OPEN ACCESS Potravinarstvo Slovak Journal of Food Sciences

potravinárstvo® Slovak Journal of Food Sciences

Potravinarstvo Slovak Journal of Food Sciences
vol. 12, 2018, no. 1, p. 116-122
doi: https://doi.org/10.5219/900
Received: 10 February 2018. Accepted: 27 February 2018.
Available online: 21 March 2018 at www.potravinarstvo.com

ISSN 1337-0960 (online)

Impact of somatic cell count and lameness on the production and composition of ewe's milk

Štefan Baranovič, Vladimír Tančin, Kristína Tvarožková, Michal Uhrinčať, Lucia Mačuhová, Jozef Palkovič

ABSTRACT

High somatic cell count (SCC) in milk and lameness are two very serious problems on the farms. The aim of the study was to evaluate the impact of lameness, SCC, month and order of entry into the milking parlour on the milk production and its composition. The relationship between lameness and SCC and their impact on the order of entry was also evaluated. The experiment was carried out at the farm, located in northern Slovakia. The farm keeps sheep crossbred of Improved Valachian and Lacaune. Milking was performed two times a day in milking parlor 1x24. Samples of milk were taken once a month by evening milking: May, July. In May, individual milk samples were taken from 214 random sampling ewes with milk yield minimum 300 mL per milking. In July, only from selected ewes in May, the milk samples, milk yield and lameness were recorded. Order of ewes entry into the milking parlour in milking row (one milking row is 24 animals) was recorded in both months. In total 23 milking rows were recorded. Ewes was divided by lameness (non-lame, slightly lame, strong lame), by SCC (A1 = to $2x10^5$ cells, A2 = from $2x10^5$ to $4x10^5$ cells, A3 = from $4x10^5$ to $7x10^5$ cells, A4 = from $7x10^5$ to $10x10^5$ cells, A5 = over $10x10^5$ cells.mL^{-1}) and by the order of entry of ewes into the milking parlour (in first group of ewes were milked in 1-5 rows, second 6-11, third 12-17, fourth 18-23 ones). No effect of lameness was found out on milk yield. Lameness in July affected the order of entry into milking parlour in July as compared with their order of entry recorded in May. The strong lame ewes entered 4.19 ±1.07 milking rows later in July than in May. Only 11.2% and 4.2% of milk samples were found out in a group with SCC >$10x10^5$ cells.mL^{-1} during May and July respectively. In both months, the production of lactose was lower in groups with higher SCC. Ewes entering into the milking parlour earlier had higher SCC as ewes entering into milking parlour later in July but no effect was seen in May. In conclusion the studies under practical conditions deserve continuous research attention to identify risk factors of management affecting lameness and udder health for further improvement of sheep breeding.

Keywords: ewes; lameness; somatic cell count; order of entry

INTRODUCTION

Mastitis is inflammatory disease of mammary gland, which is mainly presented as high somatic cell count in milk (SCC) **(Gonzalo et al., 2002)**. SCC is influenced by various factors such as age, stage of lactation **(Sitkowska, 2008)** and also depends on the infectious factor **(Ariznabarreta et al., 2002)**. Several works have been published which presented a negative correlation between SCC and milk production in ewes **(Arias et al., 2012; Gonzalo et al., 2002)** and cows **(Tančin et al., 2007)**.

Lameness is considered one of the most important health problems in sheep **(Eze, 2002)**. **Gelasakis et al. (2010)** found out the negative impact of hoof disease (the most common cause of lameness) on the milk yield.

The order of entry into the milking parlor is also important factor which could be related to ewe's **(Villagrá et al., 2007; Antonič et al., 2011)**, cow's **(Rathore, 1982; Stefanowska et al., 2000)** and goat's production **(Gorecki and Wojtowski, 2004)**. The order of entry into the milking parlor is influenced by many factors: lactation number **(Antonič et al., 2011)**, dominance and the weight of the animals **(Margetínová et al., 2003)** which also may affect the milk production. Therefore, it appears that the order of entry into the parlor affects the milk yield, milk components **(Margetínová et al., 2001)** and milkability and the quantity of machine stripping, hand stripping and volume of residual milk **(Villagrá et al., 2007)**.

The research studies related to the possible negative effect of high level of SCC and lameness have of great importance by improving of production and animal welfare. The aim of the study was to evaluate the impact of lameness and somatic cell count and order of entry into the milking parlour on the milk production and its composition. The relationship between lameness and SCC and their impact on the order of entry were also examined.

Scientific hypothesis

Lameness and high SCC in milk reduce milk yield and affect its composition.

MATERIAL AND METHODOLOGY

The experiment was carried at the farm located in northern Slovakia in year 2015. The farm kept sheep crossbred Improved Valachian and Lacaune. 85% of experimental ewes were on their first to fourth lactations. Ewes were housed on deep litter and they grazed on adjacent pastures during the day. The main components of feed were pasture (*ad libitum*) and feed concentrate during milking (200 g/per animal per day). Milking was performed two times a day in milking parlor 1x24. Lambing began in the middle February and lasted until the middle of March.

Samples of milk were taken once a month during evening milking in May, and July (MONTH). In May, individual milk samples were taken from 214 random sampled ewes with milk yield minimum 300 mL per milking. In July, only from selected ewes in May, the milk samples, milk yield and lameness were recorded. Order of ewes entry into the milking parlour as milking row (one milking row is 24 animals) was recorded in both months. In total 23 milking rows were recorded. Analysis of milk samples (428 in total) for somatic cell count and a basic component has been performed in NPPC-Research Institute for Animal Production in Nitra. Basic milk composition was done by MilkoScan FT 120 (FOSS, Denmark) and somatic cell count was determined using a Somacount 150 (Bentley Czech, USA).

Lameness was evaluated according to modified scale according **Kaler et al. (2009)**. All lameness ewes (LAMENESS) were evaluated during entering the milking parlour and standing during milking. The ewes that lamed during the entering into milking parlour and those been lifted (lighten) their limbs during milking were marked as “strong lame” ewes. Ewes that lamed during entering into milking parlour but did not lift their limbs during milking were marked as “slightly lame”. Ewes that neither did not lame during the entering into milking parlour nor did not lift their limbs during milking were marked as “non-lame”. On the basis of individual SCC in milk, the ewes were divided into five SCC groups (SOMATIC). The first group (A1) represented ewes with SCC below $2x10^5$ cells, the second (A2) from $2x10^5$ to $4x10^5$ cells, the third (A3) from $4x10^5$ to $7x10^5$ cells, fourth (A4) from $7x10^5$ to $10x10^5$ cells and the fifth one (A5) over $10x10^5$ cells per mL of milk. The logarithm of SCC ($log_{10}x.mL^{-1}$) have been used for the statistical processing.

The value „order of entry” into the milking parlor was considered as number of milking row order, in which ewes was milking. Altogether 23 rows were recorded. On the base of number of row, four groups of entries (ORDER) were created: the first five milking rows (1-5) marked as „first" entry, milking rows from 6 to 11 „second" entry, from 12 to 17 „third” entry and from 18 to 23 „fourth" entry. The value „change of the entry" represent the difference between number of row in May and the number of row in July.

Statisic analysis

The milk yield per milking (mL), fat (%), protein (%), lactose (%), non-fat dry matter - NFDM (%) and total solids (%) and logarithm of somatic cell count (log_{10} x mL^{-1}) was evaluated. The results were mathematically processed using the Microsoft Excel program and statistically evaluated by SAS/9.4 (2014). It was used paired t-test when comparing differences variables in two groups (the difference in milk yield or milk components in milk between two months). It was used analysis of variance and within Fisher's LSD test, when comparing more than two groups (the difference in milk yield or milk components in groups by lameness, SCC, the order of entry of ewes into the milking parlour). Used statistical model can be written in the following form:

$y_{ijk} = \mu + SOMATIC_i + LAMENESS_j + ORDER_k + u_p + e_{ijk}$

$y_{il} = \mu + SOMATIC_i \ /MONTH_l/ + u_p + e_{il}$

$y_{kl} = \mu + ORDER_k \ /MONTH_l/ + u_p + e_{jl}$

y_{ijk} = the measurements for milk yield and composition

μ = overall mean,

$SOMATIC_i$ = the fixed effects of SCC classes (i = 1 to 5),

$LAMENESS_j$ = the fixed effect of lameness (j = 1 to 3),

$ORDER_k$ = the fixed effect of order of entry (k = 1 to 4),

$MONTH_l$ = the fixed effect of month (l = 1 and 2)

μ_p = random effect of ewes, $u_p \sim N(0, I\ \sigma_c^2)$,

e_{ijk} = random error, assuming $e_{ijkl} \sim N(0, I\ \sigma_e^2)$.

RESULTS AND DISCUSSION

The months of study significantly influenced all measured traits (Table 1). The changes of milk components and milk yield were caused by numbers of lactating days as it is well documented in literature **(Assan, 2015; Komprej et al., 2012; Oravcová et al., 2015; Peralta-Lailson et al., 2005; Tančin et al., 2011; 2013)**.

In our trial the SCC reduced from May to July. Under practical conditions with Tsigai ewes **Vršková et al. (2015)** did not found out significant effect of season on SCC. Reduction of SCC from May to July could be probably explained by reducing milk yield creating thus more effective immune function of mammary gland.

Statistical significance of factors as lameness, SCC and the order of entry into the milking parlour on the evaluated trials are shown in Table 2.

Table 1 The effect of months on observed trials (n = 214).

	May		July	
Trail	**Mean**	**SD**	**Mean**	**SD**
Milk yield (mL)	558^a	173	349^b	143
logSCC (log $x.mL^{-1}$)	5.49^a	0.47	4.81^b	0.63
Fat (%)	5.83^a	0.97	8.88^b	1.02
Protein (%)	5.90^a	0.50	6.47^b	0.52
Lactose (%)	5.17^a	0.20	4.86^b	0.19
NFDM (%)	11.97^a	0.48	12.26^b	0.52
Total solid (%)	17.54^a	1.05	20.87^b	1.52

Note: a,b – means with different letters are significant (p <0.0001), SD – standard deviation.

Table 2 Statistical significance (P value) of lameness, SCC and the order of entry in the milking parlour on the evaluated trials.

	Lameness		SCC		Order of entry	
Trials	**May**	**July**	**May**	**July**	**May**	**July**
Milk yield (mL)	0.7367	0.2881	0.5502	0.0105	0.1477	0.4477
logSCC (log x.mL^{-1})	0.0699	0.6412	x	x	0.0127	<.0001
Fat (%)	0.0575	0.2184	0.3768	0.3874	0.0074	0.1572
Protein (%)	0.6324	0.4459	0.0165	0.0260	0.2026	0.0997
Lactose (%)	0.7415	0.2038	0.0006	<.0001	0.1454	0.1867
NFDM (%)	0.5563	0.4348	0.0029	0.0070	0.6778	0.1673
Total solid (%)	0.1361	0.3672	0.1373	0.2103	0.0126	0.2748
Change of entry (milking rows)	x	0.0345	x	0.7927	x	x

Lameness

In July, 12.15% slightly lame ewes and 8.41% strong lame ewes were recorded. Lower incidence of lameness was found out by **Gelasakis et al. (2015)** on two farms keeping breed Chios (12.4%, respectively. 16.8% - regardless of the degree of lameness), **Gavojdian et al. (2015)** by breed Tsigaia dorper (2.9% respectively. 8%), and in large long-term studies **Winter et al. (2015)** (4.9% to 10.6%).

Milk yield, SCC and milk composition were not affected by lameness of ewes (Table 2) therefore the data are not shown. However, a lower milk yield compared with non-lame ewes in study **Gelasakis et al. (2015)** was found out. There is limited information about relationship between lameness and milk composition in ewes. In dairy cows' positive correlation **(Peeler et al., 1994)**, negative correlation **(Archer et al., 2011)** or as well as in our study with ewes no effect was detected **(Hultgren et al., 2004)** between lameness and SCC.

Lameness significantly reduced the order of entry of ewes into parlour (Table 2). The same ewes when they were lame in July entered into the parlour later in July than in May. Slightly lame ewes in July entered the parlour 2.87 ±1.03 milking rows later and strong lame ewes even 4.19 ±1.07 milking rows later in July than in May. Also non-lame ewes in July entered the parlour later in July than in May but only about 1.14 ±0.42 milking rows. Later entry of lame ewes into the milking parlour was probably due to the unwillingness of lame ewes to walk. Therefore, the high attention of farmers should be given to last entering groups if the one of the reasons could be caused by lameness.

SCC

There was only slow reduction of milk yield with increasing SCC in May. The significant negative effect of SCC on milk production was found out in July only (Table 2), but statistical differences were demonstrated due to low number of animals in the last three groups in July. Similarly, a tendency to lower milk production by a higher SCC was found out in several works **(Antonič et al., 2013; Arias et al., 2012; Gonzalo et al., 2002; Leitner et al., 2008; Margetín et al., 1996; Vršková et al., 2015)**.
Production of lactose was influenced by SCC in the month May and July (Table 2 and Table 3). In both months, the production of lactose was lower in groups with higher SCC. The same significant impact of SCC on lactose was also found out by **De Olives et al. (2013)**, **Caboni et al. (2017)**, **Margetín et al. (2013)** and **Vršková et al. (2015)**.
Protein and NFDM has been affected by somatic cell count in May and in July (Table 2) but these significant effects were not clearly related to the SCC groups (Table 3). The fat content and total solid were not affected by SCC (Table 2).

The frequency of distribution of milk samples in different SCC groups are followed: in May 38.3% ewes were included in group A1, 29.4% ewes in group A2, 15.4% ewes in group A3, 5.6% ewes in group A4 and 11.2% ones in group A5. In July, the distribution among the SCC groups was follow: A1 = 80.4%, A2 = 7.5%, A3 = 3.7%, A4 = 4.2%, A5 = 4.2% of ewes. **Berthelot et al. (2006)** reported healthy ewes with SCC below $0.5x10^6$ cells and infected udders with SCC higher than $1x10^6$ cells.mL^{-1}. **Arias et al. (2012)** have recommended the limit value of $0.3x10^6$ cells.mL^{-1} in determining relationship of SCC to milk production. In our results high number of ewes in A1 (below $2x10^5$ cells.mL^{-1}) and low number of animals in group A5 (over $10x10^5$ cells.mL^{-1}) indicating a good udder health of experimental animals in both months. **Idriss et al. (2015)**, recorded a higher incidence of ewes in a group with SCC >$10x10^5$ cells.mL^{-1} cellsxmL^{-1} during May (15.83%) compared to July (11.45%) in experimental farm of our Institute. Under Slovak conditions a similar distribution of milk samples differed by SCC within the flock was found out also in other farms **(Baranovič et al., 2016)**. This distribution of samples among SCC groups explains the reduced SCC in July as compared with May (Table 1).

The order of entry of ewes into the milking parlour

The number of observed ewes entering the parlour in different groups is shown in table 4 with possible effect of months of trial.

In May, higher logSCC was in the first two groups (first, second) in compare with third group. In July higher logSCC was in the first two groups (first, second) and lower in the latter two groups (third, fourth) (Table 2 and Table 4).

Table 3 Evaluated trials (milk yield, fat, protein, lactose, NFDM and total solid) in different groups of SCC.

	Month: May – SCC groups									
	A1 (n = 82)		A2 (n = 63)		A3 (n = 33)		A4 (n = 12)		A5 (n = 24)	
Trials	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Milk yield (mL)	583	184	549	169	536	175	548	193	530	132
Fat (%)	5.71	0.929	5.93	0.865	5.72	0.830	6.14	0.833	5.93	1.455
Protein (%)	5.82^a	0.446	5.85^a	0.554	6.15^b	0.475	6.06	0.471	5.93	0.496
Lactose (%)	5.19^a	0.181	5.20^a	0.166	5.19^a	0.165	5.14^a	0.197	5.00^b	0.322
NFDM (%)	11.88^a	0.444	11.98^a	0.475	12.23^b	0.446	12.10	0.592	11.83^a	0.432
Total solid (%)	17.34	1.012	17.64	0.957	17.68	0.911	17.95	0.826	17.52	1.529
	Month: July – SCC groups									
	A1 (n = 172)		**A2 (n = 16)**		**A3 (n = 8)**		**A4 (n = 9)**		**A5 (n = 9)**	
Trials	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
Milk yield (mL)	351	143	378	191	270	53	287	93	377	109
Fat (%)	8.91	1.017	8.95	1.043	8.22	0.896	9.07	1.36	8.7	0.803
Protein (%)	6.50^a	0.539	6.22^b	0.387	6.27	0.229	6.69^a	0.623	6.27	0.344
Lactose (%)	4.88^a	0.173	4.90^a	0.197	4.69^b	0.226	4.67^b	0.184	4.72^b	0.261
NFDM (%)	12.32^a	0.52	12.03^b	0.41	11.86^b	0.373	12.31	0.637	11.91^b	0.401
Total solid (%)	20.95^a	1.549	20.67	1.265	19.83^b	1.108	21.1	1.746	20.33	1.004

Note: a, b – means with different letters are significant (p <0.05); SD – standard deviation.

Table 4 Evaluate trials (milk yield, logSCC, fat, protein, lactose, NFDM and total solid) in different groups by the order of entry of ewes into the milking parlour

	Order of entry into parlour – May							
	first (n = 65)		second (n = 68)		third (n = 71)		fourth (n = 10)	
Trials	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Milk yield (mL)	590	188	561	158	536	178	482	98
logSCC (log x.mL^{-1})	5.52^a	0.439	5.59^a	0.492	5.34^b	0.446	5.53	0.555
Fat (%)	5.57^a	0.895	6.12^b	1.044	5.83	0.901	5.52	0.825
Protein (%)	5.78^a	0.615	5.93	0.39	5.98^b	0.495	5.99	0.236
Lactose (%)	5.22^a	0.219	5.14^b	0.208	5.15	0.189	5.15	0.126
NFDM (%)	11.93	0.547	11.96	0.401	12.01	0.499	12.02	0.187
Total solid (%)	17.23^a	1.003	17.81^b	1.129	17.59^b	0.976	17.29	0.81
	Order of entry into parlour – July							
	first (n = 53)		**second (n = 66)**		**third (n = 51)**		**fourth (n = 44)**	
Trials	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
Milk yield (mL)	362	131	341	158	365	133	324	144
logSCC (log x.mL^{-1})	5.11^a	0.528	4.91^a	0.489	4.60^b	0.638	4.56^b	0.732
Fat (%)	8.87	0.96	8.93	0.964	8.64^a	1.071	9.11^b	1.098
Protein (%)	6.32^a	0.493	6.54^b	0.567	6.47	0.478	6.53^b	0.526
Lact. (%)	4.89^a	0.206	4.87	0.165	4.85	0.179	4.81^b	0.214
NFDM (%)	12.13^a	0.555	12.35^b	0.558	12.26	0.453	12.29	0.484
Total solid (%)	20.79	2.057	20.97	1.243	20.6	1.294	21.1	1.344

Note: a, b – means with different letters are significant (p <0.05); SD – standard deviation.

Lower SCC in ewes entering into the milking parlour in second half may be due to the lower age of these animals **(Antonič et al., 2011)** because young ewes have lower SCC **(Baranovič et al., 2016)**. **Villagrá et al. (2007)** and **Antonič et al. (2011)** did not record the influence of order of entry into the parlor on SCC. In the study with the dairy cows, animals entering in the milking parlour as the first had lower SCC in compare with last groups **(Rathore, 1982)**.

In May, a significant effect the order of entry into the milking parlour on the fat content and total solids was found out (Table 2 and Table 4) but changes were not related to the order of entry. These results are consistent with the **Antonič et al. (2011)**.

The remaining trials were not affected by entry of ewes into the milking parlour (Table 2).

CONCLUSION

The high incidence of lame ewes (over 20%) was found out but no effect on milk yield and its compostion was calculated. Lameness significantly postponed the entry of ewes into parlour (p <0.0345). However, on the SCC basis a relatively good health of udders was found in flock. Only 11.2% and 4.2% of milk samples were found out in a group with SCC >10x10^5 cells.mL^{-1} during May and July respectively. The lactose in milk significantly reduced in milk with high SCC in both months (p = 0.0006 and <0.0001, respectively). The studies under practical conditions deserve research attention to identify risk factors of management affecting lameness and udder health for further improvement of sheep breeding.

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Acknowledgments:

This study was funded by the projects: APVV-15-0072.

Contact address:

Štefan Baranovič, Slovak University of Agriculture, Faculty of Agrobiology and Food Resources, Department of Veterinary Science, Tr. A. Hlinku 2, 949 76 Nitra, Slovakia, E mail: stefan.baranovic@plusko.net

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, E-mail: tancin@vuzv.sk

Kristína Tvarožková, Slovak University of Agriculture, Faculty of Agrobiology and Food Resources, Department of Veterinary Science, Tr. A. Hlinku 2, 949 76 Nitra, Slovakia, E mail: kristina.tvarozkova@gmail.com

Michal Uhrinčať, NPPC-Research Institute for Animal Production Nitra, Hlohovecká 2, 95141 Lužianky, Slovakia, E-mail: uhrincat@vuzv.sk

Lucia Mačuhová, NPPC-Research Institute for Animal Production Nitra, Hlohovecká 2, 95141 Lužianky, Slovakia, E-mail: macuhova@vuzv.sk

Jozef Palkovič, Slovak University of Agriculture,Faculty of Economics and Management,Department of Statistics and Operations Research, Tr. A. Hlinku 2, 949 76 Nitra, Slovakia, E mail: jozef.palkovic@uniag.sk