Microbiological and sensory quality of Farmers cheese produced from milk with different somatic cells count

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Abstract. The aim of the present study was to evaluate the effect of somatic cell count SCC of raw milk on the microbiological and sensory characteristics during ageing and storage of Farmers cheese. Test cheese samples were produced from three batches of cow’s milk with low (batches L), medium (batches M) and high (batches H) SCC, respectively. Regardless of the differences in SCC, the physicochemical and microbiological characteristics of the three batches were similar. The SCC values in the raw milk had no significant influence on the content of the main components, active acidity and lactic acid concentration in the cheeses produced. In the cheeses made from milks with SCCs exceeding 500,000 cells/ml, the growth of Lactobacillus delbrueckii subsp. bulgaricus was slower compared to the other test samples. The changes in the Streptococcus thermophilus count in the cheese test samples showed trends similar to those established with L. delbrueckii subsp. bulgaricus. Lower sensitivity of S. thermophilus to the inhibiting factors in the milks with a high SCC in comparison with L. delbrueckii subsp. bulgaricus was established. The increase in the SCC values in the raw cow’s milk over 500,000 cells/ml had a negative effect on the organoleptic characteristics and shelf life of the Farmers cheese made from that milk.

Kay words: Microbiological quality, Sensory quality, Farmer cheese, Somatic cells count.

1. Introduction

Somatic cell count (SCC) is a well-established indicator of udder health and milk sanitary quality [1]. Normally, in milk from a healthy mammary gland, the SCC is lower than 10^5 cells/ml, while bacterial infection can cause it to increase to above 10^6 cells/mL [2]. It is well known that the higher SCC in raw milk causes adverse effects on raw milk and dairy products quality. The impact of SCC of raw milk on cheese quality is related mainly with the impairing milk coagulation properties, increasing moisture content in most cheeses and inducing cheese off-flavour development [3, 4, 5].

Cheese production from milk with high somatic cells count has been reported to be lower than from low cell-count milk [6]. Lipolysis in cheese was clearly dependent on somatic cell counts, which may have important consequences for cheese flavour [7]. The proteolytic effects of somatic cells on main caseins in cheese are different if cheeses are made with raw or pasteurized milk. The effects of somatic cells on cheese ripening also depend on the pre-treatment of milk.

Mikulec et al. [8] have researched the effects of somatic cell count of milk from the Simmental breed used in cheese production in Serbia on the cheese production. The authors stated that cheese samples made from milk with low SCC had positive effects on high yield and on cheese structure. As a result of
the study, it was indicated that yield losses in cheese production will increase due to SCC in general. Sarı et al. [9] conducted a study on a regional cheese namely Mengen and determined that the average dry matter, ash, protein, fat, salt, pH, and acidity values were 51.4±5.34%, 3.57±0.73%, 24±3.29%, 19.05±4.99%, 2.19±0.85%, 5.72±0.44 and 0.36±0.21%, respectively. The authors reported that the seasonal changes in the biochemical parameters values of the local Mengen cheese as well as of the farmers’ cheese were statistically significant. Silva et al. [10] conducted a study to investigate the effects of raw milk quality on cheese production. In the study, the effects of SCC (200 000 cells/ml, between 200 000 cells/ml and 750 000 cells/ml, and over 750 000 cells/ml) and total viable counts (for less than 100 000 CFU/ml, between 100 000 CFU/ml and 750 000 CFU/ml and more than 750 000 CFU/ml) on cheese quality were examined. The authors found that the increase in the total protein ratio in whey was significant as a result of the increase in somatic cell count, and as a result, the loss of yield in cheese was observed [10].

However, studies on the impact of SCC on the cheese making process or quality are however scarce and the impact of high SCC on cheese properties has not yet been clearly determined.

2. Materials and methods

2.1. Materials

2.1.1. Milk samples
Raw milk samples were obtained between October 2016 and March 2017 from cattle milk produced in 3 different regions (Tokatlı, Yeniçi, Çelikgürü) from the Biga district of Çanakkale province, Turkey. Raw milk samples with low (<400,000 cells/ml), medium (between 500,000 and 600,000 cells/ml) and high SCC (above 1,000,000 cells/ml) were collected from three different large-scale farms (above 100 animals). Samples (5 from each farm) were brought to the laboratory of Çanakkale Onsekiz Mart University-Biga Vocational High School (Turkey) at 4°C. The SCC and the composition of the milk samples were measured. All raw milk analyses of were carried out in triplicate.

2.1.2. Farmers cheese
Farmers cheese samples were produced according to traditional methods from cow milks with different somatic cell counts according to the following procedure: the raw milks from three batches (L, M and H) with three different SCC were accepted into the pilot dairy processing plant of Çanakkale Onsekiz Mart University-Biga Highschool (Turkey) and the platform tests (dry matter, fat, acidity and antibiotics) were carried out, pasteurization procedures were realized at 68°C for 15 minutes. Milk was cooled down to coagulation temperature of 35-36°C. Starter culture consisting of 70% Streptococcus thermophilus and 30% Lactobacillus delbrueckii subsp. bulgaricus and cheese rennet were added. After 90 min of coagulation, the curd was sliced into nut sized curd grains and a portion of the whey is removed. After 5 min of curd ventilation process, curd and the remaining whey were heated at 41-42°C for 15 min. At the end of the heating process, raw cheese is pressed for 2-3 h without applying pressure. Yong cheeses are then removed from the molds and salted in 16% NaCl solution at 15-18°C for 24 h. After salting young cheese was taken out, dried and packed in polyamide/polyethylene foil under vacuum at 90-99.8 Pa. Ripening took place in these packages at t=4±1°C and relative humidity of 75-80% for 3 months. After that the cheese samples were subjected to cold storage at t=4±1°C for another 7 months (up to the 10-th month after production).

2.2. Methods

2.2.1. Determination of somatic cells count (SCC) and chemical composition of raw milk samples
A Bactocount IBCm (Bentley Instrument, USA) device was used for somatic cell count determination. The milk fat, protein and total solids content of studied milk samples were measured using Infrared Milk Analyzer 150 (Bentley Instrument, USA).
2.2.2. Total viable count of raw milk samples (TVC)
Total viable count (TVC) was determined by using Plate Count Agar medium according to [11]. Inoculated petri dishes were subjected to incubation at 30°C for 48 to 72 h and colony forming units (CFU) were counted on petri dishes.

2.2.3. Counts of viable cells of S. thermophilus and L. delbrueckii subsp. bulgaricus
The counts of viable cells of S. thermophilus and L. delbrueckii subsp. bulgaricus in the studied cheese samples were determined by the cultivation on synthetic culture media M17 and MRS (Merck, Darmstadt, Germany). The methodology described in [12] was followed. The samples were prepared according to [13]. Ten grams of the test cheese sample were transferred into the container of a peristaltic-type blender. Ninety milliliters of diluent (20% sodium citrate solution) was added and the mixture was blended until the cheese was thoroughly dispersed. Appropriate dilutions were mixed with the molten and cooled (47±1°C) medium (M17 for S. thermophilus and MRS for L. delbrueckii subsp. bulgaricus). After solidification the Petri dishes were inverted and incubated at 30±1°C for 48 h under aerobic conditions for S. thermophilus and at 37±1°C for 72 h under anaerobic conditions for L. delbrueckii subsp. bulgaricus. After incubation all colonies were counted.

2.2.4. Physicochemical analysis
Fat content – according to Gerber-Van Gulik method [14];
Dry matter and water content - heat at 105°C to constant weight;
Sodium chloride – according to [15];
PH values – by pH meter MS 2011 (Microsyst, Plovdiv, Bulgaria), equipped with a pH electrode Sensoret (Garden Grove, CA, USA);
Lactic acid – by titration method according to [16];
Nitrogen determination was performed in duplicate by the Kjeldahl method using a Kjeltec Auto 1030 Analyzer (Tecator Sweden) combined with the Digestion System 20.
Total protein (TP) was calculated as total nitrogen multiplied by coefficient of 6.38.

2.2.5. Sensory analysis
Sensory evaluation of Farmers cheese samples was performed according to the hedonistic scale. The evaluation of the sensory quality of test samples was performed with 25 consumers, randomly selected by age, gender and social status. The color and appearance, structure of the cut surface, texture, aroma and taste were determined using a hedonic scale from 1 = Very bad to 5 = Very good. Tests were repeated three times. Preferred characteristics for Farmers cheese samples were clear creamy color, smooth texture, homogenous cut surface, specific taste and aroma of ripened cheese. Non-preferred characteristics were too hard/crumbly texture, gas indication, rough structure/residues, very salty/metallic/bitter taste, weak or non-characteristic aroma.

2.2.6. Statistical analysis
Computer processing of the results is performed using the program Microsoft Excel 2010. All determinations were carried out in triplicate and data were subjected to analysis of variance (ANOVA). ANOVA was carried out with the General Linear Models (GLM) with a significant level of P<0.05 [17]. The Fischer’s test with a significant difference set at P<0.05 was used to compare sample values [18]. The SPSS 19 package program was used to calculate the coefficient of correlations.

3. Results and discussion
The results of the physicochemical and microbiological analysis of the raw milk used for obtaining the cheese test samples have been presented in Table 1. The three raw milk batches used were marked as L, M and H, and were characterized by a low, medium and high somatic cell count, respectively. No statistically significant (P>0.05) differences were found in the total viable count values in the three test batches of raw milk. Perhaps this was related to the similar hygiene conditions during the obtaining and storage of the raw milk used in the present study. In this case, the higher SCC in batches L and M was most probably due to the increased share of mastitis milks included in the combined milk.
It can be seen (Table 1) that regardless of the differences in SCC, the content of milk fat, proteins and dry matter in the three batches was similar. Slightly lower lactose values were observed in the milks with high SCCs (batch H) compared to the other milk batches. No statistically significant (P<0.05) differences were established in the pH and lactic acid content values between the three batches of raw milk used in the current study for obtaining the test samples of cheese.

The results of the physicochemical analysis of the cheese test samples have been presented in Table 2. It is evident that the cheeses in all batches were characterized by close values of the dry matter, water content respectively, milk fat content, proteins, and NaCl. Mazal et al. [4] also reported that the SCC did not affect the protein and fat contents of the Prato cheese or the fat loss to the whey. No statistically significant (P>0.05) differences were established in the pH and lactic acid content values between the cheeses in batches L, M and H. This indicated a similar acid formation rate in the production of the cheese test samples.

The results obtained showed that the SCC values in the raw milk had no significant influence on the content of the main components, active acidity and lactic acid concentration in the cheese produced.

### Table 1. Microbiological and physicochemical characteristics of raw milk used for production of cheese samples.

| Samples | SCC, cells/ml | TVC, CFU/ml | Dry matter, % | Fat, % | Proteins, % | Lactose, % | pH |
|---------|---------------|-------------|---------------|---------|-------------|------------|-----|
| Batch L | 106 000a      | 9.4±0.5x10^5a | 12.45±0.12a  | 3.67±0.09a | 3.21±0.07a  | 4.62±0.04a | 6.57±0.07a |
| Batch M | 556 000b      | 9.7±0.7x10^5a | 12.42±0.16a  | 3.66±0.08a | 3.28±0.06a  | 4.58±0.05a | 6.59±0.05a |
| Batch H | 1 533 000c    | 1.2±0.3x10^6a | 12.41±0.13a  | 3.73±0.08a | 3.30±0.08a  | 4.47±0.03b | 6.61±0.05c |

a, b, c – means within same column bearing a common superscript did not differ significantly (P>0.05).

The results obtained showed that the SCC values in the raw milk had no significant influence on the content of the main components, active acidity and lactic acid concentration in the cheese produced.

### Table 2. Physicochemical characteristics of cheese samples.

| Samples | Water content, % | Dry matter, % | Fat, % | NaCl, % | Proteins, % | pH | Lactic acid, % |
|---------|------------------|---------------|--------|---------|-------------|----|---------------|
| Batch L | 47.48±0.42a      | 52.52±0.46a   | 32.12±0.32a | 2.15±0.12a | 18.22±0.27a | 5.84±0.05a | 0.846±0.044a |
| Batch M | 47.52±0.45a      | 52.48±0.38a   | 31.67±0.28a | 2.11±0.09a | 18.6±0.22a   | 5.81±0.05a | 0.855±0.057a |
| Batch H | 48.19±0.58a      | 51.81±0.41a   | 32.13±0.45a | 2.08±0.11a | 17.92±0.31a  | 5.85±0.04b | 0.837±0.038a |

a, b, c – means within same column bearing a common superscript did not differ significantly (P>0.05).
differences were established in the pH and lactic acid concentration values in the cheese samples from batches L and M at the different stages of their ageing and cold storage. Unlike them, the values of these indicators in the batch H cheeses were significantly ($P<0.05$) lower. These data indicated a delayed fermentation process during the ageing of the cheeses made from milks in which the SCC exceeded 500,000 cells/ml.

![Graph A](image1.png)

![Graph B](image2.png)

![Graph C](image3.png)

**Figure 1.** Changes in pH values, lactic acid concentration and lactic acid bacteria count during ageing and storage of Farmers cheese produced from raw milk with different SCC: Batch L (A); Batch M (B); Batch H (C).
This conclusion was also confirmed by the results on the lactic acid microflora development in the three cheese batches studied (Fig. 1). The data obtained showed that the lactic acid bacteria count in the test samples of cheese grew over the 3-month ageing period, then slightly decreased until the 10th month of storage. This tendency was the least pronounced with the cheese samples made from milks with SCCs exceeding 500,000 cells/ml. They exhibited the least dynamic lactic acid microflora count during ageing and cold storage. Within the 3-month ageing period, the *L. delbrueckii* subsp. *bulgaricus* count in the cheeses in batches L and M grew from 4.2±0.3x10^5 CFU/g to 8.4±0.4x10^5 CFU/g and from 9.6±0.4x10^5 CFU/g to 5.7±0.5x10^5 CFU/g, respectively. For the same period, the *L. delbrueckii* subsp. *bulgaricus* count in the batch H cheese samples grew from 1.0±0.5x10^4 CFU/g to 9.7±0.4x10^4 CFU/g. By the end of the cold storage, *L. delbrueckii* subsp. *bulgaricus* decreased slightly, reaching 1.5±0.3x10^5 CFU/g, 9.2±0.4x10^4 CFU/g and 2.4±0.3x10^4 CFU/g respectively for the cheeses from batches L, M, and H.

The results obtained showed that in the cheeses made from milks with SCCs exceeding 500,000 cells/ml, the growth of *L. delbrueckii* subsp. *bulgaricus* was slower compared to the other test samples. The high somatic cell count in the milk used for the production of these samples was probably accompanied by the existence of factors which suppress the lactic acid microflora growth in the cheese curd during ageing and cold storage. The delay in the growth of the Bulgarian rod could also explain the less intensive lactic acid process during the ageing of the batch H cheeses.

The data (Fig. 1) obtained on the changes in the *S. thermophilus* count in the cheese test samples showed trends similar to those established with *L. delbrueckii* subsp. *bulgaricus*. Within the 3-month ageing period, the *S. thermophilus* count in the cheeses in batches L and M grew from 1.7±0.4x10^6 CFU/g to 3.7±0.2x10^5 CFU/g and from 8.1±0.3x10^5 CFU/g to 2.2±0.4x10^5 CFU/g, respectively. For the same period, the *S. thermophilus* count in the batch H cheese samples grew from 9.2±0.4x10^5 CFU/g to 2.8±0.4x10^7 CFU/g. By the end of the cold storage, *S. thermophilus* decreased slightly, reaching 1.1±0.3x10^7 CFU/g, 9.5±0.4x10^6 CFU/g and 9.3±0.4x10^6 CFU/g respectively for the cheeses from batches L, M, and H. The decrease in the lactic acid bacteria count after the 3rd month may have been due to the inhibiting action of the lactic acid accumulated in the cheese. At the end of the ageing period, the values of this indicator varied from 1.224±0.018% to 1.485±0.025% in the different test samples.

This study did not establish any statistically significant (P>0.05) differences in the *S. thermophilus* count in the cheese test samples at the different stages of the ageing and cold storage processes. This showed that the somatic cell count in the milk did not exert any significant influence on the growth of this lactic acid bacteria in the cheese produced. Perhaps that was due to the lesser sensitivity of *S. thermophilus* to the inhibiting factors in the milks with a high SCC. According to Le Maréchal et al. [19] starter culture activity and growth are reduced in mastitis milk. The fermentation process is prolonged in high SCC (>400,000 cells/ml) milk. Starter lactic acids bacteria are affected in a greater extent by the antimicrobial components produced during mastitis in comparison with nonstarter microflora. According to the authors [19] the effect of high SCC might nevertheless depend on the lactic acid bacteria species. For instance the acidifying activity of *S. thermophilus* is increased while that of *L. acidophilus* is inhibited. This statement is in accordance with the results obtained in the present study for lesser sensitivity of *S. thermophilus* to the inhibiting factors in the milks with a high SCC in comparison with *L. delbrueckii* subsp. *bulgaricus*.

One of the major problems associated with mastitis is a lower acceptance by the consumer of the products produced due to flavour and texture defects. Usually, dairy products made from mastitis milk have a shorter shelf life compared with dairy products made from normal milk and always develop off-flavours especially in cheeses. The results of the organoleptic analysis of the cheese test samples during the different stages of their ageing and cold storage have been presented in Figure 2, Figure 3, Figure 4 and Figure 5. At the end of the ageing process (3rd month) (Fig. 2), no statistically significant (P>0.05) differences were established in the scores on individual organoleptic characteristics or in the total sensory evaluation score (Fig. 5) on the cheese samples obtained from raw milks with low and medium SCCs (batches L and M).
Figure 2. Individual organoleptic characteristics scores of the test cheese samples at the end of ageing (3rd month) according to the following hedonistic scale: 1-very bad; 2-bad; 3-not bad nor good; 4-good; 5-very good.

Figure 3. Individual organoleptic characteristics scores of the test cheese samples after 6 months of cold storage according to the following hedonistic scale: 1-very bad; 2-bad; 3-not bad nor good; 4-good; 5-very good.

Figure 4. Individual organoleptic characteristics scores of the test cheese samples at the end of cold storage (10th month) according to the following hedonistic scale: 1-very bad; 2-bad; 3-not bad nor good; 4-good; 5-very good.
This showed that the variations in the somatic cell count in raw milk up to 500,000 cells/ml had no significant impact on the organoleptic characteristics of the ripe Farmers cheese. At the 3rd month of the cold storage (Fig. 2), the organoleptic scores of the batch H cheeses were slightly lower compared to the other test samples. During refrigerated storage, the organoleptic scores for taste and aroma decreased and the most significant decrease was observed for batch H. At the end of storage (Fig. 4) the organoleptic evaluation of the taste, aroma and structure of the test cheeses made from milks with a high number of somatic cells were significant lower compared to the cheese from batches L and M.

![Figure 5](image)

**Figure 5.** Total scores from sensory evaluation of the test cheese samples at the end of cold storage (10-th month) according to the following hedonistic scale: 1-very bad; 2-bad; 3-not bad nor good; 4-good; 5-very good.

The results obtained in the current study (Fig. 5) indicated that the total sensory evaluation score of the cheese test samples showed a certain decrease during the cold storage process. This trend was most pronounced with the cheeses made from milk with high SCCs (batch H). The main organoleptic defects of these samples were related to their taste and aroma, evaluated as unsatisfactory as early as the 6th month of their storage. Unlike them, the cheeses from batches L and M preserved a good sensory quality until the 10th month of their cold storage. The decrease in the sensory characteristics of the cheeses made from raw milk with a high SCC (batch H) limited their storage period at temperatures of 4±1°C to less than 6 months. The reduced shelf life and worse organoleptic characteristics of these cheeses were most probably due to the too intensive proteolytic and lipolytic processes occurring during cold storage. Andreatta et al. [3] also reported for flavour and texture defects of Mozzarella, Prato or ewes cheeses made with high SCC milk. The authors explained these sensory defects by the higher levels of lipolysis or proteolysis in the studied cheeses. Chen et al. [7] stated that high SCC milk resulted in a lower texture score and thus a lower total sensory score of cheese. Other authors [7, 20, 21] did not found an adverse effect of high SCC on the sensory quality of goats’ soft cheeses. According to Raynal-Ljutovac et al. [22] some technological factors, as the short ageing time in comparison with semi-hard cows or ewes cheese, may explain the minor influence of SCC on texture and flavours of goats’ soft cheeses.

Except for cheddar, studies on the impact of mastitis on cheeses are scarce and the impact of the different factors should be tested. The results obtained in the current study showed clearly that the increase in the SCC values in the raw cow’s milk over 500,000 cells/ml had a negative effect on the organoleptic characteristics and shelf life of the Farmers cheese made from that milk.

4. Conclusion
The results reported in the present study showed that the SCC of raw milk has a significant effect on the quality characteristics of dairy products produced. Delayed growth of *L. delbrueckii* subsp. *bulgaricus* during the ageing of the Farmers cheese made from high SCC milk was found. The use of high SCC milk influences negatively the flavour, body and texture scores of Farmers cheese. The results obtained demonstrated that it is necessary to implement a program aimed to reduce the milk somatic cell count in caw milk, with the aim of improving the quality of dairy products.
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