OPEN ACCESS

Potravinarstvo Slovak Journal of Food Sciences

potravinárstvo®

Slovak Journal of Food Sciences

Potravinarstvo Slovak Journal of Food Sciences
vol. 13, 2019, no. 1, p. 396-401
https://doi.org/10.5219/1059
Received: 12 March 2019. Accepted: 12 March 2019.
Available online: 28 May 2019 at www.potravinarstvo.com

ISSN 1337-0960 (online)

SOMATIC CELL COUNT DURING FIRST AND SECOND LACTATION IN EWES

Kristína Tvarožková, Vladimír Tančin, Michal Uhrinčať, Lucia Mačuhová, Martina Vršková, Marta Oravcová

ABSTRACT

The aim of this study was to describe the frequency of distribution of ewes in SCC groups on the basis SCS (somatic cells score) per lactation and estimate changes of SCC from 1st lactation on 2nd lactation. The experiment was carried at seven farms in 1st observed period (2016 and 2017) and at eight farms in 2nd observed one (2017 and 2018). Within each of periods the same animals were sampled on their 1st and following 2nd lactation in next year of study, only. Totally 1199 milk samples from 159 ewes and 1653 milk samples from 219 ewes were collected during 1st period and 2nd period, respectively. Milk sampling were taken monthly from April to August in both periods. For evaluation only ewes with minimum three sampling per year (minimum six samples per animal) were included in the study within both periods. The ewes were divided into the five SCC groups on basis of their SCS per lactation: G1 = SCC <200 × 10³ cells.mL⁻¹, G2 = SCC ≥200 <400 × 10³ cells.mL⁻¹, G3 = SCC ≥400 <600 × 10³ cells.mL⁻¹, G4 = SCC ≥600 <1000 × 10³ cells.mL⁻¹ and G5 = SCC ≥1000 × 10³ cells.mL⁻¹. In total statistically significant impact of parity on SCC in 2nd period was detected (*p* <0.0001) only. From the farm point of view in 1st period only in two farms and in 2nd one in five farms significant effect of parity was found out. Thus in some farms no increase of SCC from first to second lactation was observed. When comparing the changes in SCC from the first to the second lactation in both first and second periods, 6.92% and 10.96%, respectively ewes moved from SCC group G1 to G5. The significant effect of farm management and parity on SCC was demonstrated.

Keywords: ewes; milk; somatic cell count; farm; milking

INTRODUCTION

Somatic cells in milk represent epithelial cells and leukocytes **(Paschino et al., 2019)**. Somatic cell count (SCC) is considered from many aspects as an indicator of udder health and generally is used for detection of subclinical mastitis in ewes **(Gonzáles-Rodríguez, Gonzalo and San Primitivo, 1995; Pengov, 2001; Olechnowicz and Jaskowski, 2005)**. However, there is still a big discussion among scientists about the physiological level of SCC in milk of ewes for detection of their udder health **(Persson et al., 2017)**.

Berthelot et al. (2006) reported in their study SCC <500 × 10^3 cells.mL^{-1} for healthy ewes and for infected ewes SCC >1000 × 10^3 cells.mL^{-1}, if SCC was in flock >650 × 10^3cells.mL^{-1} it showed 15% incidence of udder disease to have subclinical mastitis. The results of **Kern et al. (2013)** indicated threshold of SCC 400 × 10^3 cells.mL^{-1} in meat breeds of sheep, 300 × 10^3 cells.mL^{-1} in dairy breeds and 100 × 10^3 cells.mL^{-1} in extensive breeds as right value in detecting problems with udder health. **Hussein, El-Khabaz and Malek (2015)** determined value of SCC ≥400 × 10^3 cells.mL^{-1} in Ossimi sheep as limit for detection subclinical mastitis. The limit for the detection of subclinical sheep mastitis was determined by **Swiderek et al. (2016)** as 200 × 10^3 cells.mL^{-1}. Similar threshold of SCC for diagnosis of mastitis in Sarda sheep was considered at 265 × 10^3 cells.mL^{-1} **(Caboni et al., 2017)**. **Sutera et al. (2018)** in their study showed value SCC >500 × 10^3 cells.mL^{-1} as a possible limit in relation to milk quality.

In the study in our breeding practise **Idriss et al. (2015)** reported 78% of the samples of individual ewes <600 × 10^3 cells.mL^{-1}. **Vršková et al. (2015)** found out that 76% of Tsigai had SCC <300 × 10^3 cells.mL^{-1}. In recent study **Tančin et al. (2017)** found out that 82.03% individual milk samples were <400 × 10^3 cells.mL^{-1}, 71.79% milk samples were <200 × 10^3 cells.mL^{-1} and only 8.89% milk samples were >1000 × 10^3cells.mL^{-1}. **Oravcová, Mačuhová and Tančin (2018)** found out 60% samples with SCC ≤200 × 10^3cells.mL^{-1}.

The aim of this study was to describe the frequency of distribution of ewes in SCC groups on the basis somatic cell score (SCS) per whole lactation and estimate changes of SCS from1st lactation to SCS in 2nd lactation. The effect of farms was evaluated too.

Scientific hypothesis

The parity significantly influences the SCC in milk.

The most of the ewes have low SCC in milk. The udder heath in previous lactation affect the udder health in following lactation. The farm has impact on SCC in milk.

MATERIAL AND METHODOLOGY

The experiment was carried out during two periods in dairy practice. Seven ewes' dairy farms were involved in the study during 1st observed period in 2016 and 2017 and at eight farms during 2nd observed period in 2017 and 2018. On the farms they were kept Tsigai breed, Lacaune and on one farm Slovak dairy sheep. Tsigai (TS) breed were kept on farm 1st, 2nd, 3rd, 4th and farm 5th. Lacaune (LC) breed were kept on farm 6th, 7th, 8th and farm 9ath. On farm 9bth they were kept Slovak dairy sheep (SD) in 2nd observed period only. Within each of the period the same animals were sampled on their 1st and following 2nd lactation in next year of study. In 2 farms (1st, 3rd) hand milking was performed and remaining 7 flock were milked by machine milking. Milk sampling were taken once a month as a part of milk recording service. Milk samples were taken from April to August in 1st and 2nd observed periods. Analysis of milk samples has been performed in the certificated Central laboratory of Breeding services of the Slovak Republic (Plemenárske služby š.p. SR Bratislava).

For evaluation only ewes with minimum 3 and more sampling during each lactation within both 1st and 2nd periods were included into study. Thus minimum six observations were available per animal. A total of 1199 milk samples from 159 ewes (140 TS, 19 LC) were collected during 1st observed period. From 219 ewes (130 TS, 63 LC, 26 SD) were collected 1653 milk samples during 2nd observed period.

Statistic analysis

On the basis of SCC from milk recording the ewes were divided into the five SCC groups: G1 = SCC <200 × 10^3 cells.mL^{-1}, G2 = SCC ≥200 <400 × 10^3 cells.mL^{-1}, G3 = SCC ≥400 <600 × 10^3 cells.mL^{-1}, G4 = SCC ≥600 <1000 × 10^3 cells.mL^{-1} and G5 = SCC ≥1000 × 10^3 cells.mL^{-1} to evaluate the distribution of ewes into SCC groups in different parity and years of study. Animals were individually divided into above mentioned SCC groups on the basis of their SCS per lactation calculated as a mean from transformed individual SCC data into SCS obtained during milk recording throughout lactation. SCS was calculated according formula:

$$SCS = LOG_2(SCC/100000) + 3$$

Thus distribution of ewes on the basis of SCS into SCC groups was done by conversion of linear scores to somatic cell counts. The results were mathematically processed using the Microsoft Excel program. It was used paired t-test when comparing differences variables between first and second lactation (within observed periods). Data are presented as mean ± standard deviation. The statistical model using SAS (Mixed procedure; SAS/STAT 9.1, 2002 – 2003) can be written in the following form used for each observed period separately:

$$y_{ij} = \mu + FARM_i + YEAR_j + e_{ij}$$

y_{ij} = the measurements for SCS; μ = overall mean; $FARM_i$ = the fixed effects of farms; $YEAR_j$ = fixed effect of YEARS (two years, within each observed period), $u_l \sim N(0, \sigma c2)$; e_{ij} = random error, assuming $e_{ij} \sim N(0, I\ \sigma^2_e)$. Data are presented as LSmeans (Least squares means) ± standard error.

RESULTS AND DISCUSSION

Impact of parity on SCC was not statistically significant in 1st observed period (p <0.0868) but was significant in 2nd observed period (p <0.0001). Similar results were reported by **Romero et al. (2017)**. They found out that multiparous ewes had significant higher SCC compared with primiparous ewes (205 × 10^3 cells.mL^{-1} and 102 × 10^3 cells.mL^{-1}, resp.). Also **Takano et al. (2018)** showed in their study that multiparous Lacaune ewes had a higher incidence of intramammary infections during early lactation than primiparous ewes. SCC were higher in multiparous than in primiparous goats **(Diaz et al., 2011)**. The youngest ewes had the lowest SCC, while the oldest ewes showed in general the highest SCC **(Arias et al., 2012).** Subclinical mastitis occurred less frequently in primiparous ewes than those with two or more lactations significantly (p <0.05) and ewes on 3rd lactation had the most cases of subclinical mastitis **(Sani, Mahdavi and Moezifar, 2015)**.

Although the effect of parity on SCS in between 1st and 2nd lactation wasn´t detected in 1st observed period, we found out the effect of parity on SCC at the level of individual farms. During 1st observed period we detected the effect of parity on SCS in farm 4th and farm 9ath (Table 1). Significant effects of parity on SCS during 2nd observed period, and at farm level in farm 1st, 3rd, 5th, 8th and farm 9bth (Table 2). Breeds didn´t have impact on change of SCS in monitored farms (Table 3). Significant differences between farms with the same breed could indicate the effect of management level on farms.

Distribution of ewes in SCC groups during 1st observed period (2016 and 2017) was as followed: G1 (38.99%, 33.96% resp.), G2 (32.02%, 23.90% resp.), G3 cells.mL^{-1} (6.92%, 10.69% resp.), G4 (6.29%, 6.29% resp.) and G5 (15.72%, 25.16% resp.). During 2nd observed period (2017 and 2018) there were following distribution of ewes in SCC groups: G1 (57.99%, 35.16% resp.), G2 (21%, 20.09% resp.), G3 (6.39%, 9.13% resp.), G4 (3.2%, 8.68% resp.) and G5 (11.42%, 26.94% resp.). If compare changes from 1st to 2nd lactation in both observed periods the following changes occurred: In 1stmonitored period there were 8.81% ewes in SCC group with <200 × 10^3cells.mL^{-1} during 1st lactation which moved into SCC groups ≥600 × 10^3 cells.mL^{-1} during 2nd lactation. Even 6.92% from these mentioned ewes moved into SCC group ≥ 1000 × 10^3 cells.mL^{-1}. In 2nd observed period 15.53% of ewes were in SCC group with <200 × 10^3 cells.mL^{-1} during 1st lactation, which moved into SCC groups ≥600 × 10^3 cells.mL^{-1} in the following lactation. Even from these ewes 10.96% moved into SCC group ≥ 1000 × 10^3 cells.mL^{-1}.

Table 1 SCC during first (2016) and second lactation (2017) of the same animals.

		First observed period				
	n	**2016** Mean	Std.dev.	**2017** Mean	Std.dev.	***p* ≤0.05**
Farm 1	56	5.48	1.44	5.43	1.82	0.419
Farm 2	30	4.24	1.05	4.59	1.36	0.080
Farm 3	29	3.80	0.86	3.75	1.59	0.422
Farm 4	18	4.31	0.87	5.17	1.09	0.007
Farm 5	7	5.02	1.81	5.00	1.42	0.494
Farm 6	-	-	-	-	-	-
Farm 7	-	-	-	-	-	-
Farm 8	8	4.41	0.71	4.55	1.26	0.406
Farm 9a	11	5.05	2.17	6.43	2.66	0.047
Farm 9b	-	-	-	-	-	-

Note: n – number of observations.

Table 2 SCC during first (2017) and second lactation (2018) of the same animals.

		Second observed period				
	n	**2017** Mean	Std.dev.	**2018** Mean	Std.dev.	***p* ≤0.05**
Farm 1	37	4.65	1.45	6.00	1.59	<0.001
Farm 2	20	3.98	1.04	4.56	1.52	0.076
Farm 3	51	3.95	1.40	5.17	1.66	<0.001
Farm 4	-	-	-	-	-	-
Farm 5	22	4.23	1.16	4.39	1.34	0.024
Farm 6	17	5.06	1.61	5.37	2.06	0.303
Farm 7	30	3.93	0.80	3.85	1.52	0.384
Farm 8	10	4.13	1.38	5.42	1.80	0.007
Farm 9a	6	4.37	1.58	5.66	1.34	0.109
Farm 9b	26	3.63	1.49	5.41	2.03	0.001

Note: n – number of observations.

Table 3 Effect of farms on SCC for two observed periods of study.

		2016 – 2017			**2017 – 2018**		
		number (2n)	lsmeans	std. error	number (2n)	lsmeans	std. error
TS	**Farm 1**	112	5.46	0.14	74	5.32	0.18
	Farm 2	60	4.41	0.20	40	4.27	0.25
	Farm 3	58	3.77	0.20	102	4.56	0.15
	Farm 4	36	4.74	0.25	-	-	-
	Farm 5	14	5.01	0.41	44	4.31	0.24
LC	**Farm 6**	-	-	-	34	5.22	0.27
	Farm 7	-	-	-	60	3.89	0.20
	Farm 8	16	4.48	0.38	20	4.77	0.35
	Farm 9a	22	5.74	0.32	12	5.02	0.45
SD	**Farm 9b**	-	-	-	52	4.52	0.22

Figure 1 Frequency of distribution of ewes in SCC groups during first and second lactation in farm with machine milking.

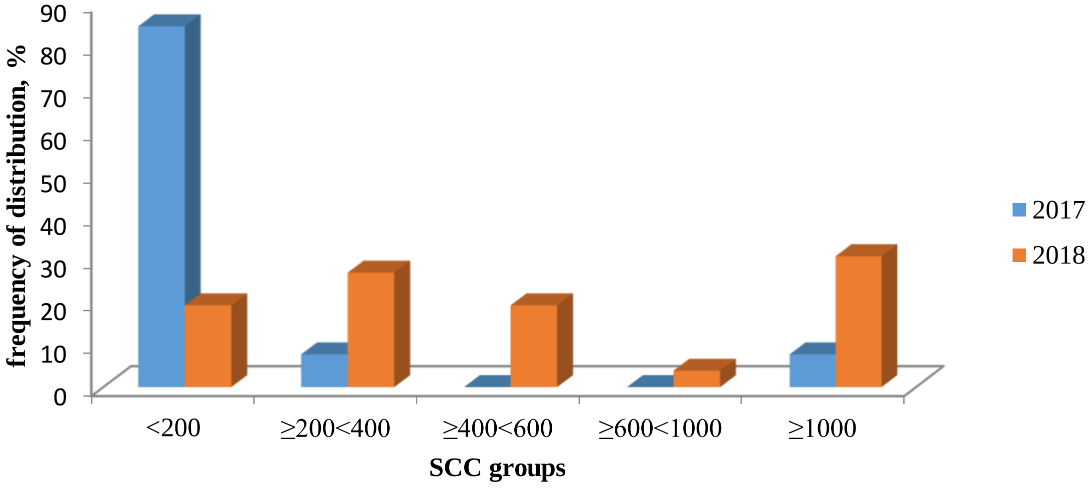
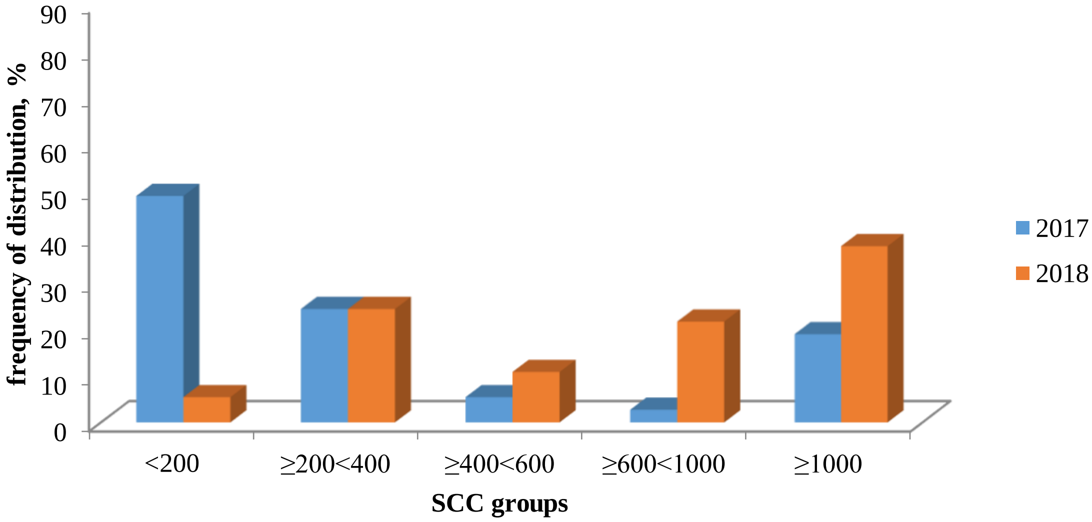


Figure 2 Frequency of distribution of ewes in SCC groups during first and second lactation in farm with hand milking.



These changes from 1st to 2nd lactation among SCC groups and clear increase of percentage of samples in SCC group ≥1000 × 10^3 cells.mL^{-1} in 2nd lactation indicate higher prevalence of subclinical mastitis. **Persson et al. (2017)** detected significant association between intramammary infection and high SCC in ewes. In contaminated samples were significantly higher SCC as compared with uncontaminated milk samples **(Ozenc et al., 2011)**. From preliminary results of **Tančin et al. (2018)** there was shown that high SCC in milk samples were associated with presence of pathogens. **Romero et al. (2017)** observed significant higher SCC in milk of primiparous and multiparous ewes with mastitis. Early diagnosis and treatment of subclinical mastitis can significantly eliminate clinical forms of mastitis **(Zigo et al., 2017)**.

Data shown in Figure 1 and Figure 2 represent examples of frequency of distribution of ewes from one farm with machine milking and another farm with hand milking during their 1st and 2nd lactation. On both figures there are presenting changes of udder heath from 1st to 2nd lactation by clear demonstration of difference between count of ewes in SCC group <200 × 10^3 cells.mL^{-1} and in SCC group ≥1000 × 10^3 cells.mL^{-1}. In both farms during the 2nd lactation there was a decrease in the distribution of ewes in the SCC group <200 × 10^3 cells.mL^{-1} regardless on the milking technique. Increase of percentage of ewes in SCC groups ≥1000 × 10^3 cells.mL^{-1} could be due to the increase prevalence of subclinical mastitis in these farms. In other study **Marogna et al. (2010)** found out that hand milking was associated with 62% higher risk of bacterial positive samples compared to machine milking which we did not confirmed in our study. **Marogna et al. (2010**) also observed that machine milking with portable devices was associated with 40% higher risk of bacterial positive samples compared to machine milking with fixed plants. **Queiroga (2017)** detected significantly higher prevalence of subclinical mastitis in herds with machine milking than those with hand milking (p <0.0001). **Vasileiou et al. (2018)** reported increased prevalence of mastitis in farms with hand milking.

CONCLUSION

In conclusion, high percentage of ewes had SCC <200 × 10^3 cells.mL^{-1} during 1st lactation only. During 2nd but not during 1st observed period the ewes on 2nd lactation had higher SCC compared with primiparous ewes, however, clear individual farm effect was recorded in both observed periods. Also significant effect of farm management on SCC was demonstrated without connection to hand or machine milking. Thus the level of management in dairy farm has to be considered.

REFERENCES

Arias, R., Oliete, B., Ramón, M., Arias, C., Gallego, R., Montoro, V., Gonzalo, C., Pérez-Guzmán, M. D. 2012. Long-term study od environmental effects on test- day somatic cell count and milk yield in Manchega sheep. *Small Ruminant Research*, vol. 106, no. 2-3, p. 92-97. https://doi.org/10.1016/j.smallrumres.2012.03.019

Berthelot, X., Lagriffoul, G., Concordet, D., Barillet, F., Bergonier, D. 2006. Physiological and pathological thresholds of somatic cell counts in ewe milk. *Small Ruminant Research*, vol. 62, no. 1-2, p. 27-31. https://doi.org/10.1016/j.smallrumres.2005.07.047

Caboni, P., Manis, C., Ibba, I., Contu, M., Coroneo, V., Scano, P. 2017. Compositional profile of ovine milk with a high somatic cell count: A metabolomics approach. *International Dairy Journal*, vol. 69, p. 33-39. https://doi.org/10.1016/j.idairyj.2017.02.001

Diaz, J. R., Romero, G., Muelas, R., Sendra, E., Pantoja, J. C. F., Paredes, C. 2011. Analysis of the influence of variation factors on electrical conductivity of milk in Murciano-Granadina goats. *Journal of Dairy Science*, vol. 94, no. 8, p. 3885-3894. https://doi.org/10.3168/jds.2011-4187

Gonzáles-Rodríguez, M. C., Gonzalo, C., San Primitivo, F. C. 1995. Relationship between somatic cell count and intramammary infection of the half udder in dairy ewes. *Journal of Dairy Science*, vol. 78, no. 12, p. 2753-2759. https://doi.org/10.3168/jds.S0022-0302(95)76906-5

Hussein, H. A., El-Khabaz, K. A. S., Malek, S. S. 2015. Is udder ultrasonography a diagnostic tool for subclinical mastitis in sheep? *Small Ruminant Research*, vol. 129, p. 121-128. https://doi.org/10.1016/j.smallrumres.2015.05.010

Idriss, S. E., Tančin, V., Margetín, M., Tančinová, D., Sláma, P., Havlíček, Z. 2015. Frequency of distribution of somatic cell count in dairy ewe's milk. *Journal of Microbiology Biotechnology and Food Sciences*, vol. 4, no. 3, p. 148-151. https://doi.org/10.15414/jmbfs.2015.4.special3.148-151

Kern, G., Traulsen, I., Kemper, N., Krieter, J. 2013. Analysis of somatic cell counts and risk factors associated with occurrence of bacteria in ewes of different primary purposes. *Livestock Science*, vol. 157, no. 2-3, p. 597-604. https://doi.org/10.1016/j.livsci.2013.09.008

Marogna, G., Rolesu, S., Lollai, S., Tola, S., Leori, G. 2010. Clinical findings in sheep farms affected by recurrent bacterial mastitis. *Small Ruminant Research*, vol. 88, no. 2-3, p. 119-125. https://doi.org/10.1016/j.smallrumres.2009.12.019

Olechnowicz, J., Jaskowski, J. M. 2005. Somatic cells in sheep milk. *Medycyna Weterynaryjna*,vol. 61, no. 2, p 136-141.

Oravcová, M., Mačuhová, L., Tančin, V. 2018. The relationship between somatic cells and milk traits and their variation in dairy sheep breeds in Slovakia. *Journal of Animal and Feed Sciences*, vol. 27, no. 2, p. 97-104. https://doi.org/10.22358/jafs/90015/2018

Ozenc, E., Seker, E., Baki Acar, D., Birdane, M. K., Darbaz, I., Dogan, N. 2011. The importance of staphylococci and threshold value of somatic cell count for diagnosis of subclinical mastitis in Pirlak sheep at mid- lactation. *Reproduction in Domestic Animals*, vol. 46, no. 6, p. 970-974. https://doi.org/10.1111/j.1439-0531.2011.01768.x

Paschino, P., Vacca, G. M., Dettori, M. L., Pazzola, M. 2019. An approach for the estimation of somatic cell´s effect in Sarda sheep milk based on the analysis of milk traits and coagulation properties. *Small Ruminant Research*, vol. 171, p. 77-81. https://doi.org/10.1016/j.smallrumres.2018.10.010

Pengov, A. 2001. The Role of Coagulase- Negative Staphylococcus spp. and Associated Somatic Cell Counts in the Ovine Mammary Gland. *Journal of Dairy Science*, vol. 84, no. 3, p. 572-574. https://doi.org/10.3168/jds.S0022-0302(01)74509-2

Persson, Y., Nyman, A. K., Söderquist, L., Tomic, N., Waller, K. P. 2017. Intramammary infections and somatic cell count in meat and pelt producing ewes with clinically healthy udders. *Small Ruminant Research*, vol. 156, p. 66-72. https://doi.org/10.1016/j.smallrumres.2017.09.012

Queiroga, M. C. 2017. Prevalence and aetiology of sheep mastitis in Alentejo regions of Portugal. *Small Ruminant Research*, vol. 153, p. 123-130. https://doi.org/10.1016/j.smallrumres.2017.06.003

Romero, G., Roca, A., Alejandro, M., Muelas, R., Díaz, J. R. 2017. Relationship of mammary gland health status and other noninfectious factors with electrical conductivity of milk in Manchega ewes. *Journal of Dairy Science*, vol. 100, no. 2, p. 1555-1567. https://doi.org/10.3168/jds.2016-11544

Sani, R. N., Mahdavi, A., Moezifar, M. 2015. Prevalence and etiology of subclinical mastitis in dairy ewes in two seasons in Semman province Iran. *Tropical Animal Health and Production*, vol. 47, no. 7, p. 1249-1254. https://doi.org/10.1007/s11250-015-0855-y

Sutera, A. M., Portolano, B., Di Gerlando, R., Sardina, M. T., Mastrangelo, S., Tolone, M. 2018. Determination of milk production losses and variations of fat and protein percentages according to different levels of somatic cell count in Valle del Belice dairy sheep. *Small Ruminant Research*, vol. 162, p. 39-42. https://doi.org/10.1016/j.smallrumres.2018.03.002

Swiderek, W. P., Charon, K. M., Winnicka, A., Gruszczynska, J., Pierzchala, M. 2016. Physiological Threshold of Somatic Cell Count in Milk of Polish Heath Sheep and Polish Lowland Sheep. *Annals of Animal Science*, vol. 16, no. 1, p. 155-170. https://doi.org/10.1515/aoas-2015-0071

Takano, P. V., Scapini, V. A. D. C., Valentini, T., Girardini, L. K., De Souza, F. N., Della Libera, A. M. M. P., Heinemann, M. B., Chande, C. G., Cortez, A., Collet, S. G., Diniz, S. A., Blagitz, M. G. 2018. Milk cellularity and intramammary infections in primiparous and multiparous Lacaune ewes during early lactation. *Small Ruminant Research*, vol. 167, p. 117-122. https://doi.org/10.1016/j.smallrumres.2018.08.015

Tančin, V., Baranovič, Š., Uhrinčať, M., Mačuhová, L., Vršková, M., Oravcová, M. 2017. Somatic cell count in raw ewes milk in dairy practice: frequency of distribution and possible effect on milk yield and composition. *Mljekarstvo*, vol. 67, no. 4, p. 253-260. https://doi.org/10.15567/mljekarstvo.2017.0402

Tančin, V., Tvarožková, K., Holko, I., Uhrinčať, M., Mačuhová, L., Vršková, M., Oravcová, M. 2018. The importance of somatic cell count in mastitis diagnostic in ewes. Brno, Czech republic: *XLVIII. Lenfeldovy a Höklovy dny*, p. 296-299. ISBN 978-80-7305-808-1.

Vasileiou, N. G. C., Chatzopoulos, D. C., Gougoulis, D. A., Sarrou, S., Katsafadou, A. I., Spyrou, V., Mavrogianni, V. S., Petinaki, E., Fthenakis, G. C. 2018. Slime-producing staphylococci as causal agents of subclinical mastitis in sheep. *Veterinary Microbiology*, vol. 224, p. 93-99. https://doi.org/10.1016/j.vetmic.2018.08.022

Vršková, V., Tančin, V., Kirchnerová, K., Sláma, P. 2015. Evaluation of daily milk production in Tsigai ewes by somatic cell count. *Potravinarstvo*, vol. 9, no. 1, p. 206-210. https://doi.org/10.5219/439

Zigo, F., Vasiľ, M., Takáč, L., Elečko, J., Tomko, J., Chripková, M. 2017. Mastitis pathogens isolated from samples of milk in dairy sheep and their rezistance. *International Journal of Scientific Research*, vol. 6, no. 8, p. 298-300.

Acknowledgments:

Supported by the Ministry of Education Science Research and Sports of the Slovak Republic/the Slovak Research and Development Agency (Project No. APVV-15-0072).

Contact address:

Kristína Tvarožková, Slovak University of Agriculture, Faculty of Agrobiology and Food Resources, Department of Veterinary Science, Tr. A. Hlinku 2, 949 76 Nitra, Slovakia, Tel.: +421944385272,
E-mail: kristina.tvarozkova@gmail.com
ORCID: https://orcid.org/0000-0003-4989-6138

*Vladimír Tančin, Slovak University of Agriculture, Faculty of Agrobiology and Food Resources, Department of Veterinary Science, Tr. A. Hlinku 2, 949 76 Nitra, Slovakia, NPPC-Research Institute for Animal Production Nitra, Hlohovecká 2, 95141 Lužianky, Slovakia, Tel.: +421903546401,
E-mail: tancin@vuzv.sk
ORCID: https://orcid.org/0000-0003-2908-9937

Michal Uhrinčať, NPPC – Research Institute for Animal Production Nitra, Hlohovecká 2, 95141 Lužianky, Slovakia, Tel.: +421376546656,
E-mail: uhrincat@vuzv.sk
ORCID: https://orcid.org/0000-0002-5378-617X

Lucia Mačuhová, NPPC – Research Institute for Animal Production Nitra, Hlohovecká 2, 95141 Lužianky, Slovakia, Tel.: +4213765466571,
E-mail: macuhova@vuzv.sk
ORCID: https://orcid.org/0000-0002-9624-1348

Martina Vršková, NPPC – Research Institute for Animal Production Nitra, Hlohovecká 2, 95141 Lužianky, Slovakia, Tel.: +421376546626,
E-mail: vrskova@vuzv.sk
ORCID: https://orcid.org/0000-0002-4206-8404

Marta Oravcová, NPPC – Research Institute for Animal Production Nitra, Hlohovecká 2, 95141 Lužianky, Slovakia, Tel.: +421376546622,
E-mail: oravcova@vuzv.sk

Corresponding author: *