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EFFECT OF ANIMAL BREED, SEASON AND MILK PRODUCTION SCALE ON SOMATIC CELL COUNT AND COMPOSITION OF COW MILK

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Abstract

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Production of high quality dairy products requires profound knowledge about factors conducting raw milk quality. Therefore, the present study aimed to provide to dairy processors the necessary information for the effect of animal breed, season and milk production scale on the quality and technological properties of raw milk.

In this respect, the main composition parameters (total solids, milk fat, protein content) and microbiological parameters (somatic cell count (SCC) and total viable count (TVC)) of bulk raw milk collected from small-scale producers and of raw milk from Simmental, Holstein and Jersey breeds produced in large-scale farms were studied over a one year period. Total solids, protein and fat levels in bulk milk demonstrated seasonal trends. Milk fat and protein contents were the highest in autumn and winter and the lowest in spring and summer. However, no significant seasonal variations were detected in total solids, milk fat and protein contents in the milk from large-scale farms. The values of these parameters were significantly higher ($P<0.05$) in milk from Jersey breed in comparison with the other two breeds studied.

Lower TVC and SCC of milk produced by large-scale farms in comparison with small-scale producers were found. The SCC values of bulk milk samples were significantly higher ($P < 0.05$) during the autumn-winter period compared to spring and summer. The milk produced by large-scale producers lacks significant seasonal variations of SCC. It was found that the SCC of milk from Jersey breed is statistically ($P < 0.05$) higher than that the other breeds studied.

Key words: raw milk; somatic cells; composition; season; breed
Abbreviations: CFU – colony forming units, SCC – somatic cell count, TVC – total viable count

Introduction

Milk is a biological fluid with high nutritional value, consisting of water, milk fat, proteins, lactose, minerals, etc. The quality of dairy products largely depends on the composition of raw bulk milk. Therefore, the factors responsible for the variations in the composition and physico-chemical properties of raw milk are of paramount importance for milk processors. The main factors affecting milk composition are season, stage of lactation, feeding, milking interval, breed and age of dairy cattle (Heck et al., 2009). The effects of seasonal variation on milk yield and composition have been investigated by many researchers (Heck et al., 2009; Dairy Co, 2013; Chen et al., 2014). Weather conditions, which are

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related with the season, could affect milk production. Temperatures between 5–25°C are so cold Comfort Zone for the animals and have no effect on the milk production. At the summer season when the temperature is very high feed consumption is greatly reduced and water intake increased resulting in decrease of milk yield and in lowering of milk fat and total solids. The increase of milk yield as well as the concentration of milk fat and total solids during the autumn and winter is probably due to a more favorable temperature and more digestible feeds available. It should be noted that the seasonal effects on the main components of raw milk are also in dependence with the geographical region and feeding regimes.

Mastitis, which is an inflammatory reaction of the mammary gland to infection, is also known to have a multitude of effects on the quantity, quality, and processing properties of produced milk. The amount of somatic cells, usually called somatic cell count (SCC), in milk is used as an important parameter of udder health since somatic cells are involved in the protection of the mammary gland from infection as part of the immune system of the animal. SCC in milk is influenced by many factors, such as animal species, milk production level, lactation stage, and also the individual and environmental factors as well as the management practices (Rupp et al., 2000).

The aim of the present study was to determine the effect of animal breed, season and milk production scale on the somatic cell count and composition of cow milk.

Materials and Methods

Milk samples

Raw bulk milk was collected from 72 small-scale dairy farms (5 to 20 animals) affiliated with Diary Producer Associations in Biga district of Çanakkale province. These small-scale farms were situated in three villages – TOKATKIR, CHELİKGURU and YENİCHİFTLİK. The individual breed milk samples were collected from three different large-scale farms (above 100 animals) raising three dairy cattle breeds – Holstein, Jersey and Simmental. Samples were brought to the laboratory at 4°C. TSCC, TVC and composition of milk samples were measured every 2 weeks during 2014 and 2015. All analyses of raw milk were carried out in triplicate.

Determination of SCC and chemical composition of milk

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).

The instrument was calibrated with certified reference milk samples from Italy Acredite Dairy Laboratories A.I.

In the Analysis System, there are one automatic sampler with a combined infrared milk analyzer and a somatic counter connected to the Flow Cytometry method, a computer unit, two monitors and a keyboard placed in two devices. Analysis Sample volume was 3 ml, and sample temperature is in the range from 5 C to 38°C.

Microbiological analysis

Total bacterial count 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.

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 $P < 0.05$ (Draper and 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

Somatic cell count and total viable count

The mean annual values for SCC and total TVC for bulk cow milk samples and for samples from three different breeds raised on large-scale farms are presented in Table 1. As can be seen, the values of the examined parameters are significantly higher ($P < 0.05$) in the bulk milk (obtained in small-scale farms) than in the milk from large-scale farms. This is an indication for better hygiene of milk production in large-scale farms in comparison with small-scale farms. In present study, no statistically significant ($P < 0.05$) differences were found in the TVC of bulk milk samples collected from three different regions of western Turkey. SCC in the milk obtained from the YENİCHİFTLİK region is lower than in the milk from the other two regions. This is probably due to the stricter mastitis control in individual farms in this area. This is also supported by the fact that the proportion of mastitis milk in the total amount of bulk milk in this region is the smallest (Figure 1c). In all three bulk milk samples, the values of the examined microbiological parameters significantly exceed the maximal permissible levels of 100 000 CFU/cm^3 for total microbial count, and 400 000/cm^3 for somatic cell counts in cow milk under European legislation.

Table 1
Somatic cell count and total viable count of bulk cow milk and cow milk from individual farms and breed

Parameter*	Bulk milk region			Milk from individual farm and breed		
	TOKATKIR	*CHELİKGURU*	*YENİCHİFTLİK*	*HOLSTAİN*	*JERSEY*	*SIMMENTAL*
Somatic cell count	866 500	947 700	763 300	255 200	428 500	376 200
Total viable count, CFU/cm^3	8.8x10^5	1.0x10^6	9.9x10^5	2.2x10^5	2.9x10^5	4.9x10^5

*mean values for years 2014 and 2015

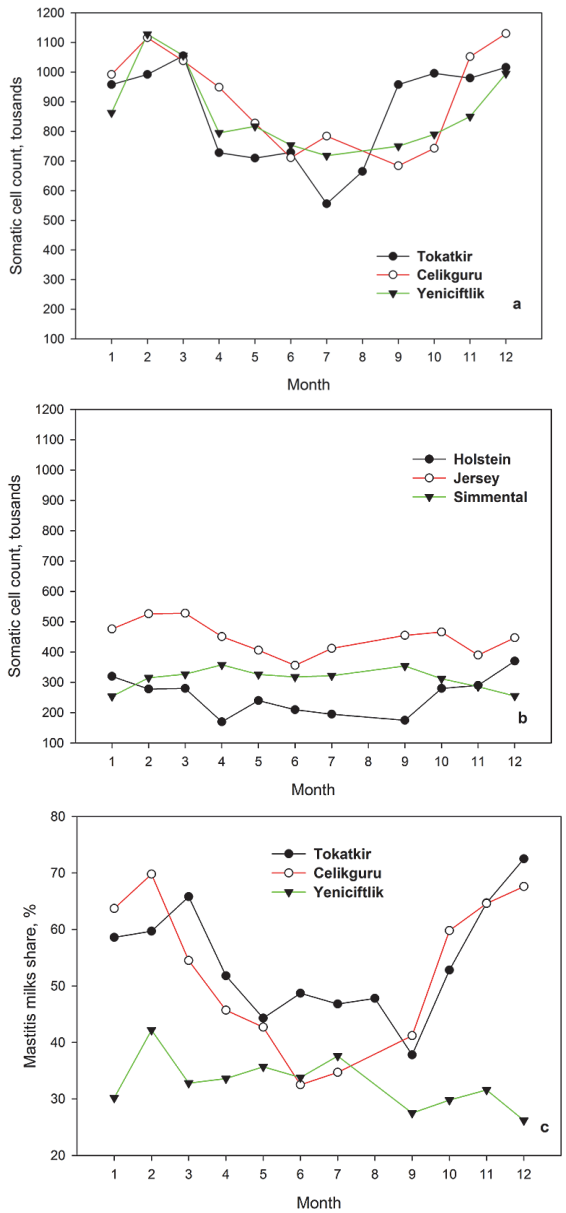

Fig.1. Changes in SCC in bulk cow milk (a), SCC in milk from individual farms and breed (b), and mastitis milk share in bulk cow milk (c) during the year

In the present study, the lowest levels of TVC and SCC were found in milk from Holstein cows. Slightly higher SCC values were observed in the milk from the Jersey and Simmental breeds, while the variations in the TVC values in the milk from the three breeds studied were minimal. It could be concluded that the TVC and SCC parameters are mostly affected by the conditions of raising the animals and the hygiene of milk production, which are significantly better in large-scale farms compared to small-scale producers with several animals. In addition, the veterinary control of animals' health is considerably stricter in large-scale farms, which is the main factor for the lower SCC found in the milk produced there. In the present study, the influence of the breed on the mean annual TVC and SCC values was minimal. A slightly higher SCC was only recorded in the Jersey breed.

Besides the breed and farming conditions, an important factor influencing the SCC in cow milk is the season. Figure 1 shows the change in SCC values in the milk samples during the year. Bulk milk reveals a pronounced seasonal variation of SCC. The values of this parameter are significantly higher ($P < 0.05$) in the autumn-winter period compared to spring and summer. This tendency was observed in bulk milk in the three studied regions, which is probably due to the higher incidence of mastitis in the autumn and winter in the studied regions. Unlike bulk milk, the milk produced by large-scale producers lacks seasonal variations of SCC. A possible reason are the significantly better hygienic conditions and the stricter veterinary health control in large-scale farms and therefore a much smaller incidence of mastitis in the autumn-winter period there. However, it is noteworthy that regardless of the season, the SCC in the milk from the Jersey breed is statistically ($P<0.05$) higher than that in the other breeds. These results indicate that the concentration of somatic cells in milk could be affected significantly from the cow breed. Other authors also have investigated the effect of caw breed on TSCC of milks. Bendelja et al. (2011) established a significantly higher ($P < 0.001$) somatic cell count in Holstein cow's milk (130 599/cm^3) compared to Simmental cow's milk (90 700/cm^3). Hojman et al. (2005) determined on average 316.000 somatic cells per cm^3 in Holstein cow's milk.

Sharma et al. (2011) also reported SCC variation between breeds of dairy animals. It was established that the high-producing cattle breeds such as Brown Swiss (423 310 cells/cm^3) and Black Holstein (310 360 cells/cm^3) have higher presence of SCC in milk. Moreover, Richoux et al. (2014) found that the somatic cell composition in milk varies depending on animal species and breed. Therefore, when setting the SCC thresholds during milk quality monitoring, the animal breed should be taken into account as a factor influencing this parameter.

Milk composition

The main components of milk total solids whose values undergo seasonal fluctuations are milk fat and proteins (Chen et al., 2014). In contrast, insignificant seasonal variations were recorded in the values of the other two main components of cow milk – lactose and mineral substances (Heck et al., 2009). The present study, therefore, followed the changes in total solids, milk fat and protein contents of the studied cow milk samples during different seasons of the year (Figures 2, 3 and 4). Statistically significant ($P<0.05$) differences were found in total solids, milk fat and protein contents of the bulk raw milk samples obtained in different seasons of the year. The lowest values of these indicators were recorded during the spring-summer period, probably in relation to the transition of the animals to pasture farming. No statistically significant ($P<0.05$) differences were found in total solids, milk fat and protein contents in the bulk milk obtained from different regions probably due to the similar breed and farming of the animals from which the bulk milk in TOKATKIR, CHELİKGURU and YENİCHİFTLİK was obtained. Thus, the main factor af-

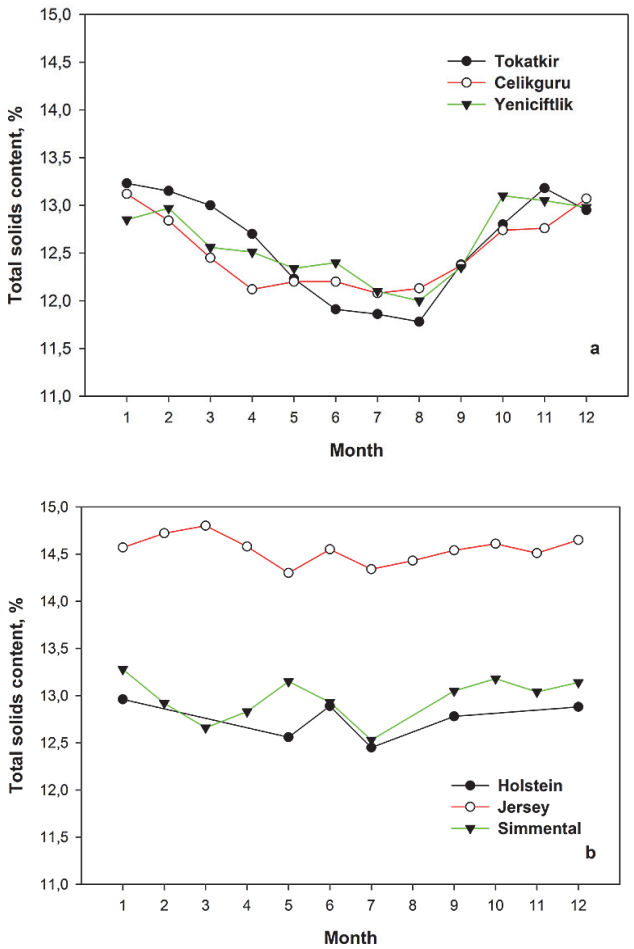

Fig. 2. Changes in total solids content of bulk cow milk (a) and cow milk from individual farm and breed (b) during the year

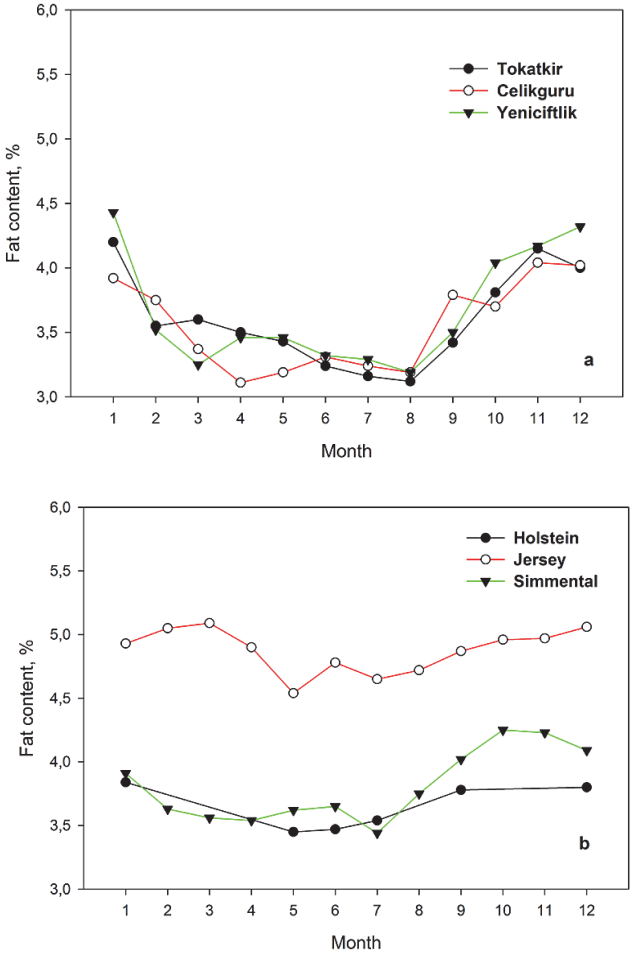

Fig.3. Changes in fat content of bulk cow milk (a) and cow milk from individual farm and breed (b) during the year

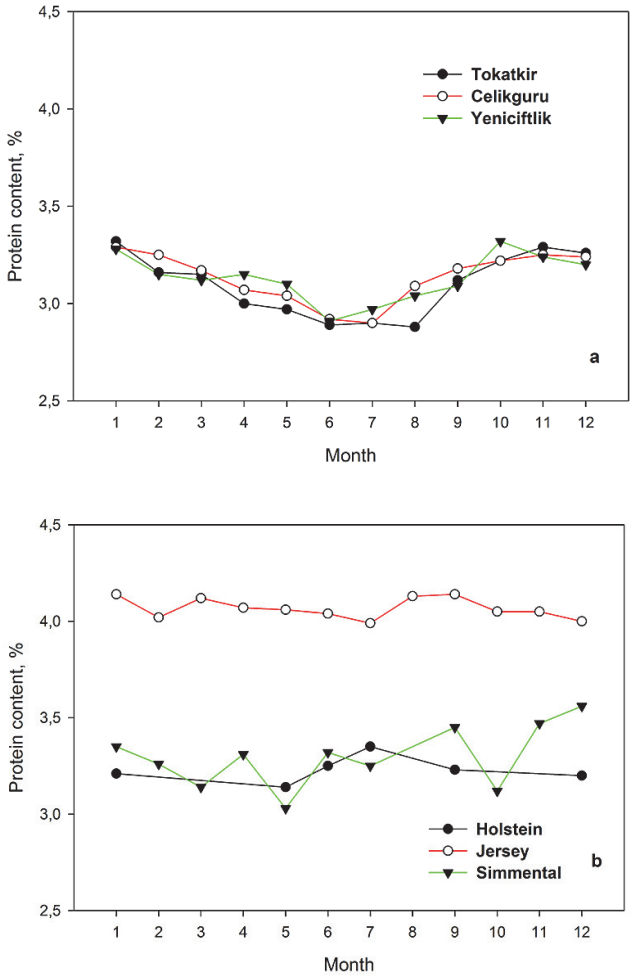

Fig.4. Changes in protein content of bulk cow milk (a) and cow milk from individual farm and breed (b) during the year

fecting the composition of the studied bulk milk samples is the season. Similar results on the impact of the season on milk composition have also been reported by other authors (Heck et al., 2009; Le Maréchal et al., 2011; Chen et al., 2014). According to Rajcevic et al. (2003) the season has a statistically highly significant influence on milk composition and somatic cell count. The authors found that the milk fat and protein percentages are the highest in autumn and winter and the lowest in spring and summer, which variation is related to changes in both the types of feed available and climatic conditions.

Unlike bulk milk, no significant variations were detected in total solids, milk fat and protein contents during the different seasons in the milk from large-scale farms. This is probably to be explained by the similar conditions of feeding and raising the animals on large-scale farms throughout the year. The raw milk obtained there has a relatively constant composition over the entire period. In this study, no statistically significant ($P < 0.05$) difference was established between the milk fat, protein and total solids contents of Holstein and Simmental milk samples. Unlike these two breeds, the milk of the Jersey breed is characterized by significantly higher values ($P < 0.05$) of the milk fat, protein and total solids contents. Similar high values of the main components of milk (milk fat and protein) are characteristic of the Jersey breed. The influence of the breed on milk composition has been investigated by a number of authors. According to Bendelja et al. (2011), the content of milk fat in milk is significantly ($P < 0.05$) higher in the milk of Holsein cows (4.31 %) than in the milk of Simmental cows (4.19 %), while no significant differences were determined for the protein content of milk. On the other hand, Pintić et al. (2007) did not determine any significant differences in the content of milk fat and protein in the milk of Holstein-Friesian and Simmental cows.

Conclusions

The results obtained in the present study showed significant effect of milk scale production on TVC and SCC of raw milk. The lower TVC and SCC values in large-scale farms probably are due to the better hygiene of milk production and stricter veterinary control of animals' health. Bulk raw milk reveals a pronounced seasonal variation of SCC. The values of this parameter were significantly higher ($P < 0.05$) in the autumn-winter period compared to spring and summer. The milk produced by large-scale producers lacks significant seasonal variations of SCC. The mean annual TVC and SCC values for milks obtained from Holstein and Simmental breeds were similar. It was found that the SCC in the milk from the Jersey breed is statistically ($P < 0.05$) higher than that in the other breeds. Therefore, the animal breed should be taken into account when setting the SCC threshold limits for milk quality monitoring.

The main factor affecting the composition of the studied bulk milk samples was the season. Milk fat and protein contents were the highest in autumn and winter and the lowest in spring and summer, which variation is related to changes in both the types of feed available and climatic conditions. No significant variations were detected in total solids, milk fat and protein contents during the different seasons in the milk from large-scale farms.

References

Bendelja, D., Z. Prpić, N. Mikulec, Z. Ivkić, J. Havranek and N. Antunac, 2011. Milk urea concentration in Holstein and Simmental cows. *Mljekarstvo,* **61** (1): 45-55.

Chen, B., M. Lewis and A. Grandison, 2014. Effect of seasonal variation on the composition and properties of raw milk destined for processing in the UK. *Food Chemistry*, **158**: 216-223.

Dairy Co, 2013. Market information, supply & production, 2013. http://www.dairyco.org.uk/market-information/supply-production/composition-andhygiene/uk-milk-composition/ (Accessed 04.04.2013)

Draper N. and Smith H., 1998. Applied Regression Analysis, 3rd ed. A Wiley-Interscience Publication *John Wiley & Sons, Inc.*, Toronto, Canada, pp. 135-149.

Heck, J., H. Van Valenberg, J. Dijkstra and A. Van Hooijdonk, 2009. Seasonal variation in the Dutch bovine raw milk composition. *Journal of Dairy Science*, **92** (10): 4745-4755. doi: http://dx.doi.org/10.3168/jds.2009-2146

Hojman, D., M. Gip and E. Ezra, 2005. Association between live body weight and milk urea concentration in Holstein cows. *Journal of Dairy Science,* **88**: 580-584.

ISO 4833-2:2013, 2013. Microbiology of the food chain – Horizontal method for the enumeration of microorganisms – Part 2: Colony count at 30 degrees C by the surface plating technique – Technical Corrigendum 1 (ISO 4833-2:2013/Cor 1:2014).

Kenward, R., 1987. Wildlife radio-tagging equipment, field techniques and data analysis. *Academic Press,* London, U.K.

Le Maréchal, C., R. Thiéry, E. Vautor and Y. Le Loir, 2011. Mastitis impact on technological properties of milk and quality of milk products – a review. *Dairy Sci. Technol.,* **91**: 247-282.

Pintić, N., F. Poljak, A. Dakić, D. Blažek, T. Jelen and V. Pintić, 2007. Quantitative indicators of milk quality and nutritional status of Simmental and Holstein cows in the Kalnik piedmont region. *Krmiva,* **49** (2): 79-88.

Rajèeviè, M., K. Potoènik and J. Levstek, 2003. Correlations between somatic cells count and milk composition with regard to the season. *Agriculturae Conspectus Scientificus*, **68** (3): 221-226.

Richoux, R., N. Li, M. Boutinaud, P. Martin and V. Gagnaire, 2014. Role of somatic cells on dairy processes and products: a review. *Dairy Sci. Technol.,* **94** (6): 517-538. doi: 10.1007/s13594-014-0176-3.

Rupp, R., D. Boichard, C. Bertrand and S. Bazin, 2000. Overview of milk somatic cell counts in the French dairy cattle breeds. *Prod Anim.,* **13**: 257-267.

Sharma, N., N. Singh and M. Bhadwal, 2011. Relationship of somatic cell count and mastitis: An Overview. *Asian-Aust. J. Anim. Sci*., **24** (3): 429-438.

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