THE EFFECT OF SOMATIC CELL ON MILK YIELD AND MILK FLOW AT QUARTER LEVEL

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Abstract. The objective of our study was to describe the effect of SCC at quarter level in different stages of lactation and front/rear position on milk yield and other parameters of milkability. A total of 62 Holstein cows, in their first to third lactation, different stages of lactation and free of clinical symptoms of mastitis, were investigated. On the base of SCC the quarters were divided into three groups: low (under 200 000 per ml), middle (SCC in range between 200 000 – 400 000 per ml) and high (over 400 000 per ml). The course of lactation was divided into three groups: first (first and third month), second (fourth and sixth month), and third (seventh and more months of lactation). For the statistical evaluation three groups of cows were selected. In the first group the effect of SCC between two quarters with low and contralateral middle SCC was tested. Thus 16 cows with 178 pairs of quarters were tested. In the second group the effect of SCC between two quarters with low and contralateral high SCC was tested. Thus 14 cows with 198 pairs of quarters were tested. In the third group, only cows with low SCC per all four quarters (17 cows and 188 pairs of quarters) were selected for testing – low quarter with contralateral low quarter on milk yield only. The milk yield was significantly reduced in high quarters as compared to contralateral low quarters. The tendency of lower milk yield in middle quarters was spotted when compared with contralateral low quarters. No milk yield differences were recorded between low quarters and contralateral low quarters. The SCC reduced milk yield in affected quarters as compared with contralateral quarters with low SCC. The reduction depended on the level of SCC in milk of that quarter. In conclusion, comparison of healthy quarters (low SCC) and contralateral quarters with higher SCC showed that the SCC reduced milk yield in the mentioned quarters. The reduction depended on the level of SCC in milk of a contralateral quarter.

Keywords: dairy cows, somatic cells, milk yield, quarter.

Introduction

The knowledge concerning the udder health and especially intramammary infection has increased all over the world but in dairy practice the problems with udder health still represent the most important negative impact on economy of milk production.

At present, technical advances, such as electronically suitable devices, are available what allows measuring milk flow kinetic from individual quarters. Such equipment also was developed at our institute and has been described in literature (Tančin et al., 2005). The exact recording of the quarter milk flow during milking gives us useful and essential information on the course of milking including the efficiency of milk ejection (Tančin & Bruckmaier, 2001, Antalík & Strapák, 2011) and possible relationship to somatic cell count in milk (SCC) (Tančin et al, 2007). In our last mentioned work, the negative effects of SCC on milk yield at a quarter level were demonstrated. It is generally accepted that high SCC is connected with lower milk yield of the udder (Wilson et al., 1997, Tančin, 2013) and quarter levels (Tančin et al., 2007). In terms of milk yield, the quarters with low and high SCC were mostly evaluated independently and then compared. Therefore limited data that compares the SCC of two quarters within the same cow and position (front or rear) are available. The pair quarters of udder at the same front or rear position differing in SCC could be a good model to better demonstrate the negative effect of SCC on milk yield. The objective of our study was to describe the effect of SCC at quarter level on milk yield and other parameters of milkability at different stages of lactation and front/rear position.

Material and Methods

A total of 62 Holstein cows, in their first to third lactation, different stages of lactation and free of clinical symptoms of mastitis, were investigated. The cows were milked twice a day at 5:30 a.m. and 4:30 p.m. in the 2 x 5 herringbone-milking parlour.

The equipment, developed at our institute, was placed in the parlour to the first milking stall. Using the four-chamber claw all quarters were milked separately. Milk yield of individual quarter was recorded monthly during evening milking throughout the whole year. The recorder consisted of four milk receiver jars, the advancing weight (tensometers) of which was recorded each third second. The quarter milk weight registrations during milking were converted into a milk flow rate profile to calculate the duration of milk flow phases (Tančin et al., 2005). The samples of milk from each quarter were taken for SCC analysis before milking according Riekerink et al. (2007).

Pre-milking udder preparation consisted of fore-stripping, cleaning and drying with a dry paper towel for a period of about 40 s per udder and milk sampling. Milking and pulsation vacuum was set at 42 kPa. Pulsation ratio was 60:40 at a rate of 52 c/min. When milk flow ceased, the gentle stripping (pushing cluster by hand down) started until milk flow ceased again.

SCC in milk was evaluated by FOSSOMATIC device. On the basis of SCC, the pairs of the quarters at the same front or rear position of udder were selected from above mentioned cows throughout lactation and divided into three groups: first group consisted of pairs of quarters with low (under 200 000 per ml) and contralateral middle (SCC in range between 200 000 – 400 000 per ml), second group of the pairs of quarters with low and contralateral high (over 400 000 per ml), and third group of the pairs of quarters with low SCC in both quarters only. The course of lactation was divided into three groups: first (first and third month), second (fourth and sixth month), third (seventh and more months of lactation).

Total milk yield (kg) was given per one quarter. Peak flow rate (kg.min^{-1}) represented the maximum milk flow rate at any given time window of 15 s. The decline phase (s) represented reducing of milk flow and lasted from the end of plateau until the flow was lower than 0.1 kg.min^{-1} per quarter. The overmilking phase (s) lasted from the end of decline phase until the milk flow from last milked quarter declined under 0.1 kg/min.

Statistical evaluation. From the above mentioned number of cows only animals which corresponded with the aim of work were selected for each group. In the first group there was tested the effect of SCC between two quarters with low and contralateral middle SCC. Thus 16 cows with 178 pairs of quarters were selected for testing. In the second group the effect of SCC between two quarters with low and contralateral high SCC was tested. Thus 14 cows with 198 pairs of quarters were selected. In the third group, only cows with low SCC on both sides of paired quarters (17 cows and 188 pairs of quarters - low quarter versus contralateral low quarter) were selected for testing –on milk yield, peak flow rate, and duration of all three milk flow phases (increase, decline and overmilking).

Two levels of SCC within three levels for stage of lactation, and two levels of SCC within the front/rear position were defined in the model. Statistical significance of the effects included in the model was tested using Fisher's F-test. The differences between the levels of the effects were tested by Scheffe multiple range test for studied traits. The data are presented as means.

For evaluation of somatic cells the following model was used:

$$y= X\beta + Zu+e$$

y – the measurements for evaluated parameters,

β – the fixed effects two levels of SCC within three levels for stage of lactation, and two levels of SCC within the front/rear position

u – random effect of cow,, u ~ N $(0, I\ \delta^2_c)$

e – random error, assuming e ~ N $(0, I\ \delta^2_e)$

X, Z – incidence matrices for fixed effects and random cow effect, resp

Results and discussion

When we compared the quarters which differ in SCC we could demonstrate throughout lactation the higher milk yield in low SCC quarters as compared with contralateral high SCC quarters (Table 1). As it is shown in Table 1, even the level of SCC between 200 000 – 400 000 SCC per ml (lower table) middle SCC quarters the milk yield was reduced when compared with the contralateral low SCC quarters. More clearly the effect of SCC was presented in Table 2 where two quarters differing in SCC were compared within the same teat position - the front and rear position. On the other side (third group), when only cows with low SCC in all quarters were evaluated, there were no significant differences in milk yield between left and right front quarters (3.62 ± 0.18 kg vs. 3.69 ± 0.17 kg, resp.) and between left and right rear quarters (4.46 ± 0.18 kg vs. 4.53 ± 0.18 kg, resp.). Also other studied parameters did not differ significantly (the data obtained did not show significant differences).

Table 1. **The effect of somatic cell counts throughout lactation on selected parameters for comparison of two opposite quarters of the same cow and at the same front/rear position differing in SCC** (upper table between low and high, lower table between low and middle)

	Stage of lactation					
	Period I.		Period II.		Period III.	
	low	high	low	high	low	high
Milk yield, kg	4.69 ± 0.33^a	4.25 ± 0.33^b	3.82 ± 0.34^a	3.27 ± 0.36^b	2.07 ± 0.36^a	1.90 ± 0.36^b
Peak flow, kg.min^{-1}	0.93 ± 0.11^a	0.82 ± 0.11^b	0.84 ± 0.10^a	0.81 ± 0.10^b	0.82 ± 0.10^a	0.68 ± 0.11^b
Increase phase, s	68 ± 7	70 ± 7	73 ± 8	67 ± 8	81 ± 8	80 ± 8
Decline phase, s	64 ± 10	62 ± 10	47 ± 10	60 ± 11	46 ± 12	47 ± 12
Overmilking, s	95 ± 15	89 ± 15	97 ± 16	100 ± 16	82 ± 12	85 ± 15
	Stage of lactation					
	Period I.		Period II.		Period III.	
	low	middle	low	middle	low	middle
Milk yield, kg	4.78 ± 0.25	4.46 ± 0.25	3.99 ± 026	3.61 ± 0.26	2.90 ± 0.27	2.63 ± 0.26
Peak flow, kg.min^{-1}	0.99 ± 0.07	0.97 ± 0.07	0.93 ± 0.07	0.93 ± 0.08	0.93 ± 0.08	0.82 ± 0.08
Increase phase, s	70 ± 7	65 ± 7	74 ± 7	69 ± 7	69 ± 8	68 ± 8
Decline phase, s	50 ± 8	57 ± 8	50 ± 9	64 ± 9	54 ± 9	67 ± 9
Overmilking, s	92 ± 15	84 ± 15	94 ± 16	106 ± 16	102 ± 17	71 ± 16
a,b, - within one factor values without a common superscript were significantly different at P<0.05						

Table 2. **The effect of somatic cell counts on selected parameters for comparison of two opposite quarters of the same cow and separately for front and rear position differing in SCC** (upper table between low and high, lower table between low and middle)

	Teat position			
	front		rear	
	low	high	low	high
Milk yield, kg	3.22 ± 0.35[a]	2.61 ± 0.35[b]	4.28 ± 0.31[a]	3.67 ± 0.31[b]
Peak flow, kg.min^{-1}	0.81 ± 0.10[a]	0.70 ± 0.01[b]	0.93 ± 0.1[a]	0.80 ± 0.10[b]
Increase phase, s	70 ± 8	69 ± 8	78 ± 7	76 ± 7
Decline phase, s	46 ± 11	47 ± 12	59 ± 9	65 ± 9
Overmilking, s	113 ± 17	126 ± 15	56 ± 14	64 ± 14
	Teat position			
	front		rear	
	low	middle	low	middle
Milk yield, kg	3.51 ± 0.27	3.34 ± 0.26	4.27 ± 0.24[a]	3.39 ± 0.24[b]
Peak flow, kg.min^{-1}	0.97 ± 0.08[a]	0.81 ± 0.08[b]	0.94 ± 0.07	0.94 ± 0.07
Increase phase, s	72 ± 7	70 ± 7	70 ± 7	65 ± 7
Decline phase, s	52 ± 7	58 ± 8	50 ± 8	68 ± 9
Overmilking, s	135 ± 16	100 ± 16	57 ± 15	74 ± 15
a,b, - within one factor values without a common superscript were significantly different at P<0.05				

Our previous results showing negative effect of SCC at udder and quarter level on milk yield (Tančin et al, 2003, 2007) confirmed these results which are more precisely evaluated by comparing the pair of quarters of the same cow at the same front or rear position. In literature there was documented that even SCC over 10^5 cells.ml^{-1} caused the reduction of milk yield (Korhonen and Kaartinen, 1995, Hortet et al., 1999). In the presented work, we could significantly demonstrate the negative effect of higher SCC on milk yield because the results were obtained by comparison of two contralateral quarters, one with low and the other with high SCC. As can be seen in model three, the milk yield in quarters with low SCC did not differ between two contralateral quarters. In our earlier study we could demonstrate the significant differences in milk production between two quarters at front or rear position (Tančin et al., 2006). On the basis of the results of the presented study we could explain the significant difference by possibly different health status of quarters in the previously mentioned work.

Peak flow rate (PFR) was affected by SCC mainly when we compared quarters with low and high SCC (Table 1). There were no statistical differences between low and middle group of quarters. Peak flow rate plays an important role in relation to the sensitivity of the udder to mastitis (Grindal and Hillerton, 1991). In our work (Tančin et al., 2005), no direct relationship between peak flow rate and SCC was detected. The changes of peak flow rate are mainly related to the certain reduction of milk yield (Tančin et al., 2006). Therefore the possible negative effect of SCC on peak flow is indirect through the milk yield. Significant but low correlation was found between SCC, high milk flow and milking speed by Juozaitienė and Japertienė (2010)

The duration of increase phase was not changed by SCC as it is shown in Table 1. Our findings are not in line with generally accepted negative effect of the duration of increase phase on udder health evaluated by SCC. In our previous work (Tančin et al., 2007), we found out a tendency of higher SCC in quarters with bimodal milk flow curves where the increase phase is significantly longer. The tendency of higher SCC in bimodal milk flow curves was found out by Sandrucci et al. (2007). From above the mentioned point of view, our finding could be interesting, because we are comparing two quarters within the same cows, at the same front or rear position which differed in SCC.

In this study, we have found a tendency of longer duration of the decline phase in quarters with high SCC (Tables 1 and 2) though in the previous study Tančin et al. (2003) the effect was either significant or not significant at the level <0.0578 (Tančin et al., 2007). The duration of the decline phase seems not to be influenced by SCC in milk.

As it is shown in Tables 1 and 2, no effect of SCC on the duration of overmilking phase was observed. The similar conclusion was published in our earlier work (Tančin et al., 2007). The overmilking is mainly influenced by quarter position where the front quarters are often overmilked longer than rear ones (Table 2). However the SCC is higher in rear than front quarters (Tančin et al., 2007). For example *Staphylococcus aureus* mastitis in hind quarters has a low cure rate compared with front quarters (Barkema et al., 2006).). Under the conditions of milk flow from the udder positive effect of overmilking on SCC was found out by Mišeikienė et al. (2011).

Conclusion

In conclusion, if we compare healthy quarters (low SCC) and contralateral quarters with higher (high or middle) SCC, the SCC reduced milk yield and peak flow in mentioned quarters as compared with quarters with low SCC. The reduction depended on the level of SCC in milk of a contralateral quarter

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