Prediction of total quarter milk somatic cell counts based on foremilk sampling

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Determination of somatic cell count (SCC) is used worldwide in dairy practice to describe the hygienic status of the milk and the udder health of cows. When SCC is tested on a quarter level to detect single quarters with high SCC levels of cows for practical reasons, mostly foremilk samples after prestimulation (i.e. cleaning of the udder) are used. However, SCC is usually different in different milk fractions. Therefore, the goal of this study was the investigation of the use of foremilk samples for the estimation of total quarter SCC. A total of 378 milkings in 19 dairy cows were performed with a special milking device to drain quarter milk separately. Foremilk samples were taken after udder stimulation and before cluster attachment. SCC was measured in foremilk samples and in total quarter milk. Total quarter milk SCC could not be predicted precisely from foremilk SCC measurements. At relatively high foremilk SCC levels (>300 x 10³ cells/ml) foremilk SCC were higher than total quarter milk. At around (50–300) x 10³ cells/ml foremilk and total quarter SCC did not differ considerably. Most interestingly, if foremilk SCC was lower than 50 x 10³ cells/ml the total quarter SCC was higher than foremilk SCC. In addition, individual cows showed dramatic variations in foremilk SCC that were not very well related to total quarter milk SCC. In conclusion, foremilk samples are useful to detect high quarter milk SCC to recognize possibly infected quarters, only if precise cell counts are not required. However, foremilk samples can be deceptive if very low cell numbers are to be detected.

Keywords: Udder health, somatic cell count, foremilk, quarter milk.

Somatic cell count (SCC) is the most widespread udder health and milk hygienic parameter in dairy practice because an infection of the mammary gland is the major factor that increases the SCC. Infections reduce both the quality and the yield of milk, and the SCC of individual quarters can affect the total milk SCC of the cow and, consequently, the bulk tank SCC. Therefore, an early detection of milk with markedly increased SCC is important to prevent its addition to the bulk tank milk. Quarter foremilk sampling before milking for monitoring milk quality and the detection of mastitis, using California Mastitis Test (CMT) or by exact determination of SCC, is well established. However, the estimation of quarter SCC based on foremilk measurements is critical and it has to be taken into account that different milk fractions of a quarter can show different SCC. It was previously shown that the SCC of cisternal milk is higher than in the first 25% of alveolar milk in cows with <100 x 10³ cells/ml in whole udder milk (Ontsouka et al. 2003) and the SCC increased in later milk fractions until the end of milking (Vangroenweghe et al. 2002; Sarikaya et al. 2005). In addition, Sarikaya & Bruckmaier (2006) distinguished between strict foremilk (taken without udder preparation) and cisternal milk where the SCC decreased with each squirt of milk and was higher than in the alveolar milk fractions. This difference between foremilk and alveolar milk was more distinctive at increased total quarter SCC (> 100 x 10³ cells/ml). Therefore, the definition of the tested fraction is of most importance if the results are used for the prediction of total quarter milk SCC.

To obtain strict foremilk samples without an intermix with alveolar milk, samples of all quarters must be taken within a lag time of 40–50 s, i.e. before the start of milk ejection (Bruckmaier & Hilger, 2001). This is often not possible under practical farming conditions. Therefore,
it is more suitable to remove foremilk samples after milk ejection has commenced. However, the use of foremilk SCC (SCC-F) taken after udder preparation and induction of milk ejection to estimate total quarter SCC (SCC-T) in dairy cows has not been systematically investigated.

The goal of the present study was to test the usefulness of quarter foremilk samples taken after udder stimulation to provide representative data of total quarter SCC.

Material and Methods

Animals and sampling

Nineteen dairy cows of different breeds (10 Holstein, 6 Simmental, 3 Swiss Brown) in the middle (week 14–28) of their 1st to 5th lactation were used. The cows had a daily milk yield of 27.1±1.5 kg and an average whole udder milk SCC of (122±8)×10³/ml. They were sampled during routine milking twice a day at 5.30 and 15.30 for 10 subsequent days (378 milkings in total). Immediately before the onset of the milking clusters, 10-ml foremilk samples of each quarter were taken after a 1-min udder stimulation by massage of the teats and removing 2–3 jets of milk from each quarter. Milking was performed with a special milking device to collect separate quarter milk. At the end of the milking procedure samples from total milk of each quarter were collected for SCC measurements. Milk samples were kept at 4°C and SCC analyses were performed within 24 h. SCC was measured with the DeLaval cell counter (DCC; DeLaval International, Tumba, Sweden).

Statistical analysis

Pairs of quarter milk recordings (foremilk v. total quarter milk) were analysed by various regression analyses. A random effects linear regression model with maximum likelihood estimates (MLE) and exact confidence intervals was fitted to predict values of log(SCC-T). The model included a constant term (intercept), the linear and quadratic form of the predictor log(SCC-F), and cow as a random effect (STATA 10; function xtreg). The inclusion of cow as a random effect accounted for the repetition of measurements within cow over quarter, milking (morning, afternoon) and time (10 measuring days per cow). Model predictions of log(SCC-T) by log(SCC-F), therefore, are averages over the possible differences between quarters, milking time, and sampling date. A polynomial regression of all quarter SCC (log10) was used to test the relationship between all SCC-T and SCC-F (Fig. 1).

In addition, for a better characterization of the predictability of SCC-T by SCC-F the samples were grouped into six different SCC-F classes (<20 (n=217), 20 to <50 (n=412), 50 to <100 (n=300), 100 to <300 (n=373), 300 to <500 (n=99), and >500 (n=111)×10³ cells/ml). (Table 1, Fig. 2). Data are presented as means with SEM. The association between foremilk and total quarter milk SCC at different SCC classes was determined by simple linear regression (Fig. 3). In all analyses, P<0.05 was considered as significant.

Table 1. Foremilk and total quarter milk SCC in groups of different foremilk SCC

<table>
<thead>
<tr>
<th>SCC group (×10³ cells/ml)</th>
<th>n</th>
<th>Mean SCC values, log₁₀</th>
<th>Number of quarters with numerically lower SCC in foremilk, %</th>
<th>Coefficient of linear regression (P&lt;0.001)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Foremilk</td>
<td>Total quarter</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;20</td>
<td>217</td>
<td>4.10±0.50a</td>
<td>4.33±0.00b</td>
<td>70.5</td>
</tr>
<tr>
<td>20 to &lt;50</td>
<td>412</td>
<td>4.52±0.39a</td>
<td>4.55±0.00b</td>
<td>46.3</td>
</tr>
<tr>
<td>50 to &lt;100</td>
<td>300</td>
<td>4.85±0.61a</td>
<td>4.86±0.65a</td>
<td>42.0</td>
</tr>
<tr>
<td>100 to &lt;300</td>
<td>373</td>
<td>5.26±0.47a</td>
<td>5.14±0.65a</td>
<td>23.3</td>
</tr>
<tr>
<td>300 to &lt;500</td>
<td>99</td>
<td>5.58±0.75a</td>
<td>5.40±1.18b</td>
<td>19.2</td>
</tr>
<tr>
<td>&gt;500</td>
<td>111</td>
<td>6.07±1.93a</td>
<td>5.77±1.64b</td>
<td>6.3</td>
</tr>
</tbody>
</table>

a,b = Means without common superscript letters are significantly different between foremilk and total quarter milk within SCC groups (P<0.05)
Veolar fractions have fewer cells than later milk fractions and decreases SCC of the cisternal milk because the first alveolar milk was already mixed with alveolar milk at the time of sampling. This has already commenced and cisternal milk was already sampled from 19 dairy cows were compared with total quarter SCC. The samples were taken after a 1-min udder stimulation by massage of the teats and removing 2–3 jets of foremilk total quarter milk (Urech et al. 1999; Walldmann et al. 1999; Ontsouka et al. 2003; Bruckmaier et al. 2004; Tančin et al. 2007). However, taking foremilk samples after udder stimulation was chosen because this is the procedure usually used to collect milk samples for SCC measurement under practical milking conditions and particularly in automatic milking systems where, for technical reasons, no milk samples can be taken before intensive teat cleaning and teat cup attachment. This routine of udder preparation inevitably induces milk ejection before a milk sample can be taken (Dzidic et al. 2004a, b). In conventional milking systems sampling of strict foremilk, i.e. without alveolar milk ejection, is hardly possible in all four quarters because milk sampling induces milk ejection within 40–50 s of the start of stimulation (Bruckmaier & Hilger, 2001). Induction of milk ejection via oxytocin is a systemic effect reaching the whole udder; the sampling of the first quarters can induce milk ejection within this short time also in the quarters not yet sampled, and it may well happen that in two or three quarters a sampling of strict foremilk is possible while in the last quarters milk ejection has already occurred (Bruckmaier & Hilger, 2001; Bruckmaier et al. 2004). However, the purpose of this study was to test the usefulness of foremilk sampling to predict total quarter milk SCC under regular practical conditions.

The results show that total quarter milk SCC cannot be predicted precisely from foremilk SCC measurements. Only when SCC-F was (50–300) × 10^3 cells/ml did foremilk and total quarter SCC not differ considerably. At SCC-F lower than (50–300) × 10^3 cells/ml, SCC were numerically even lower in foremilk than in total quarter milk for most quarters. Coefficients of linear regression (P<0.001) in the groups <20, 20 to <50, 50 to <100, 100 to <300, 300 to 500, and >500 × 10^3 cells/ml were 1.54, 1.05, 1.01, 0.75, 0.67 and 0.44, respectively (Fig. 3).

Discussion

In the present study 1512 SCC measurements of foremilk samples from 19 dairy cows were compared with total quarter SCC. The samples were taken after a 1-min udder stimulation by massage of the teats and removing 2–3 jets of milk from each quarter. Therefore, milk ejection had already commenced and cisternal milk was already mixed with alveolar milk at the time of sampling. This decreases SCC of the cisternal milk because the first alveolar fractions have fewer cells than later milk fractions.
25% and 50% of the alveolar milk fraction. Only the last 50% of the alveolar fraction and the residual milk (after high-dosage oxytocin injection) had higher SCC than the cisternal fraction. Furthermore, comparable results were found by Urech et al. (1999). They also described a higher SCC in foremilk than in bucket milk (main milk fraction) if SCC was elevated (>100 x 10³/ml) during subclinical mastitis. These differences between studies are probably due to a different distribution of SCC levels. If the selection criteria are below a threshold SCC of (100–200) x 10³/ml

Fig. 3. Linear regressions (black lines; elongations: dotted lines) of total quarter and foremilk SCC grouped into different foremilk SCC: A: <20 x 10³ cells/ml (n=217); B: 20 to <50 x 10³ cells/ml (n=412); C: 50 to <100 x 10³ cells/ml (n=300); D: 100 to <300 x 10³ cells/ml (n=373); E: 300–500 x 10³ cells/ml (n=99); F: >500 x 10³ cells/ml (n=111). A line where x=y is indicated in dash – dotted grey.
the part of quarters below or above 50 × 10³ cells/ml have to be taken into account.

The question arises why there is such a difference between foremilk (milk of the cistern) and the alveolar milk. In the presence of chemokines, which are produced during an infection by different cells, there is a high influx of cells in the time between milkings. It is possible that, owing to the large numbers of cells invading the alveoli, a substantial number of these cells leave the alveoli and accumulate in the cisternal milk fraction, leading to a high SCC in the foremilk fraction. Another explanation could be that different mechanisms exist for the transport of cells from blood into milk. While it can be assumed that in the entire secretory parenchyma leucocytes pass by paracellular mechanisms through the tight junctions of the epithelium, it is likely that cells invade the cistern directly in the area of the Fürstenberg’s rosette. In this area, a lot of immune cells are found in the tissue, specifically in the epithelial lining (Nickerson & Pankey, 1983). In addition, it has been shown that in quarters with high cell counts (>100 × 10³/ml) an increased number of cells that express L-selectin and 2-integrin, which they need for diapedesis, are found in this area (Simon et al. 2007). The specific transfer of leucocytes close to the potential entrance port of pathogenic microorganisms would be advantageous in the case of infection. However, in a healthy gland there are almost no chemokines produced and, therefore, the cell influx during the milkings is very low. Then most cells invade the mammary gland are in the alveoli and increase the total quarter milk SCC as compared with the foremilk.

The worldwide goal today is to decrease the SCC as much as possible for the best hygienic quality and, most importantly, for the farmers to get the highest price for their milk. The present study showed that foremilk measurements were not suitable to predict the exact value of very low SCC, albeit prediction of the range is well possible. However, under practical farming conditions there is usually no necessity for detection of exact low SCC, only increased SCC values that can reduce the milk quality are of great importance.

In addition, in the present study it was seen that in some cows the differences of foremilk and total quarter milk were extreme, as outliers in the regression analyses illustrate. This variation was not necessarily related to high SCC and shows that single sampling for SCC always has to be interpreted very carefully.

In conclusion, foremilk samples can predict values of quarter milk SCC if the milk contains around (50–300) × 10³ cells/ml. At higher SCC values, foremilk samples contain more cells and the difference relative to total quarter milk increases with increasing SCC. At very low SCC levels foremilk contains fewer cells than total quarter milk. Therefore, foremilk samples are useful to detect high quarter milk SCC to recognize infected quarters only when precise cell counts are not required. However, foremilk samples can be misleading if very low cell numbers are to be detected. In addition, it has to be taken into account that individual cows can show dramatic variations in foremilk SCC that are not very well related to total quarter milk SCC.

References


