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EVALUATION OF FACTORS AFFECTING SOMATIC CELL COUNT IN MILK [1]

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ABSTRACT

Somatic cell count (SCC) is an important indicator of health status of mammary gland, which affects also technological quality of milk. The aim of the present work was to analyse factors influencing SCC (breed, parity, calving season and year, herd and cow productivity). The analysis comprised AT4 milk recording data for the 5-years period for Slovenia (n≈3.2×106 recordings). A subset of 10 % randomly selected herds (n≈220,000 recordings) was used for evaluation of important factors. According to our results, cow productivity, parity and breed are the most influential factors affecting SCC. Higher milk yield (per day or per standard lactation) is related to lower SCC. Among breeds, the highest SCC was observed for Holstein breed, followed by Brown and Simmental breed and Simmental crossbreeds (Simmental × milk breeds). Significant increase in SCC was recorded with parity. Other studied factors showed smaller or negligible effect on SCC.

Key words: milk, somatic cells, mastitis, influencing factors

1 INTRODUCTION

The economics of milk processing in dairies largely depends on the quality of produced milk with somatic cells being the key parameter of its technological quality, *i.e.* milk processing quality (Ruegg and Pantoja, 2013). Lower somatic cell count (SCC) is related to the increased yield in the production of milk products, extended stability of milk and milk products and a favourable content/ratio of nutrients in these products. Besides the composition (the content of protein, fat, lactose, calcium, phosphorus, *etc.*), technological quality of raw milk in a large part also depends on the health and hygiene in milk production chain. An increase in SCC in milk is a consequence of immune response to inflammatory processes in the mammary gland. Somatic cells consist mainly of leukocytes (> 95 %, the rest are dead epithelial cells). SCC is thus an indicator of the udder health status and signifies the prevalence of clinical and subclinical mastitis in dairy herds (Smith, 1996; Dohoo and Leslie 1991), which, together with other factors, causes also a drop of cow milk production capacity (Barbano *et al.*, 2006).

Due to recent lowering of milk purchase prices, Slovenian farmers are increasingly seeking for new solutions to lower the costs of milk production. One of the possibilities is the improvement of udder health status, which would contribute to higher quantity and better quality of produced milk as well as to the improved animal welfare. In Slovenia, overall monitoring of SCC began in 2007 within regular milk recording (Jeretina *et al.*, 2007). Breeders can access the SCC information (and many other useful breeding information) through the web por-

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tal Cattle of the Central database (CPZ Govedo at Agricultural Institute of Slovenia); they are also informed via printed reports (Verbič *et al*., 2006), SMS messages and different educational activities. However, breeders insufficiently use these sources of information to improve their breeding work (Unuk *et al*., 2010). They usually underestimate the losses (reduced milk production) due to udder disorders and do not recognize the SCC reduction as a necessary measure to increase the efficiency of milk production. The progress in improving the udder health status in cattle is thus slower as desired (Praprotnik, 2013). Another reason is probably insufficient cooperation of breeders, veterinarians, dairies and other professional services. The experiences of many EU and worldwide countries (for review see Flere, 2016) show considerable decrease of incidence of subclinical mastitis due implementation of preventive programs to reduce SCC (mastitis control programs) together with constant teamwork of all actors from the milk production area. Among the most recognised programs is the program for quality assurance in dairy cattle breeds (Cullor *et al*., 1994), which sets out the rules for implementing the program on farms with the proposals of researchers and experts (NMC, 2013). It was a base for many other mastitis control programs.

Since the beginning of monitoring SCC (in 2007), the improvement of the state (*i.e*. decrease of SCC) in Slovenia is estimated to about 4 % (CPZ Govedo, unpublished data), which is below the desired level. Respecting current situation, it would be highly appreciable to prepare and implement mastitis control program for Slovenia. However, to construct efficient practical guidelines, it is important to analyse current situation. For this reason, it was the aim of the present work, to study the problem of SCC in Slovenia with special emphasis on factors affecting it.

2 MATERIAL AND METHODS

The analysis comprised the data for the period of 5 years (2010 to 2014) from the cattle database CPZ Govedo. Data originated from regular AT4 method of milk performance testing (test-day every 4 weeks – alternatively morning/evening) in all cows in the herd and comprised the data on milk yield and composition. In the first step, all available data for the selected period were taken for Slovenian population of Holstein (SH), Brown (SB) and Simmental (SS) breed and Simmental crossbreeds (SSX), *i.e*. crossings of SS with milk breeds such as Red Holstein and Montbeliard. After the removal of about 5 % of records (e.g. missing or invalid SCC data, AT recording performed from 1st to 4th day after calving) the resulted dataset comprised 3,208,309 milk recordings of 142,503 cows reared on 5,716 herds in all regions of Slovenia. Some basic statistics were calculated to elucidate recent situation in Slovenia.

In the next step, the subset representing 10 % of randomly selected herds from the previous sample set was created. Some additional conditions were set: *i*) milk recordings in standard lactation only, *ii*) number of daily recordings per lactation per cow ≥ 6 and *iii*) number of cows per herd ≥ 3. The obtained subset comprised 221,387 milk recordings, 24,234 lactations, 1,359 herds and 22,338 cows of SH (n = 9,955), SB (n = 2,889) and SS (n = 6,398) and SSX (n = 3,096). It was used to assess the effect of breed, parity, calving season and year, herd production (as an indicator of farm management) and milk yield (as an indicator of cow productivity) on:

i) SCC_{CON} – SCC measured at the recordings (6–12 records per lactation),

ii) *average* SCC_{100} – average value for SCC for the recordings within first 100 days in milk (one record per lactation).

For the purpose of statistical analyses, logarithmic transformation of SCC data was applied to reach normal distribution of this variable.

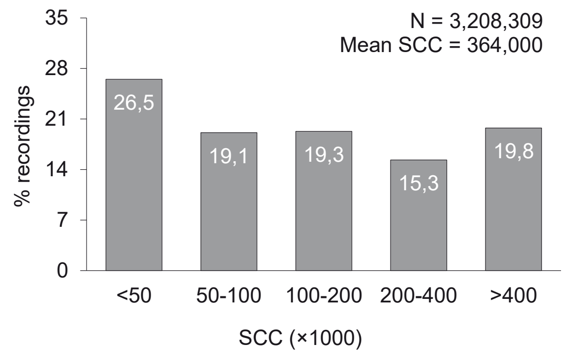
Data treatment was carried out in SAS 9.2 using MIXED procedure with breed, parity, season and year of calving in the model as fixed effects. Herd production and milk yield were added in the model as covariables and the effects of herd and bull as random effects.

$$y_{ijkl} = \mu + B_i + P_j + S_k + Y_l + \beta_1(HP) + \beta_2(MY) + e_{ijkl},$$

where:

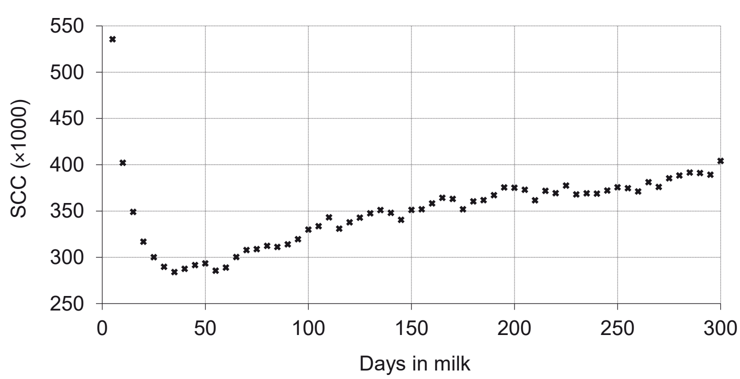
- μ – average,
- B_i – effect of breed (i = 1–4; *1*-SB, *2*-SS, *3*-SH, *4*-SSX crossing),
- P_j – effect of parity (j = 1–5; *1*-1st, *2*-2nd, *3*-3rd, *4*-4th, *5*-5th or latter),
- S_k – effect of calving season (k = 1–4; *1*-spring, *2*-summer, *3*-autumn, *4*-winter),
- Y_l – effect of calving year (l = 1–5; *1*-2010, *2*-2011, *3*-2012, *4*-2013, *5*-2014),
- β_1, β_2 – regression coefficients,
- HP – herd production average,
- MY – milk yield (daily yield for SCC_{CON}, standard lactation yield for *average* SCC_{100}),
- e_{ijk} – error.

In case of statistically significant effects, the differences among treatments were tested using *Tukey* test.



SCC – somatic cell count, N – number of milk recordings

***Figure 1:** Distribution of milk recordings according to SCC classes*



SCC – somatic cell count

***Figure 2:** SCC according to days in milk for the period of standard lactation*

3 RESULTS AND DISCUSSION

According to the literature, the default limit between healthy and potentially inflamed mammary gland is set at 200,000 somatic cells per millilitre (ml) of milk, although only values between 50,000 and 100,000 highly reliably denote healthy udder (Barkema *et al.* 1999). Another important threshold related to SCC is acceptability of milk for the processing in dairies, which varies considerably among countries (Hillerton and Berry, 2004). In the EU, this value is set to 400,000 somatic cells per ml of milk (the EU milk quality standard; Council Directive …, 1992); however, it refers to a three-monthly geometric average of bulk samples of cows in the herd. Current situation in Slovenia (Fig. 1) shows that the limit of 200,000 somatic cells per ml of milk is exceeded in one third of recordings. Moreover, in almost 20 % of recordings SCC is even over 400,000 per ml of milk. Overall, the average SCC for the whole lactation amounts to about 360,000, but it varies a lot during lactation (Fig. 2, presentation for standard lactation period). Very high SCC values observed soon after calving drop fast in a few days and reach minimum in the second month of lactation. After that, SCC continuously rises until the end of lactation.

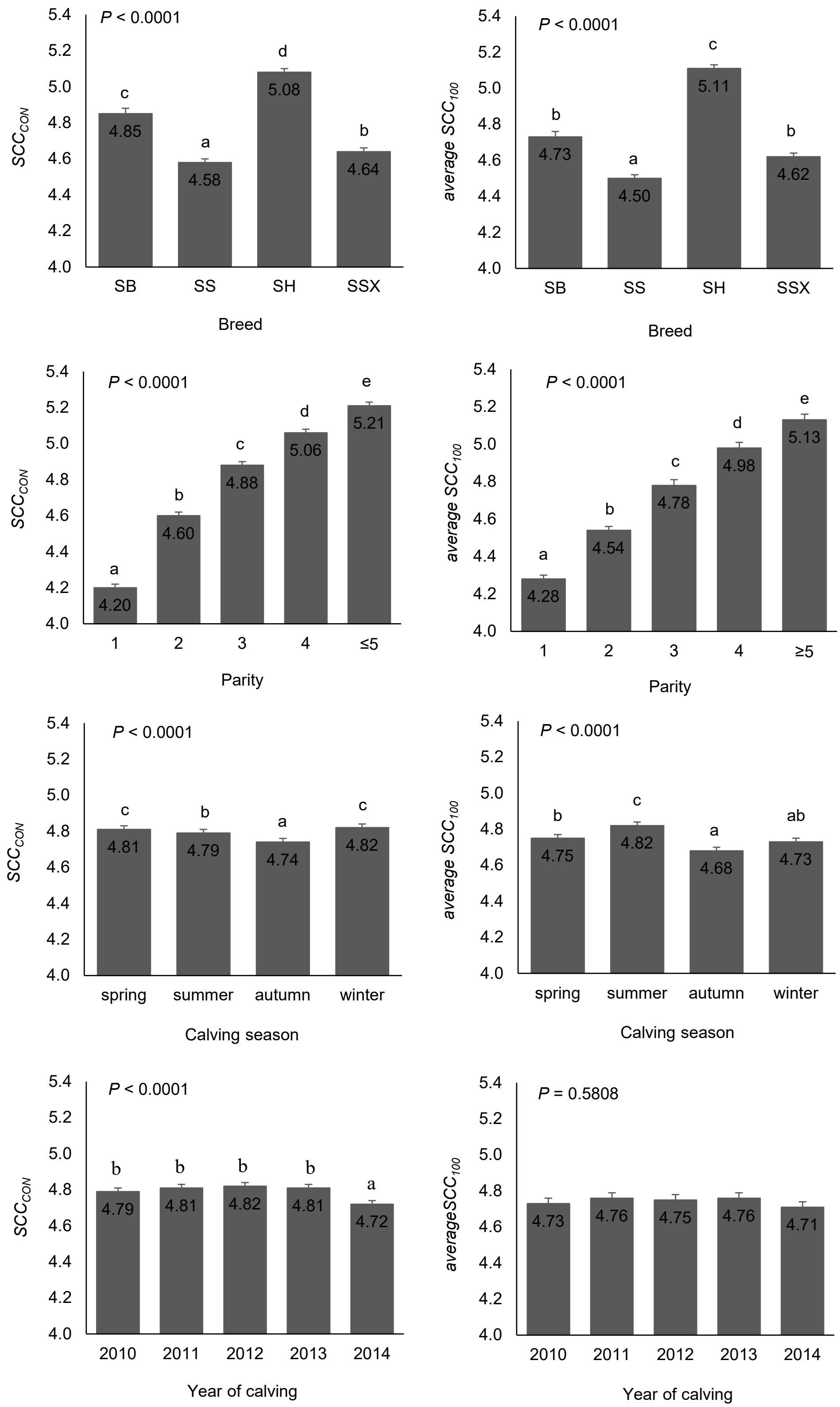
The main aim of the present study was to evaluate the effect of different factors on SCC_{CON} (SCC measured at recording) and *average* SCC_{100} (average SCC value for all recordings within first 100 days of lactation). *Average* SCC_{100} was of our interest as the first 100 days in milk represent critical lactation stage; this is a period with the lowest level of SCC (Fig. 2) and the peak of lactation curve (highest milk production). Thus, increased SCC in the first 100 days of lactation has the greatest influence on lactation milk production.

Analysis of variance for SCC_{CON} showed statistically significant effect of breed, parity, calving season, year of calving and daily milk yield, while herd production average had no effect (Table 1). Based on *F*-value, the effect of daily milk yield is evidently higher as compared to other factors. Estimated regression coefficient (*b*) for

***Table 1:** Analysis of variance for SCCcon and average SCC100*

	SCC_{CON}					*average* SCC_{100}				
Effect	DF	SS	MS	*F*-value	*p*-value	DF	SS	MS	*F*-value	*p*-value
Breed	3	10,249	3,416	179	< 0.0001	3	72.3	24.1	15.6	< 0.0001
Parity	4	28,929	7,232	2,672	< 0.0001	4	1039	259.8	167.8	< 0.00001
Season of calving	3	187	62	46	< 0.0001	3	54.7	18.2	11.8	< 0.0001
Year of calving	4	220	55	8.3	< 0.0001	4	6.58	1.64	1.06	0.3736
Herd production	1	51	51	0.10	0.7459	1	0.00	0.00	0.00	0.9548
Milk yield*	1	18,751	18,751	12,362	< 0.0001	1	724	724	468	< 0.0001

SCC – somatic cell count, SCCcon – SCC measured at milk recording, average SCC100 – average SCC for all recordings within first 100 days of lactation, DF – degrees of freedom, SS – sum of squares, MS – mean sum of squares (=SS/DF)
* daily value in case of SCCcon and standard lactation value in case of average SCC100



SCC – somatic cell count, SCC_{CON} – SCC measured at milk recording, *average* SCC_{100} – average SCC for all recordings within first 100 days in milk, SH – Holstein, SB – Brown, SS – Simmental, SSX – crossbreeds of SS and milk breeds.

***Figure 3:** Effect of breed, parity, calving season and year on SCCcon and average SCC100*

daily milk yield was –0.049 (data not shown). In respect of relevance, the effect of milk yield is followed by the effect of parity, breed, calving season and year.

Similar results in analysis of variance were found for *average* SCC_{100}. The effect of milk yield (in standard lactation) was apparently higher as compared to other studied factors. Estimated regression coefficient (*b*) for standard lactation milk yield was –0.00016 (data not shown). Regarding the relevance, the effect of standard lactation milk yield is followed by the effect of parity, breed and calving season (no significant effect of calving year). Differences in SCC_{CON} and *average* SCC_{100} among treatments are presented on Figure 3.

Overall, a bit lower values could be observed for *average* SCC_{100} as this parameter refers to the period of first 100 days in milk, while parameter SCC_{con} coved the period of standard lactation. Among breeds, the greatest difference in SCC_{CON} and *average* SCC_{100} was observed between SH and SS breed, which is in accordance with findings of Zavadilova *et al.* (2011), where higher SCC was observed in Holstein as compared to Simmental breed in the first third of lactation. SB breed and SSX crossbreeds had intermediate position, in case of *average* SCC_{100} they were even not significantly different. In SSX, the SCC was very similar compared to pure SS breed. This proves that crossbreeding with milk breeds did not affect considerable the udder health. With parity, SCC_{CON} and *average* SCC_{100} noticeably increased from the first to the fifth and later lactations with all studied lactations differing significantly (the greatest difference between 1st and 2nd lactation). This could be the consequence of animals' history, *i.e.* illnesses in previous lactations and higher sensibility of udder in latter lactations, which is reflected in more intensive reaction of mobilising somatic cells from surrounding tissue and higher susceptibility of older cows for inflammations caused by pathogen agents. Constant increase in SCC with parity is in agreement with results of Barkema *et al.* (1999). The effects of calving season and year were also significant; however, the differences among treatments were less pronounced as for breeds and parities. SCC_{CON} and *average* SCC_{100} reached the lowest value in case of calving in autumn. The likely reasons are moderate temperatures and constant feeding during this season. In contrast, hot weather in summer and poorly ventilated stables with high relative humidity could contribute to the rise in mastitis occurrence. Regarding the year of calving, we can see significantly lower SCC_{CON} for the last studied year (2014) and no differences among years for *average* SCC_{100}. No special progress in lowering SCC over time was reported for Slovenia also by Jeretina and Babnik (2010). Negative correlation between SCC and milk yield (daily or standard lactation) denotes that only healthy udder is expected to have the potential for high production. It is also related to farm management as balanced nutrition and favourable environmental conditions contribute to better health status and higher milk production.

4 CONCLUSIONS

Cow productivity (milk yield), parity and breed are the most influential factors affecting SCC. Lower milk yield (per day or per standard lactation) is related with higher SCC. Among breeds, the highest SCC was observed for SH, followed by SB, SS breeds and SSX crossbreeds. Crossbreeding of SS with milk breeds did not affect considerable the SCC in milk. Distinctive increase in SCC was recorded with parity (from 1st to 5th and latter). Other studied factors (herd productivity, year and season of calving) showed smaller or negligible effect on SCC. In one third of milk recordings, the SCC exceeds the limit (200,000 somatic cells per ml) denoting healthy udder. To our opinion, such situation is a matter of concern and deserves more attention. It would be necessary to establish cooperation of breeders, experts and dairy industry with the purpose to prepare and implement mastitis control program in Slovenian dairy herds.

5 REFERENCES

Barbano, D. M., Ma, Y., Santos, M.V. (2006). Influence of raw milk quality on fluid milk shelf life. *Journal of Dairy Science*, *89*, 15–19.

Barkema, H. W., Deluyker, H. A., Schukken, Y. H., Lam, T. (1999). Quarter-milk somatic cell count at calving and at the first six milkings after calving. *Preventive Veterinary Medicine*, *38*, 1–9.

Council Directive 92/46/EEC of 16 June 1992 laying down the health rules for the production and placing on the market of raw milk, heat-treated milk and milk-based products.

Cullor, J. S., Eenennaam, A., van Gardner, I., Perani, L., Dellinger, J., Smith, W. L., Thompson, T., Payne, M. A., Jensen, L., Guterbock, W. M. (1994). Performance of various tests used to screen antibiotic residues in milk samples from individual animals. *Journal of AOAC International*, *77*, 862–870.

Dohoo, I. R., Leslie, K. E. (1991). Evaluation of changes in somatic cell counts as indicators of new intramammary infections. *Preventive Veterinary Medicine*, *10*, 225–238.

Flere, D. (2016). Spremljanje stanja in predlog ukrepov za zmanjšanje pogostosti mastitisov pri molznicah v slovenskih čredah. Magistrsko delo, Univerza v Mariboru, Fakulteta za kmetijstvo in biosistemske vede: 55 p.

Hillerton, J. E., Berry, E. A. (2004). Quality of the milk supply: European regulations versus practice. Proceedings 43rd NMC Annual Meeting, 207–214.

Jeretina, J., Babnik, D. (2010). Rezultati analize gibanja števila somatskih celic pri molznicah med leti 2007 in 2009. Retrieved from http://www.kgzs-ms.si/users_slike/metkab/ZED10/ZEDP13-Jeretina.doc

Jeretina, J., Babnik, D., Verbič, J. (2007). Monitoring of somatic cell count in milk by means of web application entitled Cattle. Proceedings of the 16th Symposium on Nutrition of Domestic Animals "Zadravec-Erjavec Days": 8–9 Nov 2007, Radenci, Slovenia, 137–149.

NMC. (2013). Recommended Mastitis Control Program. Retrieved from https://www.nmconline.org/docs/NMC-checklistInt.pdf

Praprotnik, Č. (2013). Poročilo o spremljanju gibanja števila somatskih celic v Sloveniji za obdobje 2007–2012. Retrieved from http://zdravovime.blogspot.com/2013/09/porocilo-o-spremljanju-gibanja-stevila.html

Ruegg, P. L., Pantoja, J. C. F. (2013). Understanding and using somatic cell counts to improve milk quality. *Irish Journal of Agricultural and Food Research*, *52*, 101–117.

Smith, K. L. (1996). Standards for somatic cells in milk: physiological and regulatory. *Newsletters of the International Dairy Federation*, *144*: 7–9.

Unuk, N., Tumpej, I., Korošec, S. (2010). Izvajanje projekta »MLEKO« na območju LAS »Bogastvo podeželja ob Dravi in Slovenskih goricah«. Retrieved from http://www.shrani.si/f/J/jp/mjCj3xX/clanek-somatske-celice.pdf

Zavadilová, I., Wolf, J., Štípková, M., Němcová, E., Jamrozik, J. (2011). Genetic parameters for somatic cell score in the first three lactations of Czech Holstein and Fleckvieh breeds using a random regression model. *Czech Journal of Animal Science*, *56*(6), 251–260.

Verbič, J., Babnik, D., Jeretina, J., Perpar, T. (2006). Habits of farmers in dairy cow feeding in Slovenia and their influence on milk production, milk composition and health status. Proceedings of the 15th Symposium on Nutrition of Domestic Animals "Zadravec-Erjavec Days": 9–10 Nov 2006, Radenci, Slovenia: 119–135.