Effect of Somatic Cell Count on Prato Cheese Composition

G. Mazal,* P. C. B. Vianna,* M. V. Santos,† and M. L. Gigante*

*State University of Campinas-UNICAMP, Faculty of Food Engineering, Department of Food Technology, Caixa Postal 6121, CEP 13083-970 Campinas/São Paulo, Brazil
†University of São Paulo, School of Veterinary Medicine and Animal Science, Department of Nutrition and Animal Production, Av. Duque de Caxias Norte, 225 Campus Administrativo da USP, CEP 13630-000 Pirassununga/São Paulo, Brazil

ABSTRACT

The objective of this research was to evaluate the effect of 2 levels of somatic cell counts (SCC) in raw milk on Prato cheese composition, protein and fat recovery, cheese yield, and ripening. A 2 × 6 factorial design with 3 replications was performed in this study: 2 levels of SCC and 6 levels of storage time. Initially, 2 groups of dairy cows were selected to obtain low (<200,000 cells/mL) and high (>600,000 cells/mL) SCC in milks that were used to manufacture 2 vats of cheese: 1) low SCC and 2) high SCC. Milk, whey, and cheese compositions were evaluated; clotting time was measured; and cheese yield, protein recovery, and fat recovery were calculated. The cheeses were evaluated after 5, 12, 19, 26, 33, and 40 d of ripening according to pH, moisture, pH 4.6 soluble nitrogen, 12% trichloroacetic acid soluble nitrogen as a percentage of total nitrogen, and firmness. High-SCC milk presented significantly higher total protein and nonprotein nitrogen and lower true protein and casein concentrations than did low-SCC milk, indicating an increased whey protein content and a higher level of proteolysis. Although the pH of the milk was not affected by the somatic cell level, the cheese obtained from high-SCC milk presented significantly higher pH values during manufacture and a higher clotting time. No significant differences in cheese yield and protein recovery were observed for these levels of milk somatic cells. The cheese from high-SCC milk was higher in moisture and had a higher level of proteolysis during ripening, which could compromise the typical sensory quality of the product.

Key words: somatic cell count, Prato cheese, proteolysis, ripening

INTRODUCTION

Mastitis is defined as an inflammation of the mammary gland usually resulting from a bacterial infection. The inflammatory response is characterized by an influx of white blood cells that causes an increase in the number of somatic cells in the milk (Andrews et al., 1983). The epithelium is commonly affected, resulting in a reduced milk yield and a change in milk composition (Auldist and Hubble, 1998). Milk with a high SCC is also characterized by a higher concentration of endogenous milk proteases and, consequently, higher enzymatic activity (Santos et al., 2003). These major alterations are detrimental to the quality of dairy products and represent reduced profits for the farmer and the dairy industry.

Many studies have been developed to determine the effect of SCC on the yield and quality of dairy products, especially cheeses. Milk with a high SCC is associated with an increased clotting time (Rogers and Mitchell, 1994), increased protein and reduced fat contents (Politis and Ng-Kwai-Hang, 1988), increased cheese moisture (Mitchell et al., 1986a), and reduced cheese yield (Klei et al., 1998). Kalit et al. (2002) observed a more intense proteolysis during ripening in the cheese from milk with a high SCC. The greater hydrolysis of the $\alpha_{s1}$-CN in cheese made with high-SCC milk observed by Cooney et al. (2000) could be responsible for the defects in Cheddar cheese texture described by other authors (Grandisson and Ford, 1986; Mitchell et al., 1986a; Rogers and Mitchell, 1994).

The majority of developed countries have improved the quality of their dairy products by implementing programs to reduce the milk somatic cell level. In 2002, Brazil established a maximum level of 1,000,000 cells/mL by law as a criterion for milk acceptability by the industry. However, little research has been done in Brazil to correlate the somatic cell level with dairy product quality.

Prato cheese is similar to Danish cheeses such as Tybo, Elbo, Fynbo, Havarti, and Danbo, and to the Dutch cheese Gouda. This cheese was chosen because it is widely consumed in Brazil and there are few studies related to the effect of SCC on this typical Brazilian cheese. The objective of this research was to evaluate the effect of 2 levels of raw milk SCC on Prato cheese composition, protein and fat recovery, cheese yield, and ripening.
MATERIALS AND METHODS

Cow Selection

The cows used in this experiment were in the intermediate lactation stage and had not been treated with antibiotics in the last 7 d. Milk from 40 Holstein cows from the University of São Paulo, Pirassununga Campus, were screened for their milk fat and protein contents (AOAC, 2000; methods 33.2.31 and 972.16) and SCC (AOAC, 2000; methods 17.13.01 and 978.26) 3 d prior to milk collection. Milk samples (50 mL) were collected at the morning milking, preserved with 8 mg of bronopol (2-bromo-2-nitropropano-1,3-diol; D&F Control Systems, Inc., Dublin, CA), and shipped at room temperature for laboratory analyses the same day.

The milk SCC and milk composition were determined by infrared spectrophotometry using a Bentley Soma-count 500 (Bentley Instruments Inc., Chaska, MN) and Bentley 2000 (Bentley Instruments Inc.), respectively. For each replication, 5 cows that produced milk with low SCC (<200,000 cells/mL) and 5 cows that produced milk with high SCC (>600,000 but <1,000,000 cells/mL) were selected to produce the 2 batches of milk for this study. The milk from all the cows was collected on the same day at the same milking within a replicate.

Milk Collection and Prato Cheese Manufacture

On the day of milk collection, all the milk from one milking was collected separately for each cow and the milk yield was recorded. Raw milk from individual cows was immediately transported to the University of São Paulo Dairy Plant and cooled to 4°C. Milk produced by cows in the same group was commingled to obtain 2 batches: one with SCC <200,000 cells/mL and one with SCC >600,000 cells/mL. A sample of milk from each batch was taken, preserved with bronopol at room temperature, and tested for SCC (AOAC, 2000; methods 17.13.01 and 978.26). The 2 batches of commingled raw, unpreserved milk were stored overnight at 4°C.

On the morning following milk collection, the 2 batches of milk were transported to the Food Technology Department pilot plant at the University of Campinas. The milks were heat treated at 68°C for 2 min in a batch pasteurizer (100-L capacity), cooled to 4°C, placed into sanitized cans, and stored overnight in a cooler (4°C) until further processing. This heat treatment is commonly used by artisanal cheese factories in Brazil. The next day, 2 cheeses were manufactured in 150-L vats with a heating-cooling jacket, stirrers, and speed control: 1) Prato cheese from milk with low SCC and 2) Prato cheese from milk with high SCC. The same procedure was applied to each vat. Pasteurized milk was heated to 35°C before adding calcium chloride (0.025%), a starter culture (1%) of Lactococcus lactis ssp. lactis and Lactococcus lactis ssp. cremoris (Wisby-Visbyaco LC-MIX F0 2 01; Danisco Brazil Ltda., Cotia, Brazil), annatto color (0.008%), and rennet (chymosin and bovine pepsin, HA-LA GIN:612619; Chr. Hansen, Valinhos, Brazil). After stirring, the milk was allowed to set at 35°C. The clotting time was monitored and the curd was cut when it was firm. The firmness of the curd was evaluated by inserting a small sanitized spatula into the coagulum at a 45° angle, gently lifting the spatula straight up, and observing the curd as it split open. The coagulum was then slowly cut with 1-cm wire knives for 7 min. After cutting, the curd and whey were gently stirred for 13 min while maintaining the temperature at 35°C. The cooking process was then started by removing 30% of the whey, which was replaced by progressively adding hot water (80°C) to increase the temperature by 1°C every 3 min. While the curd and whey were stirred continuously, the temperature of the curd was increased from 35 to 42°C. After stirring for 30 min at 42°C, all of the whey was drained off, and the curd was placed in 0.5-kg molds and pressed for 3 h. Finally, the cheeses were immersed for 12 h in brine containing 20% salt, dried for 24 h at 10°C, vacuum packaged, and stored for 40 d at 12°C.

Sampling and Analyses

After pasteurization, the pH of the milk was evaluated by introducing the electrode directly into the sample. Total solids (AOAC, 1995; methods 33.2.09/A and 925.23), fat (Gerber methodology; British Standards Institution, 1989), total nitrogen (TN; AOAC, 1995; methods 33.2.11 and 991.20), pH 4.6 soluble nitrogen (pH 4.6 SN; AOAC, 1995; methods 33.2.18 and 927.03), and 12% TCA soluble nitrogen (12% TCA SN; AOAC, 1995; methods 33.2.12 and 991.21) were also determined. Casein nitrogen was calculated as the difference between TN and noncasein nitrogen (pH 4.6 SN). Total protein was calculated by multiplying TN by 6.38. The clotting time of the curd was monitored and the firmness evaluated as described before. The pH was monitored during the following steps: cutting, first draining, heating, and second draining.

For each vat, all of the whey was collected, mixed, and sampled. The whey was analyzed for fat using the Mojonnier method (AOAC, 1995; methods 33.2.26 and 989.05), TN (AOAC, 1995; methods 33.2.11 and 991.20), pH 4.6 SN (AOAC, 1995; methods 33.2.18 and 927.03) and 12% TCA SN (AOAC, 1995; methods 33.2.12 and 991.21). Five days after manufacture, the pH of the cheeses was determined by introducing the electrode directly into the triturated samples. The samples were also analyzed for moisture (AOAC, 1995; methods
33.2.09/A and 925.23), fat (Gerber methodology; British Standards Institution, 1989), TN (AOAC, 1995; methods 33.7.12 and 920.123), pH 4.6 SN, and 12% TCA SN by the macro-Kjeldahl method according to Bynum and Barbano (1985), and salt was analyzed by the Volhard method (Richardson, 1985).

Characterization of Cheese Ripening

After 5, 12, 19, 26, 33, and 40 d of storage at 12°C, the cheeses from both low- and high-SCC milk were evaluated for pH, moisture, proteolysis, and firmness. The pH was determined by introducing the electrode directly into the triturated cheese sample, and moisture was evaluated according to AOAC (1995) methods (methods 33.2.09/A and 925.23). As a measure of proteolysis, pH 4.6 SN and 12% TCA SN were determined by the macro-Kjeldahl method according to Bynum and Barbano (1985). Both soluble nitrogen values were expressed as a percentage of the TN of the cheese. Cheese firmness was measured using the texture profile analysis defined by Bourne (1978). The experiment was conducted using a TAXT2 Universal Texture Analyzer (Stable Micro Systems Ltd., Godalming, Surrey, UK) and a 35-mm-diameter cylindrical aluminum P35 probe. Ten cylindrical samples (2 cm in diameter × 2.4 cm in height) were tested for each cheese at each stage. The cheese cylinders were tempered at 10°C for 3 h prior to analysis by using a refrigerated water bath. The cylinders were placed in the texture analyzer at ambient temperature and compressed immediately. Each sample was subject to 50% compression using a crosshead speed of 1 mm/s.

Calculation of Recoveries and Cheese Yield

Protein and fat recoveries (%R) were calculated according to the following equation:

\[
\text{%R}_{ij} = \left( \frac{m_j \times c_{ij}}{m_{milk} \times c_{i \text{ milk}}} \right) \times 100
\]

where \( i \) is the milk component (protein, fat), \( j \) is the sample (cheese or whey), \( m \) is the weight of the sample (g), \( c_{ij} \) is the percentage of \( i \) in sample \( j \), \( m_{milk} \) is the weight of the milk (g), \( c_{i \text{ milk}} \) is the percentage of \( i \) in the milk.

The actual cheese yield (\( Y_{\text{act}} \)) was determined according to the following equation:

\[
Y_{\text{act}} = \left( \frac{\text{weight of cheese (g)}}{\text{weight of milk (g)}} \right) \times 100
\]

Because there were variations in the cheese moisture and salt content, the adjusted yield (\( Y_{\text{adj}} \)) was also calculated. A desirable salt content of 1.6% and a desirable moisture content of 42% were considered:

\[
Y_{\text{adj}} = \frac{Y_{\text{act}} \times [100 - (% \text{ real moisture content} + % \text{ real salt content})] \times 100}{[100 - (% \text{ desirable moisture content} + % \text{ desirable salt content})]}
\]

Experimental Design and Statistical Analyses

A 2 × 6 factorial design with 3 replications was performed in this study with the SCC at 2 levels (high and low) and the storage time at 6 levels (5, 12, 19, 26, 33, and 40 d after manufacture). The effects of SCC on the pasteurized milk, whey, and cheese composition, the clotting time, the fat and protein recoveries, and the cheese yield were evaluated using ANOVA. A split-plot design was used for the analysis of proteolysis, firmness, pH, and moisture content in which the SCC level was considered as the main plot and the storage time as the subplot. Analyses were performed using SAS (version 8.02; SAS Institute Inc., Cary NC). Significance was declared at \( P < 0.05 \).

RESULTS AND DISCUSSION

Effect of SCC on the Milk Composition

Commingled low-SCC raw milk presented a mean of 170,000 cells/mL (153,000, 186,000, and 170,000 cells/mL). The mean SCC value was thus lower than 200,000 cells/mL and was representative of milk coming from healthy cows, whose cells were coming from the natural scaling of the mammary gland epithelium (Kitchen, 1981). The commingled raw milk with a high SCC had a mean of 800,000 cells/mL (779,000, 976,000, and 631,000 cells/mL), a level that respects the limit for SCC defined by the Brazilian legislation (1,000,000 cells/mL). This milk was considered as having a high SCC.

High-SCC milk had a significantly higher total protein content (Table 1) than did low-SCC milk, which could be due to a higher whey protein content (Politis and Ng-Kwai-Hang, 1988). High-SCC milk had a significantly lower true protein (as a percentage of CP) and a higher NPN content than did low-SCC milk, reflecting a more intense proteolysis (Table 1). Plasmin is normally found in milk and is found in larger quantities in high-SCC milk. Its higher activity in the udder at the optimal temperature of the cow’s body could have affected the true protein content with the production of NPN. O’Brien et al. (2001) observed significantly higher plasmin activity in milk with 300,000 to 370,000 cells/mL as compared with milk with 120,000 to 230,000 cells/mL. The proteolytic action of plasmin is also fa-
EFFECT OF SOMATIC CELL COUNT ON PRATO CHEESE COMPOSITION

Table 1. Effect of high and low SCC on the composition of pasteurized milk

<table>
<thead>
<tr>
<th>Milk composition</th>
<th>Low SCC</th>
<th>Mean</th>
<th>SE</th>
<th>High SCC</th>
<th>Mean</th>
<th>SE</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>TS, %</td>
<td>11.7</td>
<td>0.4</td>
<td></td>
<td>12.1</td>
<td>0.2</td>
<td></td>
<td>NS</td>
</tr>
<tr>
<td>Fat, %</td>
<td>3.5</td>
<td>0.3</td>
<td></td>
<td>3.8</td>
<td>0.1</td>
<td></td>
<td>NS</td>
</tr>
<tr>
<td>Total protein, total N × 6.38</td>
<td>2.8</td>
<td>0.1</td>
<td></td>
<td>3.3</td>
<td>0.1</td>
<td>&lt;0.05</td>
<td></td>
</tr>
<tr>
<td>CN, %</td>
<td>2.20</td>
<td>0.07</td>
<td></td>
<td>2.3</td>
<td>0.1</td>
<td></td>
<td>NS</td>
</tr>
<tr>
<td>NPN, %</td>
<td>0.136</td>
<td>0.008</td>
<td></td>
<td>0.209</td>
<td>0.009</td>
<td>&lt;0.05</td>
<td></td>
</tr>
<tr>
<td>True protein, % of CP</td>
<td>95.2</td>
<td>0.1</td>
<td></td>
<td>93.7</td>
<td>0.1</td>
<td>&lt;0.01</td>
<td></td>
</tr>
<tr>
<td>CN, % of CP</td>
<td>77.2</td>
<td>0.4</td>
<td></td>
<td>69</td>
<td>2</td>
<td>&lt;0.05</td>
<td></td>
</tr>
<tr>
<td>CN, % of true protein</td>
<td>81.1</td>
<td>0.2</td>
<td></td>
<td>74</td>
<td>4</td>
<td>&lt;0.05</td>
<td></td>
</tr>
</tbody>
</table>

1n = 3.
2Mean SCC = 170,000 cells/mL.
3Mean SCC = 800,000 cells/mL.
4P < 0.05.
5True protein = total N − 12% TCA soluble N.
6Crude protein = total N × 6.38.

vored by the activators produced during the inflammatory process (Verdi and Barbano, 1991) and by a higher milk pH (Bastian and Brown, 1996). Although there was no difference in the CN content between the high- and low-SCC milks, the values for CN as a percentage of CP and as a percentage of true protein were lower in the high-SCC milk than in the low-SCC milk. These results are in agreement with those of other studies presenting lower amounts of CN in high-SCC milk (Klei et al., 1998; Ma et al., 2000; Santos et al., 2003). According to Politis and Ng-Kwai-Hang (1988), the total protein in milk increases with SCC because of the increase in whey protein, whereas CN decreases in mastitis-positive milk.

No significant differences were observed at these SCC levels for the contents of TS, fat, and CN (Table 1). Other authors have also reported a lack of significant differences in the contents of TS and fat (Klei et al., 1998) and in the CN content (Rogers et al., 1989) for milk with SCC levels varying from 83,000 to 1,000,000 cells/mL. Conversely, other authors have demonstrated significantly higher (Mitchell et al., 1986b) or lower (Leavitt et al., 1982) TS contents in high-SCC milk. The same was observed for the fat content, which was significantly higher (Cooney et al., 2000; Ma et al., 2000; Machado et al., 2000) or lower (Leavitt et al., 1982; Politis and Ng-Kwai-Hang, 1988) in high-SCC milk. The great variability observed between different authors is a consequence of many factors, such as the type of infectious animal process and the experimental conditions.

Effect of SCC on Cheese Manufacture

In this study, the SCC levels did not affect the initial milk pH (Table 2); thus, the milk pH was not adjusted at the beginning of cheese manufacture. Barbano et al. (1991) also did not observe significant differences in the initial pH values of milk with SCC varying from <106,000 to 1,300,000 cells/mL. However, other authors observed that the milk pH increased significantly with increasing SCC (Klei et al., 1998). Although the milk pH was not different, cheeses produced from high-SCC milk presented significantly higher pH values during manufacture (Table 2). The higher pH indicated lower activity of the starter culture and hence a lower acid production. According to Hampton and Randolph (1969), acid production by single-strain cultures of *Streptococcus lactis* C2 and *Streptococcus cremoris* R1 is slower in mastitis-positive milk. High-SCC milk has a higher level of leukocytes, which produce antimicrobial factors (Sordillo and Streicher, 2002) that could inhibit development of the starter culture and so delay the fall in pH and, consequently, the action of the rennet. During manufacture, cheese from high-SCC milk presented a mean pH value that was 0.25 units higher than that from low-SCC milk. This higher pH affected

Table 2. Effect of the SCC on pH during cheese manufacturing

<table>
<thead>
<tr>
<th>pH</th>
<th>Low SCC</th>
<th>Mean</th>
<th>SE</th>
<th>High SCC</th>
<th>Mean</th>
<th>SE</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Milk</td>
<td>6.84</td>
<td>0.07</td>
<td></td>
<td>6.99</td>
<td>0.05</td>
<td></td>
<td>NS</td>
</tr>
<tr>
<td>Cutting</td>
<td>6.60</td>
<td>0.03</td>
<td></td>
<td>6.84</td>
<td>0.01</td>
<td>&gt;0.01</td>
<td></td>
</tr>
<tr>
<td>First draining</td>
<td>6.59</td>
<td>0.02</td>
<td>6.85</td>
<td>0.01</td>
<td>&lt;0.001</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Heating</td>
<td>6.60</td>
<td>0.02</td>
<td></td>
<td>6.86</td>
<td>0.02</td>
<td>&lt;0.001</td>
<td></td>
</tr>
<tr>
<td>Final draining</td>
<td>6.59</td>
<td>0.02</td>
<td>6.82</td>
<td>0.03</td>
<td>&lt;0.01</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cheese, 5 d of aging</td>
<td>5.33</td>
<td>0.06</td>
<td></td>
<td>5.34</td>
<td>0.05</td>
<td></td>
<td>NS</td>
</tr>
</tbody>
</table>

1n = 3.
2SCC mean = 170,000 cells/mL.
3SCC mean = 800,000 cells/mL.
4P < 0.05.
Table 3. Effect of the SCC on clotting time, chemical compositions of cheese and whey, cheese yield, and recovery of cheese protein and fat

<table>
<thead>
<tr>
<th>Item</th>
<th>Low SCC&lt;sup&gt;2&lt;/sup&gt;</th>
<th>SE</th>
<th>Mean</th>
<th>SE</th>
<th>High SCC&lt;sup&gt;3&lt;/sup&gt;</th>
<th>SE</th>
<th>P-value&lt;sup&gt;4&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clotting time, s</td>
<td>2,100</td>
<td>0</td>
<td>2,410</td>
<td>5</td>
<td>&lt;0.001</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Moisture, %</td>
<td>42.9</td>
<td>0.5</td>
<td>44.9</td>
<td>0.2</td>
<td>&lt;0.05</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fat, %</td>
<td>30</td>
<td>2</td>
<td>29.3</td>
<td>0.9</td>
<td>NS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total protein, total N × 6.38</td>
<td>22.6</td>
<td>0.7</td>
<td>21.8</td>
<td>0.6</td>
<td>NS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>pH 4.6 soluble N, %</td>
<td>0.182</td>
<td>0.004</td>
<td>0.28</td>
<td>0.02</td>
<td>&lt;0.01</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12% TCA soluble N, %</td>
<td>0.069</td>
<td>0.005</td>
<td>0.10</td>
<td>0.01</td>
<td>NS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Salt, %</td>
<td>1.59</td>
<td>0.04</td>
<td>1.77</td>
<td>0.05</td>
<td>&lt;0.05</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| Whey                        |                      |    |      |    |                      |    |                     |
| Total protein, total N × 6.38 | 0.66                | 0.05| 0.92 | 0.03| <0.05                |    |                     |
| pH 4.6 soluble N, %         | 0.50                 | 0.03| 0.63 | 0.04| NS                    |    |                     |
| 12% TCA soluble N, %        | 0.13                 | 0.01| 0.19 | 0.01| <0.05                 |    |                     |
| Fat, %                      | 0.64                 | 0.06| 0.7  | 0.1 | NS                    |    |                     |

| Recovery                    |                      |    |      |    |                      |    |                     |
| Protein, %                  | 73                   | 2  | 69   | 2  | NS                    |    |                     |
| Fat, %                      | 78                   | 3  | 81   | 3  | NS                    |    |                     |

| Cheese yield                |                      |    |      |    |                      |    |                     |
| Actual                      | 9.2                  | 0.5| 10.4 | 0.3| NS                    |    |                     |
| Moisture- and salt-adjusted,%| 9.3                 | 0.6| 10.1 | 0.4| NS                    |    |                     |

<sup>1</sup>n = 3.
<sup>2</sup>SCC mean = 170,000 cells/mL.
<sup>3</sup>SCC mean = 800,000 cells/mL.
<sup>4</sup>P < 0.05.

As expected, total protein and 12% TCA SN were significantly higher in high-SCC whey than in low-SCC whey (Table 3). A higher protein loss to the whey was also observed for cottage cheese (Klei et al., 1998) and Cheddar cheese (Rogers and Mitchell, 1994) made from milk with SCC >850,000 and >250,000 cells/mL, respectively. The higher total protein content observed in the whey is a consequence of higher proteolysis in the milk and may include the loss of fines resulting from disturbance during the coagulation stage. The higher pH observed during the manufacture of cheese from high-SCC milk could prejudice the formation of the protein matrix, resulting in a more fragile curd with a loss of fines to the whey.

The SCC did not affect the protein and fat contents of the cheese or the fat loss to the whey (Table 3). In fact, cheese produced with the high-SCC milk presented significant alterations in its composition, namely, lower protein (Grandisson and Ford, 1986; Cooney et al., 2000) and fat contents (Mitchell et al., 1986a). Consequently, Barbano et al. (1991) reported that more fat was lost to the high-SCC whey.

At these SCC levels, the higher loss of protein to the high-SCC whey did not result in a lower protein recovery or lower cheese yield for the cheese obtained from high-SCC milk (Table 3). As in the present study, Grandisson and Ford (1986) detected no effect of the somatic cell level on the yield of cheese manufactured...
Table 4. Effect of the SCC, storage time, and their interaction on pH, moisture content, soluble N at pH 4.6, and soluble N in 12% TCA as a percentage of total N<sup>1</sup>

<table>
<thead>
<tr>
<th>Item</th>
<th>Cheese from low-SCC milk&lt;sup&gt;2&lt;/sup&gt;</th>
<th>Cheese from high-SCC milk&lt;sup&gt;3&lt;/sup&gt;</th>
<th>P-value&lt;sup&gt;4&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SE</td>
<td>Mean</td>
</tr>
<tr>
<td>pH</td>
<td>5.35</td>
<td>0.02</td>
<td>5.42</td>
</tr>
<tr>
<td>Moisture, %</td>
<td>42.7</td>
<td>0.2</td>
<td>44.8</td>
</tr>
<tr>
<td>pH 4.6 soluble N, % of total N</td>
<td>10.8</td>
<td>0.9</td>
<td>13.6</td>
</tr>
<tr>
<td>12% TCA soluble N, % of total N</td>
<td>5.7</td>
<td>0.6</td>
<td>6.7</td>
</tr>
<tr>
<td>Firmness, g</td>
<td>2,315</td>
<td>157</td>
<td>2,182</td>
</tr>
</tbody>
</table>

<sup>1</sup>n = 3.<br>
<sup>2</sup>Mean SCC = 170,000 cells/mL.<br>
<sup>3</sup>Mean SCC = 800,000 cells/mL.<br>
<sup>4</sup>P < 0.05.<br>
<sup>5</sup>Storage time: 5, 12, 19, 26, 33, and 40 d after manufacture.

Effect of SCC on Prato Cheese Ripening

As expected, the cheese moisture content did not vary significantly throughout the storage period because the product was vacuum packaged (Table 4). The SCC significantly affected the cheese moisture content and, on average, the cheese from high-SCC milk presented a higher moisture content during the 40 d of aging. Moreover, the cheese from high-SCC milk showed, on average, more intense proteolysis, as measured by the significantly higher pH 4.6 SN content (Table 4). Proteolysis contributes to cheese ripening and is characterized by primary and secondary reactions that are followed by increases in pH 4.6 SN and 12% TCA SN, respectively (Fox et al., 2000). Degradation of the small peptides liberates simple amine components, favoring a significant increase in pH during aging (Table 4). Other studies have demonstrated higher proteolysis in Swiss cheese (Cooney et al., 2000) and in Podravec cheese (Kalit et al., 2002) manufactured from milk with high levels of SCC.

Although cheese from the high-SCC milk presented more intense proteolysis and a higher moisture content during aging than did cheese from the low-SCC milk, these differences did not result in lower firmness of the cheeses from high-SCC milk (Table 4). These data differed from those obtained by Mitchell et al. (1986a) and by Grandisson and Ford (1986), which demonstrated a negative correlation between the SCC and cheese firmness. In this study, a sensory analysis was not carried out, but Rogers and Mitchell (1994) reported a depreciation in the scores for firmness with an increase in the SCC when texture was evaluated by a sensory test, and Arcuri et al. (1990) observed a decrease in the scores for body and texture in Prato cheese manufactured from milk with 500,000 cells/mL.

For all the cheeses, independent of the SCC level, proteolysis, as measured by pH 4.6 SN and 12% TCA SN as a percentage of the TN, increased significantly (Table 4) and the firmness decreased significantly during ripening (Table 4).

CONCLUSIONS

Clotting time was higher for cheeses from milk with high SCC levels. This increased clotting time represents higher manufacturing costs and reduced profits for the dairy industry. Even at the SCC allowed by the Brazilian legislation, the cheese from high-SCC milk presented a higher moisture content and more intense proteolysis during ripening, demonstrating the negative effects of using milk with high SCC to manufacture Prato cheese. Higher moisture contents and proteolysis could negatively affect the sensory quality of this traditional Brazilian cheese. Further studies are needed to determine the influence of SCC on the microbial flora of Prato cheese and on the sensory acceptability of the final product.

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