9 genotypes, ewes were presented in the first, second, third and subsequent lactations in each of the monitored years. Most measurements were taken in May and July. Experimental measurements were always performed in the evening, and then in the morning milking. During the milking period, at least 2, and in some years up to 4, milk control measurements were performed. Some ewes were included in the experiment within two or even more years, which shows that we performed up to 8 control measurements of milk on some ewes. The specific number of observations of the selected indicators, depending on genotype, order and stage of lactation, are given in the relevant Tables 2 to 5.

During the individual control measurements, the milk flow was recorded for each ewe, at individual time intervals after the attachment of the teat cups to the udder of the ewe. Certified milk meters standardly used by Breeding Services, š. p. Bratislava for the control of sheep milk yield, were applied, with the measurement accuracy ± 10 mL. In this case, we recorded the amount of milked milk at 10-second intervals until the milk flow stopped and the amount

Table 1. Basic variational-statistical characteristics of selected indicators characterizing milk production and milkability of ewes

Indicators	n*2	$\overline{x}$	s	v	min.	max.
Milk yield in 10 s (MY10s) (mL)	1029	90.13	76.45	84.82	0	400
Milk yield in 30 s (MY30s) (mL)	1218	220.40	100.78	45.73	0	650
Milk yield in 60 s (MY60s) (mL)	1159	307.15	154.09	50.17	0	1200
Machine milk yield (MMY) (mL)	1218	318.26	166.90	52.44	10	1200
Milking time (s)	1218	62.67	16.10	25.69	15	160
Total milk yield (mL)	1218	436.58	197.11	45.15	30	1339
Machine stripping (mL)	1218	118.69	91.85	77.39	0	775
Machine stripping ratio MS/TMY (%)	1218	27.73	15.53	56.00	0	95
Milk yield ratio in 30s MY30s/MMY (%)	1218	53.83	18.35	34.09	0	100
Milk yield ratio in 60s MY60s/MMY (%)	1159	69.35	17.01	24.52	0	100

*[2]n – number of observations; $\overline{x}$ – mean value; s – standard deviation; v – variation coefficient

Table 2. Analysis of covariance of indicators of milk production and milkability of ewes

Source of variance	**(df)**	**Trait**									
		MY10s		MY30S		MY60S		MMY		MT	
		f value	*p* > *f*	*f* value	*p* > *f*	*f* value	*p* > *f*	*f* value	*p* > *f*	*f*value	*p* > *f*
Year	5	97.04	< 0.0001	36.68	< 0.0001	24.82	< 0.0001	22.58	< 0.0001	32.69	< 0.0001
Lactation stage	3	0.60	0.6147	2.25	0.0808	8.88	< 0.0001	10.11	< 0.0001	0.37	0.7749
Genotype	8	4.01	0.0001	3.61	0.0004	9.45	< 0.0001	12.92	< 0.0001	7.11	< 0.0001
Parity	2	1.95	0.1434	3.15	0.0043	5.33	0.0050	4.86	0.0080	0.52	0.5947
Days in milk	1	0.41	0.5231	9.76	0.0018	21.87	< 0.0001	38.46	< 0.0001	9.10	0.0026
Source of variance	**(df)**	**Trait**									
		TMY		MS		MS/TMY		MY30s/MMY		MY60s/MMY	
		f value	*p* > *f*	*f* value	*p* > *f*	*f* value	*p* > *f*	*f* value	*p* > *f*	*f* value	*p* > *f*
Year	6	32.10	< 0.0001	8.71	< 0.0001	6.64	< 0.0001	8.65	< 0.0001	4.97	< 0.0001
Lactation stage	3	14.52	< 0.0001	1.93	0.1235	0.80	0.4960	3.88	0.0090	1.68	0.1688
Genotype	8	29.30	< 0.0001	21.58	< 0.0001	8.54	< 0.0001	15.69	< 0.0001	9.59	< 0.0001
Parity	2	0.60	0.5469	8.10	0.0003	9.37	< 0.0001	2.74	0.0652	10.15	< 0.0001
Days in milk	1	48.69	< 0.0001	1.52	0.2175	0.25	0.6163	0.30	0.5848	0.00	0.9582

+++ $p < 0.001$; ++$p < 0.01$; +$p < 0.05$

Table 3. Influence of genotype on individual indicators characterizing milk production and milkability of ewes – I

Source of variance				Trait									
				MY10s *1		MY30S*2		MY60S*3		MMY*2		MT*2	
				LSM ± SE		LSM ± SE		LSM ± SE		LSM ± SE		LSM ± SE	
				Genotype									
Improved Valachian (100)	**186*1**	**218*2**	**200*3**	**88.79**	**5.584**	**200.93**	**9.116**	**277.46**	**12.666**	**274.35**	**13.001**	**57.65**	**1.268**
IVxSDB (25%) (125)	49	68	67	88.15	10.994	249.87	15.448	341.35	21.052	354.97	22.115	63.47	2.161
IVxSDB (50%) (150)	69	93	91	84.53	8.791	221.87	12.955	324.24	17.666	343.16	18.529	63.05	1.813
IVxSDB (75%) (175)	79	82	82	72.65	8.560	220.56	13.720	337.87	18.663	366.49	19.617	67.31	1.926
Tsigai (200)	**244**	**268**	**244**	**80.52**	**5.027**	**176.42**	**8.411**	**209.21**	**11.766**	**207.60**	**12.004**	**55.12**	**1.171**
TxSDB (25%) (225)	10	18	15	109.87	22.724	226.64	31.429	331.59	43.245	314.55	44.573	56.79	4.281
TxSDB (50%) (250)	135	169	164	89.11	6.422	226.42	9.989	307.06	13.571	327.16	14.226	62.48	1.379
TxSDB (75%) (275)	25	47	47	85.27	13.014	212.24	20.324	305.18	27.383	337.05	28.778	66.43	2.746
Lacaune (300)	**222**	**255**	**249**	**53.61**	**5.294**	**216.59**	**8.642**	**315.18**	**11.773**	**332.70**	**12.312**	**62.88**	**1.194**
Significant differences				100:300+++; 125:300+; 150:300++; 175:300+; 200:300+++; 225:300+; 250:300+++; 275:300+;		100:125++; 100:200+; 125:200+++; 175:200++; 200:250,300+++;		100:125,175++; 100:150,300+; 100:200+++; 125:200+++; 150:200+++; 175:200+++; 200:250,300+++; 200:225,275++;		100:125,150,250++; 100:175,200,300+++; 100:275+; 125:200+++; 150:200+++; 175:200+++; 200:225+; 200:250,275,300++;		100:125,150,250+; 100:175+++; 100:275,300++; 125:200+++; 150:200+++; 175:200+++; 175:225,250,300+; 200:250,275,300+++; 225:275+;	

+++ $p < 0.001$; ++$p < 0.01$; +$p < 0.05$; ns – non-significant; *1, *2, *3 – number of measurements depending on the indicator

Table 4. Influence of genotype on individual indicators characterizing milk production and milkability of ewes – II

Source of variance			Trait									
			TMY*1		MS*1		MS/TMY*1		MY30s/MMY*1		MY60s/MMY*2	
			LSM ± SE		LSM ± SE		LSM ± SE		LSM ± SE		LSM ± SE	
Genotype												
IV (100)	**218*1**	**200*2**	**349.61**	**14.314**	**76.81**	**8.298**	**24.06**	**1.435**	**58.92**	**1.669**	**75.21**	**1.607**
IVxSDB (25%) (125)	68	67	446.98	24.258	91.68	14.022	23.09	2.442	55.06	2.833	72.80	2.671
IVxSDB (50%) (150)	93	91	460.40	20.343	119.88	11.772	27.79	2.046	50.27	2.375	68.89	2.241
IVxSDB (75%) (175)	82	82	495.08	21.544	130.00	12.478	27.96	2.166	46.03	2.514	65.31	2.367
T (200)	**268**	**244**	**278.53**	**13.208**	**73.39**	**7.656**	**27.41**	**1.324**	**64.03**	**1.540**	**71.87**	**1.492**
TxSDB (25%) (225)	18	15	429.11	49.353	115.94	28.721	27.97	4.906	52.93	5.741	73.01	5.480
TxSDB (50%) (250)	169	164	435.95	15.685	110.82	9.104	26.71	1.568	54.45	1.828	69.79	1.720
TxSDB (75%) (275)	47	47	496.30	31.915	159.43	18.507	32.48	3.165	45.59	3.710	63.25	3.464
LC (300)	**255**	**249**	**524.69**	**13.571**	**194.51**	**7.875**	**37.69**	**1.357**	**42.93**	**1.582**	**58.93**	**1.492**
Significant differences			100:125,150,175, 200,250,275,300+ ++; 125:200+++; 125:300++; 150:200+++; 150:300++; 175:200+++; 175:250+; 200:225++; 200:250,275,300+++; 250:300+++;		100:150,250++; 100:175,275,300+++; 125:175+; 125:275++; 125:300+++; 150:200,300+++; 175:200,300+++; 200:250++; 200:275,300+++; 225:300++; 250:275+; 250:300+++;		100:275+; 100:300+++; 125:275+; 125:300+++; 150:300+++; 175:300+++; 200:300+++; 225:300+; 250:300+++;		100:150,275++; 100:175,300+++; 100:200+; 125:175,275+; 100:200++; 100:300+++; 150:200+++; 150:300+; 175:200+++; 175:250++; 200:250,275,300+++; 250:275+; 250:300+++;		100:150,250+; 100:175,300+++; 100:275++; 125:175,275+; 125:300+++; 150:300+++; 175:200,300+; 200:275+; 200:300+++; 225:300+; 250:300+++;	

+++ $p < 0.001$; ++ $p < 0.01$; + $p < 0.05$; ns – non-significant; *1, *2, – number of measurements depending on the indicator

Table 5. The influence of the order and stage of lactation on the indicators characterizing milk production and milkability of ewes

Source of variation					MY10S*1		MY30S*2		MY60S*3		MMY*2		MT*2	
					LSM ± SE		LSM ± SE		LSM ± SE		LSM ± SE		LSM ± SE	
Parity														
1.	(1)	370*1	434*2	425*3	87.87	4.302	226.25	6.167	323.04	8.546	335.41	8.893	61.76	0.892
2.	(2)	317	348	321	80.76	4.444	214.71	6.862	300.69	9.608	310.88	10.046	61.12	1.039
3+	(3)	342	436	413	79.86	4.804	209.55	7.122	292.64	9.914	306.39	10.335	62.18	1.046
Significant differences					ns		1:3+;		1:2+; 1:3++;		1:2,3++;		ns	
Lactation stage														
40.– 99. day	(1)	184	261	251	91.21	9.183	225.46	12.489	330.04	18.088	334.05	19.063	61.94	2.151
100.–129. day	(2)	324	366	357	86.16	5.191	223.27	7.204	302.46	10.110	305.74	10.660	61.29	1.136
130.–159. day	(3)	289	335	316	81.05	5.106	205.36	7.755	277.06	11.250	293.79	11.545	61.28	1.244
160.–210. day	(4)	232	256	235	72.92	8.347	213.26	12.071	312.28	17.846	336.64	18.417	62.25	2.078
Significant differences					ns		ns		1:3+; 3:4++;		1:2+; 3:4+++;		ns	

Source of variation				TMY*1		MS*1		MS/TMY*1		MY30s/MMY*1		MY60s/MMY*2	
				LSM ± SE		LSM ± SE		LSM ± SE		LSM ± SE		LSM ± SE	
Parity													
1.	(1)	434*1	425*2	440.33	9.684	226.25	6.167	323.04	8.546	335.41	8.893	61.76	0.892
2.	(2)	348	321	429.85	10.774	214.71	6.862	300.69	9.608	310.88	10.046	61.12	1.039
3+	(3)	436	413	435.36	11.182	209.55	7.122	292.64	9.914	306.39	10.335	62.18	1.046
Significant differences				ns		1:2+;1:3+++;2:3+;		1:2+;1:3+++;2:3+;		1:3+;		1:2++; 1:3+++; 2:3+;	
Lactation stage													
40.– 99. day	(1)	261	251	462.81	19.609	132.18	10.874	26.65	2.157	48.54	2.352	70.21	2.333
100.–129. day	(2)	366	357	420.67	11.311	117.44	6.412	27.03	1.193	53.18	1.340	70.71	1.294
130.–159. day	(3)	335	316	405.87	12.176	112.46	6.872	29.25	1.295	53.90	1.450	67.34	1.443
160.–210. day	(4)	256	235	451.38	18.952	114.57	10.514	30.48	2.084	53.37	2.273	67.07	2.302
Significant differences				1:2++; 1:3+;3:4+++;		ns		ns		1:2++;		ns	

+++ $p < 0.001$; ++$p < 0.01$; +$p < 0.05$; ns – non-significant; *1, *2, *3 – number of measurements depending on the indicator of milk remained at the same level for at least 20 seconds. If the milk flow was not detectable for 20 seconds using our specific meters, the timekeeper instructed the milker to start the machine stripping. All ewes were machine stripped for another 60 seconds. If the milk flow was noticeable for more than 60 seconds, then machine milking continued and a new machine stripping was done only from the moment when no milk flow was recorded in the previous 20 seconds. The sheep were machine stripped again at the instruction of the timekeeper until the milk flow stopped. We also recorded the amount of milk drawn at 10-second intervals during each machine stripping. Based on the individual recording of the milk release of each ewe in 10 seconds, or at second intervals, we evaluated:

- Milk yield in 10 s (MY10s)
- Milk yield in 30 s (MY30s)
- Milk yield in 60 s (MY60s)
- MY30s/MMY (%)
- MY60s/MMY (%)
- Machine milk yield (MMY) (mL)
- Machine stripping (MS) (mL)
- Total milk yield (mL)
- MS/TMY (%)
- Milking time (s)

The machine milk yield represented the amount of milk drawn after the milking set was put on (without prior udder stimulation) until the milk flow was completed within 20 seconds time interval. Machine stripping represents the amount of milk drawn from the beginning of machine stripping to the withdrawal of the milking set.

Data were processed by REML methodology using a MIXED procedure from the SAS statistical package. The following statistical model with fixed and random effects was applied:

$$yijklm = \mu + Y_i + LSj + GEN_k + P_l + an_m + a*DIM_{ijklm} + e_{ijklm}$$

where:

y_{ijklm} is an observed trait (see above for details); Y_i – year (a fixed effect with 4 to 7 levels); LSj – lactation stage, a fixed effect with 4 levels (from 40th to 99th lactation day, from 100th to 129th lactation day, from 130th to 159th lactation day and from 160th to 210th lactation day); GEN_k – genotype (breed group; a fixed effect with 9 levels; see above for detail characterization); P_l – parity (a fixed effect with 3 levels; first, second, third and further parity); an_m – animal (random effect); DIM_{ijklm} – days in milk (covariate; 40 to 210 days in milk); e_{ijklm} – the random error.

The differences were statistically significant at $p < 0.05$, or less.

Results

As can be seen from Table 1, we observed a large variability in the evaluated population for all indicators characterizing milk production and milk yield of ewes. The average total milk yield at the level of 436.58 mL is not high, if we consider the fact that in the monitored population there were also high-producing purebred ewes of the Lacaune breed. In the case of selection of sheep for milk production obtained by machine milking, the machine stripping ratio should be reduced, which significantly affects labour productivity and the udder health of machine-milked ewes. For the whole monitored population of ewes, the machine stripping reached on average 318.26 mL, while the range was relatively large (10 to 1200 mL). The machine stripping ratio in the monitored population of ewes was relatively high (27.73; Table 1). When evaluating the milk flow rate, we found that in some ewes, the amount of milk yield in 10 s, 30 s or 60 s was at the level of 400 mL, 650 mL or 1200 mL, and vice versa, some ewes did not run milk at all during this time. In the best ewes, the ratio of milk yield in 30 s or 60 s of the total milk yield was up to 100%.

Our results (Table 2) show that the genotype factor has a statistically significant effect on all monitored production factors. The influence of the factors like lactation sequence, lactation stage and the day of lactation were not so highly statistically significant. On the contrary, the accompanying variable "year" had a statistically highly significant effect on all indicators we surveyed ($p < 0.001$).

Table 3 shows that the most milk yield in 10 s was found in T x SDB crosses (25% SDB) (109.87 ± 22.724 mL) and, conversely, the least milk yield in the first 10 s was found in purebred Lacaune ewes (53.61 ± 5.294 mL). Regarding the amount of milk yield in 30 seconds as an indicator, we found the most milk yield for this indicator in crosses IV x SDB (25% SDB) at the level of 249.87 ± 15.448 mL, and vice versa, the lowest average value for this indicator was found in purebred Tsigai ewes (176.42 ± 8.411 mL). For the indicator of the amount of milk yield in 60 s, we found the highest average value in crosses IV x SDB (25% SDB) (341.35 ± 21.052 mL), and vice versa, in purebred ewes of the breed Improved Valachian, we found the lowest average value for this indicator (277.46 ± 12.666 mL). The indicators evaluated by us: the amount of milk yield in 10 s, 30 s and 60 s well characterize the milk release rate of milked ewes. In practice, the more milk is yield in 60 s, the more advantageous it is for the breeder (more sheep will be milked per unit of time). As expected, we found the highest average machine milk yield in purebred ewes of the Lacaune breed (332.70 ± 12.312 mL), and conversely, the lowest average machine milk yield in the monitored population was found in purebred ewes of the Tsigai breed (207.60 ± 12.004 mL).

Table 4 shows that, as expected, we found the largest average total milk yield in purebred Lacaune ewes (524.69 ± 13.571 mL), and conversely, the lowest average value in this indicator was found in purebred Tsigai ewes at (278.53 ± 13.208 mL). The highest average machine stripping was again found in purebred ewes of the Lacaune breed (194.51 ± 7.875 mL), and conversely, the lowest average value in this indicator was found in purebred ewes of the Tsigai breed (73.39 ± 7.656 mL). The highest average machine stripping was found in purebred ewes of the Lacaune breed, up to (37.69 ± 1.357%), and vice versa, the lowest average machine stripping ratio was found in crossbreeds IV x SDB (25% SDB) at the level (23.09 ± 2.442%). In the indicator of the milk yield ratio in 30 s, we found the highest average value in purebred ewes of the Tsigai breed (64.03 ± 1.540%) and, vice versa, the lowest in purebred ewes of the Lacaune breed (42.95 ± 1.582%). In the indicator of the milk yield ratio in 60 s, we found the highest average value in purebred ewes of the Improved Valachian breed, namely (75.21 ± 1.607%), and vice versa, the lowest average value was found in purebred ewes of the Lacaune breed (58.93 ± 1.492%). Another factor considered to affect milk production and the milkability of ewes is the "lactation order" factor.

Table 5 shows that the factor "lactation order" had a statistically highly significant effect ($p < 0.001$) on the indicators of the machine stripping, the machine stripping ratio and the milk yield ratio in 60 s. We found a statistically significant effect ($p < 0.01$) in the indicators of the milk yield in 30 s and 60 s and machine mild yield. The influence of the lactation order on the indicators of the milk yield in 10 s and the time of machine milk yield was not statistically significant. The differences between the ewes on the 1st to 3rd lactation were statistically insignificant for the indicators of the milk yield in 10 s and the time of machine milk yield, except for the indicators of the milk yield in 30 s and 60 s and machine milk yield ($p < 0.01$). The best ejection of milk in the first 10 s, 30 s and 60 s and the highest average machine milk yield had ewes on the 1st lactation. Total milk yield was not statistically significantly affected by the "lactation order" factor. The ewes in the first lactation had the largest total milk yield, and the milk yield ratio in 30 s and 60 s. On the contrary, the machine stripping ratio gradually increased, reaching the highest average value (30.77 ± 1.148%) in ewes on the 3rd lactation. The influence of the factor "lactation stage" on individual indicators of milk production and milkability of ewes was statistically highly evident in the indicators of total milk yield ($p < 0.001$) and the milk yield ratio in 30 s ($p < 0.01$) and, vice versa, inconclusive for machine stripping, the machine stripping ratio, the time of machine milk yield, the milk yield in 10 s and 30 s and the milk yield ratio in 60 s.

Discussion

In dairy ewes, 25% of the total milk yield for the entire lactation is produced during the first month (Folman et al., 1966; Ricordeau et al., 1962). This is primarily due to the fact that milk production is increasing from parturition to about 24 days of lactation when the peak milk production is attained. To complicate matters, ruminants have the highest probability of mastitis during the first 45 days post-partum (Hamann, 2000). Generally, milk yield and length of lactation in sheep vary across breeds (i.e., dairy and non-dairy breeds). The East Friesian breed is widely reported as the highest milk producer with around 3100 g/day (at peak lactation) and 500–700 kg total milk yield, with the longest lactation length (around 240 days) compared with non-dairy breeds (90–150 days) (Green et al., 2016). Boyazoglu (1991) reviewed the results of experiments that evaluated the East Friesian in countries of the Mediterranean region. In all countries, the pure East Friesian was found to be unacceptable due to high incidence of respiratory disease and poor adaptability to high environmental temperatures. Only in Israel, a cross of the East Friesian with the local Awassi breed was found to result in a more productive animal than the local breed (Gootwine and Goot, 1996). East Friesian ewes also have been reported to have some undesirable milking characteristics relative to the Lacaune. Bruckmaier et al. (1997) reported that East Friesian ewes had a greater proportion of the udder cistern located below the exit into the teat channel, delayed oxytocin release and milk iniciation, slower milk flow rates during milking, and longer milking times compared with Lacaune ewes. Macuhova et al. (2007) found in 80 ewes of the breeds Improved Valachian, Tsigai, Lacaune and their crossbreeds that 28% of the ewes initiated milk during the first 10 seconds of machine milking.

According to Menzies et al. (2013), the total milk production in sheep is dependent on the shape of the lactation curve, which deals with the time and height of peak milk production (maximum daily milk yield during lactation) and the length of lactation. However, the length of lactation and peak milk production are influenced by breed, photoperiod (daylight length), nutrition, multiplicity of lactacion (first- or second-time lactation), stress and pain at milking, milking frequency and presence of intramammary infections (Pollott and Gootwine, 2004). Some studies have demonstrated that milk production is associated with litter size, i.e., in twin- and triplet- bearing ewes, thereby production is about 20 litres of milk per lactation and a 1% increase in lactation persistency than in single-bearing ewes. This was recorded in some Assaf dairy breed in Israel where the animals were kept under an intensive management system, and surprisingly, the lambs were weaned at birth (and reared artificially) on the premise of accurate measurement of the ewes' milk production (Pollott and Gootwine, 2004). A similar effect is possible in non-dairy breeds, but some differences may occur because they produce lower quantity of milk (averagely 47–103 litres) compared with the dairy breeds which produce about 234–354 litres of milk per lactation (Shrestha et al., 2008). Nieto et al. (2018) have reported a 30% reduction in milk yield of merino ewes bearing single lambs compared with the twin-bearing ewes, and there was no effect of production in the dams suckling ewe lambs or ram lambs. This impact of milk production was further explained –there was a consistently higher milk production in twin-bearing ewes than the single-bearing ones, and with a 33% and 28% decline from days 28 and 56 for the single- and twin-bearing ewes respectively. Meanwhile, the sharp decline from day 56 to 70 (57% for the singles and 42% for the twins) was associated with a lambs' decreasing dependence on milk. However, the milk yield between parturition and day 28 was not given in the study, which may be in order not to compromise the growth and development of the lambs; hence the ewes were milked near their peak lactation period (Bencini et al., 1992; Bencini and Purvis, 1990). In addition, multiparous ewes have higher peak milk production and lactation persistency than the primiparous ewes. It has been further observed in some studies (Bencini and Pulina, 1997; Paten et al., 2017; Snowder and Glimp, 1991) that heavier ewes (multiparous ewes) produced more milk than their lighter counterparts, i.e., primiparous ewes. This may be because the multiparous ewes are usually older and more matured than the primiparous, which are still undergoing physiological development.

Conclusions

Based on our results, we propose to use the indicators of the machine milk yield and the machine yield ratio in the selection of sheep for better milkability. Optionally also some others are recommended. In accordance with the trend in all sheep-developed countries, we propose to include them in the routine performance control and later in the genetic evaluation of dairy sheep in Slovakia.

Acknowledgments

M. Nagy was supported by project KEGA č. 002PU-4/2021 „Univerzitná výučba genetiky inovovanými formami a metódami."

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Received 10 March 2022
Accepted 15 June 2022