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Comparative study on the quality characteristics of yoghurt produced by caw milks with different somatic cells count

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Abstract

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The present study aimed to provide the necessary information for the effect of somatic cells count (SCC) of raw cow milk on the fermentation process and quality characteristics of yoghurt.

Test yoghurt samples were produced from three different batches of cow milk with low (< 400 000 cells.cm^{-3}), medium (between 500 000 and 600 000 cells.cm^{-3}) and high (1 000 000 cells.cm^{-3}) SCC, respectively. The main physicochemical parameters as pH, total solids, milk fat, protein, lactose, lactic acid content and microbiological parameters as somatic cells count (SCC) and total viable count (TVC) of raw milk and yoghurt samples were studied. It was found that, the SCC of the raw milk did not have a significant effect on the composition and pH values of the yoghurt. A similar rate of acidification during fermentation of the milks having different SCC, as well as during the cold storage of yoghurt samples was established. The variations in the SCC of the raw milk within the range up to 500 000 cells.cm^{-3} had no significant effect on the organoleptic properties of the yoghurt. The increase in the SCC values up to 1 000 000 cells.cm^{-3} in the raw cow's milk affected negatively the organoleptic characteristics of the yoghurt made from it.

Keywords: somatic cells; yoghurt; quality; fermentation process
Abbreviations: CFU – colony forming units; SCC – somatic cells count; TVC – total viable count

Introduction

The health of the animal is the leading factor affecting the quality of raw milk. The most important disease seen in dairy animals is the breast inflammation called Mastitis. Mastitis is causing great economic losses due to reduction in milk yield and lowering its nutritive value. The milk from an affected animal usually contains microorganisms which are potentially pathogenic for humans (Barbano, 1989). Normally, in milk from a healthy mammary gland, the somatic cells count (SCC) is lower than 100 000 cells.cm^{-3}, while bacterial infection can cause it to increase to above 1 000 000 cells.cm^{-3} (Bytyqi et al., 2010).

The largest negative consequences of the increased SCC of milk are related to shorter shelf life and less sensory quality or un-desirable organoleptic characteristics of the final product, due to enzymatic activities of somatic cells (Töpel, 2004). It was found that the high presence of SCC in milk affects the activity of yogurt fermentation (Tamime & Robinson, 1999), and can even stop this process. Fernandes et al.

(2007) studied the effect of SCC in raw milk on the chemical and physical properties of yogurt. The authors suggested that raw milk used to produce yoghurt should not contain more than 400 000 cells.cm^{-3}. Rogers et al. (1994) stated that the sensory qualities of yogurt produced from milk with low SCC were superior to yogurts made from milk with high SCC. Oliveira et al. (2002) reported for decrease in the sensory quality of yoghurt produced from milk with more than 800 000 cells.cm^{-3}. According to the authors the grades for consistency and taste of yoghurt samples decreased progressively from day 10 after production to day 30 of storage at 5°C. Bulca et al. (2016) did not found a significant effect of the SCC of raw milk ranging from 52 000 to 585 000 cells. cm^{-3} on the sensory characteristics of the yoghurt.

The information about the influence of SCC on the quality of fermented milks is insufficient. Furthermore, there are no studies on the possible effects of SCC on dynamics of the fermentation process during yoghurt production and storage. Therefore, the aim of the present work was to determine the effects of SCC levels in raw cow milk on the fermentation process and quality characteristics of yoghurt.

Materials and Methods

Milk samples

Raw bulk milk samples were collected from small-scale dairy farms affiliated with Diary Producer Associations in Biga district of Çanakkale province. Samples were brought to the laboratory of Çanakkale Onsekiz Mart University-Biga Highschool (Turkey) at 4°C. SCC, TVC and composition of milk samples were measured. All analyses of raw milk were carried out in triplicate. For experimental yoghurt samples preparation were selected three different batches of raw milk with low (< 400 000 cells.cm^{-3}), medium (between 500 000 and 600 000 cells.cm^{-3}) and high (1 000 000 cells.cm^{-3}) SCC, respectively.

Yoghurt samples

Yoghurt samples were produced with traditional methods from cow milks with different SCC according to the fallowing procedure: the raw milks from three batches (L, M and H) were accepted into the pilot dairy processing plant of Çanakkale Onsekiz Mart University-Biga Highschool (Turkey) and clarification and fat ratio standardization procedures were performed at 55-60°C. After homogenization at 55°C under 180 kg/cm^2 pressure, the standardization is carried out by evaporation method up to 14% dry matter ratio. Milk was pasteurized at 90°C for 15 min and cooled down to 45-46°C, the fermentation temperature. Yogurt starter culture (2 %) consisting of *Streptococcus thermophilus* (70%) and *Lactobacillus bulgaricus* (30%) bacteria is added in a process tank. After mixing inoculated milk was packaged in containers and incubated at 44-45°C until pH value reaches 4.40. At the end of the incubation, the yogurts were cooled down to approximately 4°C and then stored at the same temperature for 15 days.

Determination of SCC and chemical composition of raw milk

Bactocount IBCm (Bentley Instrument, USA) device was used for SCC determination. The milk fat, protein, lactose and total solids content of studied milk samples were measured by using Infrared Milk Analyzer 150 (Bentley Instrument, USA). The instrument was calibrated with certified reference milk samples from Italy Acredite Dairy Laboratories A.I.

Microbiological analysis

Total viable count (TVC) was determined by using Plate Count Agar medium according to ISO 4833-2:2013. Inoculated petri dishes were subjected to incubation at 30°C for 48 to 72 hours and colony forming units (CFU) were counted on petri dishes.

Physicochemical analysis of yoghurt

The milk fat, protein, lactose and dry matter content of studied yoghurt samples were measured by using Infrared Milk Analyzer 150 (Bentley Instrument, USA). pH values were measured by pH meter. Lactic acid content of milk and yoghurt samples was determined by titration method according to BNS 1111-80.

Sensory analysis

The evaluation of the sensory quality of yoghurt samples was performed with 25 consumers, randomly selected by age, gender and social status. The consumers expressed their opinion by means of hedonic scale. The color, thickness (by spoon), thickness (by taste of mouth), aroma and taste of the yoghurt samples were determined using a five point hedonic scale from 1 = dislike a lot to 5 = like a lot. Tests were repeated three times. Preferred characteristics were visual and natural thickness, mild sour taste, smooth structure, strength and resistance of the coagulum and clear creamy color. Non-preferred characteristics were stickiness, serum separation, gas indication, high thickness, rough structure, very sour, sweet and/or salty metallic flavor, weak aroma, neutral taste.

Statistical analysis

Computer processing of the results was performed by 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 $P < 0.05$ (Draper & Smith, 1998). The Fischer's test with a significant difference set at $P < 0.05$ was used to compare sample values (Kenward, 1987).

Results and Discussion

Physicochemical and microbiological analysis of raw milk and yoghurt samples with different SCC

The results of the physicochemical and microbiological analysis of the raw milk used for obtaining the test samples of yoghurt have been presented in Table 1. The three batches of raw milk used were marked as L, M and H and were characterized by a low, medium and high SCC, respectively. Similar tendencies were observed in the TVC values, which confirmed the existence of a correlation between these two indicators.

It was evident (Table 1) that regardless of the differences in the SCC and the total viable count, the main milk components such as milk fat, proteins and lactose had similar content in the three batches. The pH (pH) values and the lactic acid concentration in the test samples were within the admissible limits for raw cow's milk. The pH values were lower ($P < 0.05$) and the lactic acid concentration was higher ($P < 0.05$) in raw milk batch H compared to the other batches. This could be attributed to the occurrence of more intensive microbiological processes in these samples, which was also indicated by the high TVC of up to $9.4x10^5$ $CFU.cm^{-3}$ established in the raw milk of batch H. The differences observed in TVC were probably due to the different hygienic conditions of milk handling. Poor hygiene during the raising and milking of animals is related both to the higher percentage of mastitis, the higher SCC respectively, and to the increased microbial contamination of milk (Rysanek et al., 2007).

The results of the physicochemical analysis of the yoghurt test samples have been presented in Table 2.

It can be seen that the three batches of fermented milk were characterized by similar values of the dry matter, milk fat, protein and lactose content. No statistically significant differences ($P < 0.05$) were established in the pH values and the lactic acid content. The results obtained showed that the SCC values in the raw milk did not have a significant effect on the content of the main components, the pH and the lactic acid concentration in the yoghurt.

Fermentation process development during production and storage of yoghurt samples produced from raw milk with different SCC

The changes in the pH values, the lactic acid and residual lactose concentration during the coagulation of the test samples have been presented in Figure 1, Figure 2 and Figure 3. A significant ($P < 0.05$) decrease in pH from 6.58±0.05 to 4.38±0.04, and a respective increase in lactic acid concentration ($P < 0.05$) from 0.18±0.02 % to 0.68±0.01 % were observed. No statistically significant differences ($P < 0.05$) were established in the values of these indicators during the different stages of the fermentation process occurring in the three milk batches. These data indicated a similar rate of fermentation in the milks having different SCC.

The milk coagulation time was 4 hours for all test samples. The residual lactose amount at the end of the coagulation varied within the 3.81±0.07 % range. The results obtained showed that the SCC in the raw milk did not have any significant effect on the acidification capacity of lactic acid bacteria of the *Lb. delbrueckii* subsp. *bulgaricus* and *S. ther-*

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

Characteristics / Samples	SCC, $cells.cm^{-3}$	TVC, CFU. cm^{-3}	Dry matter, %	Fat, %	Proteins, %	Lactose, %	pH	Lactic acid, %
Batch L	377 000	$3.3.10^5$	12.18	3.52	3.27	4.49	6.68	0.162
Batch M	519 000	$4.5.10^5$	12.39	3.64	3.26	4.59	6.63	0.169
Batch H	1 000 000	$9.4.10^5$	12.40	3.73	3.30	4.47	6.62	0.176

Table 2. Physicochemical characteristics of yoghurt samples

Characteristics / Samples	Dry matter, %	Fat, %	Proteins, %	Lactose, %	pH	Lactic acid, %
Batch L	13.20	3.8	3.28	3.77	4.4	0.680
Batch M	13.26	3.7	3.27	3.87	4.35	0.682
Batch H	13.25	3.8	3.35	3.75	4.38	0.684

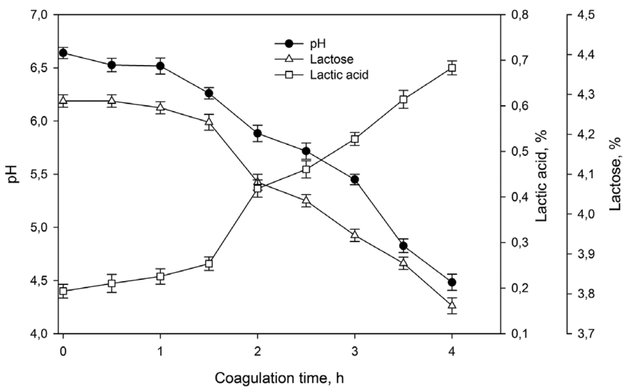

Fig. 1. Changes in the pH values, lactic acid and residual lactose concentrations during coagulation of milk samples from batch L

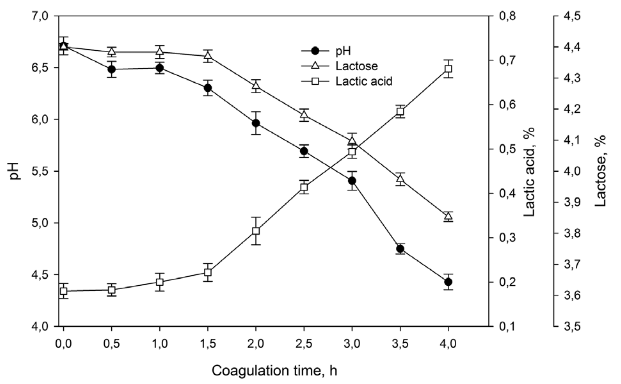

Fig. 2. Changes in the pH values, lactic acid and residual lactose concentrations during coagulation of milk samples from batch M

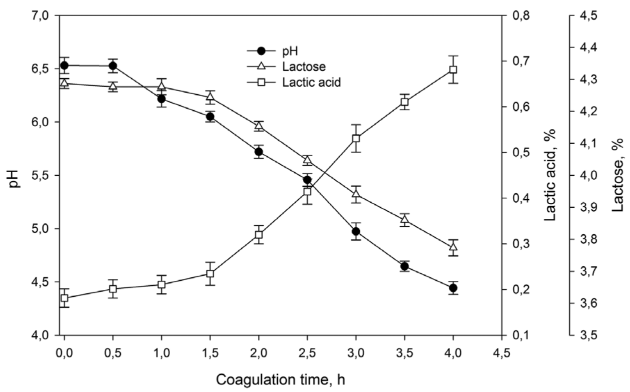

Fig. 3. Changes in the pH values, lactic acid and residual lactose concentrations during coagulation of milk samples from batch H

mophilus starter culture. Similar conclusions were made by Fernandes et al. (2007), who did not find any statistically significant effect of the SCC on the titratable acidity, pH, fat and total nitrogen content, and proteolysis index in the yoghurt.

The changes in the pH values, the lactic acid and residual lactose concentrations during the storage of the three batches of fermented milk (L, M and H) have been presented in Figure 4, Figure 5 and Figure 6.

During the 15 days of storage, a slight decrease in the pH ($P < 0.05$) values from 4.18±0.05 to 3.45±0.04 on average, and a respective increase in lactic acid concentration ($P < 0.05$) from 0.83±0.03 % to 1.33±0.04 % on average were observed. These data showed that, though at a slower rate, the fermentation process continued during the cold storage of the fermented milks. In the present study, no statistical-

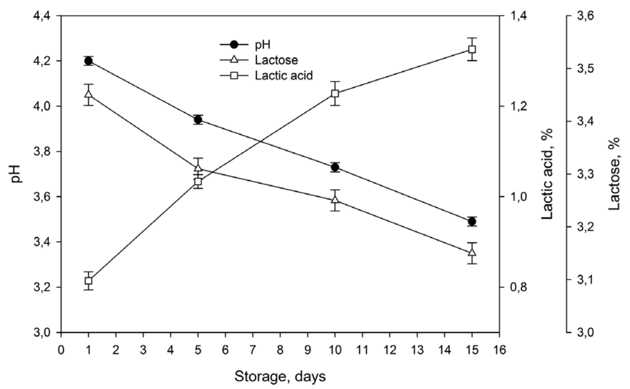

Fig. 4. Changes in the pH values, lactic acid and residual lactose concentrations during cold storage of yoghurt samples from batch L

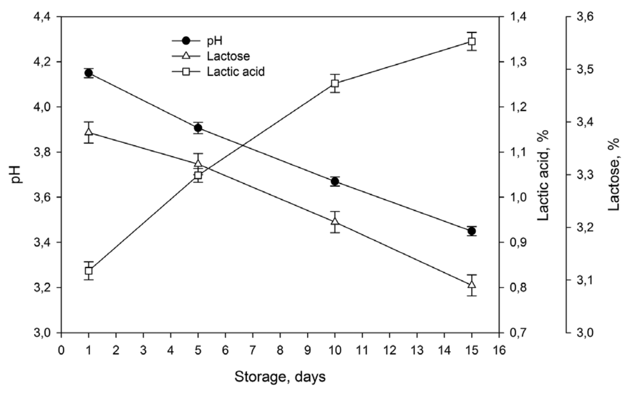

Fig. 5. Changes in the pH values, lactic acid and residual lactose concentrations during cold storage of yoghurt samples from batch M

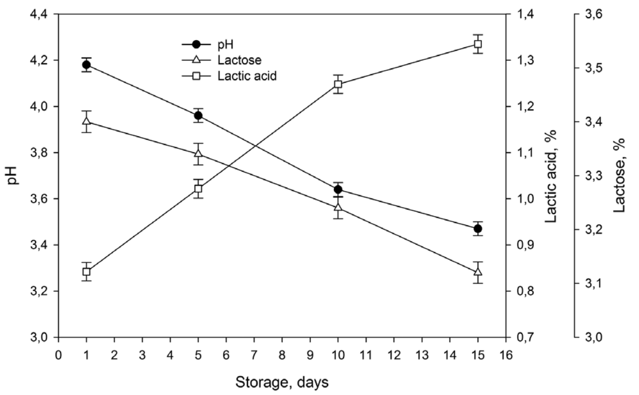

Fig. 6. Changes in the pH values, lactic acid and residual lactose concentrations during cold storage of yoghurt samples from batch H

ly significant differences (P < 0.05) were established in the pH values, the lactic acid and residual lactose concentrations at the different cold storage stages of the test samples. The residual lactose content at the end of the storage of the three fermented milk batches varied within the 3.46±0.04 % range. These data indicated a similar rate of post-acidification in the milks having different SCC. Therefore it could be assumed that the values of this indicator had no significant effect on the post-acidification of the lactic acid bacteria of the *Lb. delbrueckii* subsp. *bulgaricus* and *S. thermophilus* starter culture.

The dependences established within the current study were in conformity with the results obtained by other authors. According to Fernandes et al. (2007) and Oliveira et al. (2002), the SCC levels in cow's milk did not have any considerable effect on the pH values, titratable acidity, milk fat and protein content, or the microbiological characteristics of the yoghurt obtained.

Sensory analysis

The results on sensory evaluation of the yoghurt test samples at the end of cold storage have been presented in Figure 7. In this study, no statistically significant (P < 0.05) differences were established in the organoleptic scores of the yoghurts in these batches. This showed that the variations in the SCC in the raw milk within the range up to 500 000 cells.cm^{-3} had no significant effect on the organoleptic properties of the yoghurt.

The results obtained in this study (Figure 7) showed that the total sensory evaluation scores on the yoghurts produced from raw milk with a higher SCC (batch H) were considerably lower (P < 0.05) than those of batches L and M. The

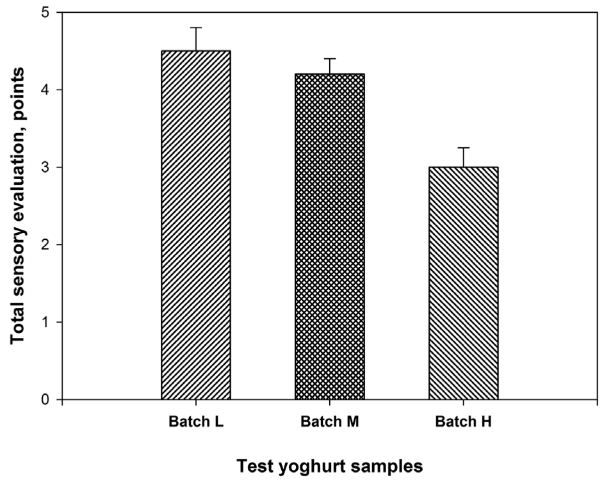

Fig. 7. Total sensory evaluation scores of the test yoghurt samples according to the following hedonistic scale: 1 – very bad; 2 – bad; 3 – not bad nor good; 4 – good; 5 – very good

colour evaluations were an exception since no statistically significant (P < 0.05) differences were established in color scores of all test samples. The most significant effect of the SCC was observed with the thickness and aroma characteristics. A possible explanation could be the negative effect of the increased somatic cell concentration on the carbonyl compound profile in the yoghurt demonstrated mainly in the lack of well-expressed aroma of the finished product. The looser coagulum of the yoghurt made from milk with a higher SCC is also a common flaw (Fernandes et al., 2007; Oliveira et al., 2002). This was also the reason for the lower organoleptic score on this indicator for the batch H test samples. Though to a lesser extent, the increased SCC had a negative effect on the taste and texture of the yoghurt. The results made it evident that the increase in the SCC values exceeding 500 000 cells.cm^{-3} in the raw cow's milk affected negatively the organoleptic characteristics of the yoghurt made from it. Oliveira et al. (2002) also reported lower organoleptic scores for yoghurt made from raw cow's milk with a SCC of over 800 000 cells.cm^{-3}. The scores on the texture and taste of the samples studied showed a progressive decrease between the 10th and the 30th day of the cold storage.

Conclusions

The results obtained in the present study showed that the SCC values of the raw milk did not have a significant effect on the yoghurt composition. A similar rate of acidification during fermentation of the milks having different SCC was found. Therefore, it could be suggested that SCC in the raw milk did not have significant effect on the acidification activity of the starter lactic acid bacteria *Lb. delbrueckii* subsp. *bulgaricus* and *S. thermophilus*. In the present study, no statistically significant differences ($P < 0.05$) were established in the pH values, the lactic acid and residual lactose concentration at the different cold storage stages of the three milk batches. This data indicated for similar rate of post-acidification in the milks having different SCC.

The variations in the SCC in the raw milk within the range up to 500 000 cells.cm^{-3} had no significant effect on the organoleptic properties of the yoghurt. The total sensory evaluation scores on the yoghurts produced from raw milk with a higher SCC were significantly lower ($P < 0.05$) than those of the other batches. It can be concluded that the increase in the SCC values up to 1 000 000 cells.cm^{-3} in the raw cow's milk affected negatively the organoleptic characteristics of the yoghurt.

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