Effect of somatic cell count on milk yield and composition of first and second lactation dairy cows

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Abstract

This study was carried out to investigate the effect of somatic cell count (SCC) on milk yield and milk composition in first and second lactation Holstein dairy cows. Thirty cows in first lactation and 49 cows in second lactation were used in the study. Animals were 15±9.87 days in milk. Individual milk samples were collected monthly from June 2009 to March 2010, and somatic cell counts, milk protein, milk fat, lactose and milk urea-N were determined. Four SCC groups were formed for determining effect of SCC on milk yield and composition. These groups were as follows: ≤200, 201-500, 501-999, and ≥1,000×10³ cells/mL. It was observed that SCC had a high significant effect on milk yield, milk protein, milk lactose (P<0.01), total solids and milk urea-N (P<0.05), however, the effect of SCC on milk fat was not significant (P>0.05). This study indicates that high SCC negatively affects not only milk yield but also milk composition and quality.

Introduction

Milk yield, composition, and quality are important factors affecting dairy farm's profitability. Milk composition and somatic cell count (SCC) play a key role to monitor milk quality. Somatic cells in the milk of a healthy cow include 75 to 85% leucocytes and 15 to 25% epithelial cells (Barrett, 2002), and the SCC level is ≤100×10³ cells/mL (Hillerton, 1999).

Somatic cell count in milk is used as an indicator to monitor the degree of the udder health. Increase in SCC is widely accepted as an early emergence of inflammatory changes of mammary gland and SCC between 200 and 299×10³ cells/mL may be considered as sub-clinical mastitis (Tahawy and Far, 2010; Bramley et al., 1996). The number of neutrophils, macrophages (Kaswan et al., 2012) and lymphocytes in milk increases with sub-clinical mastitis (Tahawy and Far, 2010) and more than 90% of leukocytes consists of neutrophils (Ba tan, 2010; Jones, 2009; Ten Napel et al., 2009).

Significant increase in SCC (rate of 5 to 20%) is associated with abnormalities in udder health, decrease in milk quality and production loss of milk (Juozaitiene et al. 2006; Tekeli, 2010). Milk with elevated high SCC has been associated with changes in milk protein, milk fat, lactose and minerals, thus, poor quality of milk and milk products (Rajcevic et al., 2003; Fernandes et al., 2004; Lindmark et al., 2006).

Besides intramammary infections, number and stage of lactation (Eyduuran et al., 2005; Güncü and Özkütük, 2002) udder anatomy (Uzmay et al., 2003), breed, milking frequency, season (Koç, 2008), proper milking hygiene and the education of employees in dairy farms (Yalçın et al., 2010) are the other factors affecting SCC. The present study was performed to reveal the effect of SCC of Holstein-Friesian dairy cows in first and second lactation on milk yield and composition.

Materials and methods

The study was conducted in a private modern dairy farm, where udder health and milking hygiene were determined in monthly intervals, between June 2009 and March 2010, to minimise the differences related to factors affecting the milk SCC.

Animals

In the present study, 30 and 49 Holstein-Friesian cows were used in first and second lactations, respectively. The cows were 2 to 4 year-old, 500 to 550 kg on average weight and 15±9.87 days in milk. Moreover, the body condition score of all animals was 2.5 to 3.5 and the cows had either no generalised or udder health problems. The animals were milked three times per day and were housed in a free-stall barn and fed diets as total mixed ration (TMR), following the National Research Council (2001) requirements. The components of the TMR were corn silage, alfalfa hay, and home blend concentrate.

Collecting of milk samples and grouping of somatic cell count

Individual mixed milk samples were collected monthly at second milking throughout lactation by special sample collecting cup mounted to automatic milking system. Milk samples were transferred to 50 ml plastic tubes and somatic cells of fresh milk samples were immediately counted (CellCount; DeLeval, Tumba, Sweden).

Four different SCC groups were composed to determine the effect of SCC on milk yield and composition as described by Jia-zhong et al. (2010) in International Dairy Foods Association and National Mastitis Council of America as ≤200, 201-500, 501-999 and ≥1,000×10³ cells/mL. After determining SCC, milk samples were preserved via 2-bromo-2-nitro-1,3-propanediol (Bronopol; D&F Control Systems Inc., Dublin, CA, USA) and stored at +4°C for further analysis of milk total solids, protein, fat, lactose and urea-N using Milksocan FT-120 (FT-120; Foss, Hillerod, Denmark). Daily milk yield of animals were recorded from the computer herd recording system of the farm. Milk urea-N was calculated as in the following formula:

\[
\text{milk urea-N (mmol/L)} = \text{milk urea-N (mg/dL)} / 2.8
\]

Statistics

PROC MIXED procedure in experimental design with repeated measurements was used to evaluate the effect of SCC groups on milk yield of animals were recorded from the computer herd recording system of the farm. Milk urea-N was calculated as in the following formula:

\[
\text{milk urea-N (mmol/L)} = \text{milk urea-N (mg/dL)} / 2.8
\]
### Table 1. The effect of number, average and month of lactation on milk yield, somatic cell count and milk composition.

| Parameter                  | LN     | ALY     | June | July | August | September | October | November | December | January | February | March | LN | Month | LN×month |
|----------------------------|--------|---------|------|------|--------|-----------|---------|----------|----------|---------|----------|-------|-----|-------|-----------|
| Milk yield, kg/day         | 1      | 27.10   | 26.73| 30.68| 28.73  | 29.42     | 28.82   | 25.51    | 24.44    | 26.20   | 24.24    | 2.750 | <0.001 | <0.001 | <0.001    |
|                           | 2      | 29.68   | 37.27| 38.03| 34.06  | 28.92     | 23.70   | 25.26    | 23.96    | 25.37   | 22.15    |       |       |       |           |
| SCC, ×10^6 cell/mL        | 1      | 246.7   | 292.23| 180.81| 123.00 | 239.80    | 381.77  | 392.50   | 174.30   | 148.57  | 402.33   | 0.112 | 0.034 | <0.001 | 0.889      |
|                           | 2      | 303.1   | 296.60| 191.89| 307.75 | 244.83    | 278.96  | 348.33   | 555.12   | 213.91  | 413.83   |       |       |       |           |
| Total solids, %           | 1      | 12.75   | 12.32| 12.49| 12.79  | 12.33     | 12.71   | 13.09    | 12.12    | 13.42   | 13.21    | 0.074 | 0.026 | <0.001 | 0.960      |
|                           | 2      | 12.96   | 12.51| 12.52| 12.66  | 12.67     | 13.03   | 13.34    | 12.51    | 13.18   | 13.28    |       |       |       |           |
| Milk fat, %               | 1      | 3.83    | 3.65 | 3.84 | 4.03   | 3.55      | 3.81    | 4.06     | 3.92     | 3.84    | 4.20     | 0.067 | 0.101 | <0.001 | 0.967      |
|                           | 2      | 3.98    | 3.85 | 3.77 | 3.92   | 3.79      | 4.01    | 4.26     | 3.28     | 3.99    | 4.72     |       |       |       |           |
| Milk protein, %           | 1      | 3.28    | 3.14 | 2.97 | 3.21   | 3.22      | 3.28    | 3.34     | 3.30     | 3.43    | 3.30     | 0.005 | <0.001 | <0.001 | 0.463      |
|                           | 2      | 3.41    | 3.13 | 3.12 | 3.26   | 3.35      | 3.44    | 3.48     | 3.62     | 3.55    | 3.52     |       |       |       |           |
| Milk lactose, %           | 1      | 4.67    | 4.66 | 4.61 | 4.66   | 4.65      | 4.69    | 4.78     | 4.72     | 4.62    | 4.72     | 0.002 | 0.002 | <0.001 | 0.932      |
|                           | 2      | 4.62    | 4.64 | 4.59 | 4.60   | 4.62      | 4.64    | 4.73     | 4.62     | 4.50    | 4.64     |       |       |       |           |
| Milk urea-N, mmol/L       | 1      | 6.69    | 6.76 | 7.06 | 6.58   | 6.30      | 6.40    | 6.51     | 6.78     | 6.49    | 6.79     | 0.034 | 0.141 | <0.001 | 0.622      |
|                           | 2      | 6.59    | 6.67 | 6.76 | 6.36   | 6.19      | 6.47    | 6.62     | 6.50     | 6.42    | 6.48     |       |       |       |           |

LN, lactation number; ALY, average lactation yield; SCC, somatic cell count.

### Table 2. The effect of somatic cell count on milk yield and composition.

| Parameter                  | LN     | SCC, ×10^6 cell/mL | SEM | P |
|----------------------------|--------|--------------------|-----|---|
| Milk yield, kg/day         | 1      | ≤200               | 26.76| 26.76 | 25.50 | 24.00  | 2.646 | 0.054 | <0.001 | 0.346 |
|                           | 2      | 30.93              | 29.49 | 29.41 | 25.68 |        |       |       |       |       |
|                           | 1      | 201-500            | 12.60| 12.99 | 12.80 | 13.10  | 1.026 | 0.237 | 0.044 | 0.705 |
|                           | 2      | 12.87              | 13.11 | 13.35 | 13.04 |        |       |       |       |       |
| Total solids, %            | 1      | 501-999            | 3.23 | 3.33  | 3.42  | 3.46   | 0.544 | 0.153 | <0.001 | 0.742 |
|                           | 2      | ≥1000              | 3.35 | 3.45  | 3.45  | 3.50   |        |       |       |       |
| Milk fat, %                | 1      | ≤200               | 3.75 | 3.95  | 3.70  | 3.99   | 0.973 | 0.104 | 0.321 | 0.762 |
|                           | 2      | 3.91               | 4.08  | 4.30  | 4.32  |        |       |       |       |       |
| Milk lactose, %            | 1      | ≤200               | 4.68 | 4.67  | 4.68  | 4.68   | 0.420 | <0.001 | <0.001 | <0.001 |
|                           | 2      | 4.65               | 4.61  | 4.56  | 4.32  |        |       |       |       |       |
| Milk urea-N, mmol/L        | 1      | ≤200               | 6.65 | 6.83  | 6.83  | 6.47   | 0.891 | 0.802 | 0.046 | 0.620 |
|                           | 2      | 6.54               | 6.72  | 6.57  | 6.33  |        |       |       |       |       |

LN, lactation number; SCC, somatic cell count.
yield and composition. The relationship between SCC and milk composition was determined by PROC CORR procedure (SAS, 2000). Correlations between SCC and milk composition were calculated as Pearson’s correlations.

Results and discussion
Milk yield, somatic cell count and milk composition
The average milk yield, SCC, total solids, milk fat, protein, lactose and urea-N values of cows in first lactation were 27.10 kg/day, 246.7 x10^3 cell/mL, 12.75, 3.83, 3.28, 4.87 and 6.69% mmol/L; in second lactation they were 29.68 kg/day, 303.1 x10^3 cell/mL, 12.96, 3.98, 3.41, 4.62 and 6.59% mmol/L (Table 1). The effect of lactation number on milk yield, protein, lactose (P<0.01), SCC and total solids was significantly different (P<0.05), while no significant differences in milk fat and urea-N were found between first and second lactation number. The month of lactation significantly affected all examined parameters (P<0.01), moreover the interaction of number and month of lactation had a significant relationship on milk yield only (P<0.01).

The effect of somatic cell count on milk yield and composition
It was observed that the effect of SCC on milk yield, milk protein, lactose (P<0.01), milk total solids, and milk urea-N (P<0.05) was significant, while SCC was not significantly different (P>0.05) in milk fat (Table 2). When the SCC increased, it was seen that milk yield decreased, whereas milk protein, milk fat and total solids increased, though these differences were not significant (P>0.05). Moreover, milk lactose level did not change in cows in first lactation but it decreased in cows in second lactation.

Correlation between somatic cell count and milk composition
Somatic cell counts had negative correlation with milk yield and lactose (P<0.01) and positive correlation with total solids, milk fat and protein (P<0.05), while the correlation between SCC and milk urea-N was not statistically significant (P>0.05) (Table 3).

It is well known that there is a linear relationship between increasing SCC and milk production loss and the milk production loss rate may be presumed by the level of SCC (Barlett et al., 1990). Yalçın et al. (2000) estimated that the daily rate of milk production loss per each cow with SCC of 403, 1.097 and 1.900 x10^3 cell/mL was 0.6 (2.1%), 3.8 (14.1%) and 6.8 kg (25.2%), respectively. Jia-zhong et al. (2010) reported daily milk yields were 26.7, 26.3, 25.7 and 24.4 kg for cows with SCC of <200, 201-500, 501-999 and ≥1000 x10^3 cell/mL, respectively.

In the present study, the percentage of milk yield loss in first and second lactation for cows with SCC of 201-500, 501-999 and ≥1000 x10^3 cell/mL when compared to cows with SCC≤200 x10^3 cell/mL was 1, 5, 10.4 and 4.6, 4.9, and 16.9%, respectively. However, the total decreasing rate of milk yield was calculated as 2.67, 5.35 and 12.26%. The results obtained in the study were similar to other observations (Jia-zhong et al., 2010; Yalçın et al., 2000). In addition, our findings support that milk yield decreases when SCC increases.

The presence of inflammatory changes in mammary gland can be characterised by an increase in SCC. It has been reported that permeability changes related to inflammatory reactions in milk secretory cells might cause changes in milk components such as protein, fat and lactose, etc. and decrease in milk yield (Korhonen and Kaartinen, 1995). In the present study, it was determined that milk yield decreased in cows in all groups when compared to cows with SCC≤200 x10^3 cell/mL, and the levels of milk protein, milk fat and total solids increased. In groups with higher SCC, it was observed that the level of milk lactose did not change in cows in first lactation; however it decreased in cows in second lactation.

Jia-zhong et al. (2010) reported the level of milk fat and milk protein in Holstein cows with SCC≥200, 201-500, 501-999 and ≥1000 x10^3 cell/mL, as 3.65, 3.83, 3.84, 3.92, 2.94, 2.98, 2.99, 3.11% respectively. In this study, the presented level of milk fat was similar to Jia-zhong et al. (2010), merely the level of milk protein was low. On the other hand, the average milk fat and protein levels were in agreement with Lindmark et al. (2006). However, Forsbäck (2010) reported higher milk protein (3.6%) and milk fat rates (4.01%). The average milk fat and protein levels described by Suriyasathaporn et al. (2010) were similar to the presented study, except for the milk protein level which was lower than those reported. Rajcic et al. (2003) demonstrated higher milk fat and similar milk protein levels, when milk fat and protein rates were compared to the present study. In the present study, the milk fat level was lower and milk protein and lactose levels were higher than the findings presented by Tsenkova et al. (2001). The difference between our results and other findings could be attributed to lactation stage, parity, and farms conditions.

There are some reports that milk urea-N level increases and milk yield, lactose and fat rates decrease when SCCs≥150 x10^3 cell/mL. In the present study, the decrease in milk yield and milk lactose rates were observed when SCC increased and these findings were in accordance with previous reports (Kelly et al., 2000; Fernandes et al., 2004; Bansal et al., 2005). However, it was determined that the milk fat rate was increased.

The negative correlation between milk yield and SCC is well documented by many authors (Koldeweij et al., 1999; Rupp and Boichard, 2000; Rajcic et al., 2003; Juozaitiene et al., 2006; Jia-zhong et al., 2010). Fernandes et al. (2004) indicated no correlation between milk fat and other components of milk. However, the presence of negative correlation between total solids and milk lactose and positive correlation between milk protein and SCC were reported when SCC was 1.000 x10^3 cell/mL and <500 x10^3 cell/mL, respectively. In the present study, SCC showed negative correlation between milk yield and milk lactose (P<0.01), while there was a positive correlation between total solids, milk fat and milk protein (P<0.05). However, no significant correlation was observed between SCC and milk urea-N.

Table 3. Correlation of somatic cell count with milk yield and composition.

| Parameter | Milk yield | Total solids | Milk fat | Milk protein | Milk lactose | Milk urea-N |
|-----------|------------|--------------|----------|--------------|--------------|-------------|
| SCC       | -0.251**   | 0.164*       | 0.103*   | 0.291*       | -0.206**     | 0.005       |

SCC, somatic cell count. **P<0.01; *P<0.05.
Conclusions

This study indicates that high SCC negatively affects not only milk yield but also milk composition and quality. Therefore, it is suggested that monthly control of SCC in dairy farms is one of the most effective methods to monitor and evaluate changes in the amount of production of milk and milk quality.

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