

# The impact of changes in the milk payment system and season on the hygienic quality of milk

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## Abstract

The aims of this paper were to investigate the impact of changes in the milk payment system and the season on the hygienic quality of raw milk. The bulk cow's milk samples were collected throughout the whole area of Bosnia and Herzegovina over the period of four years (2010-2013), from farms that deliver milk to the dairy industry. The total bacterial count (TBC) was analysed in 52,999 milk samples and the somatic cell count (SCC) in 53,363 milk samples. The results of the research showed that the proportion of bulk milk with the SCC < 300,000 mL<sup>-1</sup> significantly increased in the observed period, as well as the proportion of farms that produce milk of EU quality (P < 0.05). The season had a significant effect (P < 0.05) on the SCC; in April the proportion of bulk milk with SCC < 300,000 mL<sup>-1</sup> was significantly higher (P < 0.05). A significant increase (P < 0.05) in the proportion of milk with the TBC < 200,000 cfu·mL<sup>-1</sup> was perceived, as well as the proportion of farms which deliver that type of milk (P < 0.05). A Significant lower (P < 0.05) proportion of milk in the summer period with TBC < 200,000 cfu·mL<sup>-1</sup> was determined. It can be concluded that consistent appliance of regulations which determine the quality of milk, leads to the improvement of the hygienic quality of redeemed milk, as illustrated by the case of Bosnia and Herzegovina. This kind of milk payment system is important for both, the higher economic benefit of farms and the dairy processing industry.

**Keywords:** milk, payment system, season, somatic cell count, total bacterial count

## Introduction

In general, chemical composition, physical properties and hygienic quality determine the total quality of raw milk. The total bacterial count (TBC) and the somatic cell count (SCC) are commonly used parameters for the evaluation of the hygienic quality of

raw milk. In addition, they are part of many official payment schemes for raw milk in European countries (Kalit and Havranek, 2004; Samaržija et al., 2007). According to the EU directive 853/2004 the threshold value of the TBC and SCC in cow's milk is 100,000 and 400,000 mL<sup>-1</sup>, respectively.

In a healthy udder the number of bacteria in milk is negligible and it is considered to be a natural udder population (Mutukumira et al., 1996). The somatic cell count represents the hygienic quality of the milk and it is also an indicator of the health condition of the udder (Čačić et al., 2003; Samaržija et al., 1991). Consequently, immediately after proper and hygienic milking the TBC is between 100 and 5,000 cfu·mL<sup>-1</sup> and the SCC less than 250,000 mL<sup>-1</sup> (Demasures et al., 1997; Heeschen, 1996). Opposite to that, in the cases of unsanitary conditions during milking, the handling of the milk, and bacterial udder inflammation, the TBC in the milk may be greater than 10<sup>7</sup> cfu·mL<sup>-1</sup>. At the same time, the SCC in milk, as a response to the infection could be more than 10<sup>6</sup> mL<sup>-1</sup> (Ariznabareta et al., 2002; Poutrel et al., 1996; Slaghuis, 1996).

The increase of TBC and SCC above the threshold value significantly reduced the technological properties of the milk. Therefore, the quality of the dairy products cannot meet the standards required by the common markets (Antunac et al., 1997). It is common knowledge that an increased number of somatic cells has a negative effect on the milk yield (Arias et al., 2012), the quality and the shelf life of pasteurized milk (Santos et al., 2003), as well as on the coagulation time and the curd firmness (Caballero Villalobos et al., 2015), the cheese yield (Summer et al., 2015) and the sensory attributes of cheese (Chen et al., 2010; Vianna et al., 2008).

In countries that do not have a milk payment system according to the hygienic parameters, the hygienic quality of milk is usually very poor. Bosnia and Herzegovina accepted this model of milk payment in 2010. From 2010 till 2015 a transitional period was established, which means that the threshold value of the total bacterial count was 200,000 cfu·mL<sup>-1</sup>, while the threshold value of the somatic cell count was the same as in EU countries (400,000 mL<sup>-1</sup>). The high quality of milk for Bosnia and Herzegovina is of great importance in keeping its long tradition in artisan cheese production. Therefore, the objective of this paper was to investigate the changes in the hygienic quality of raw milk as a consequence of the implementation of the new milk payment system in Bosnia and Herzegovina over the period of 2010-2013. In addition, another aim was to estimate the impact of the season on the hygienic quality of raw milk.

## Materials and methods

### The design of the experiment

The bulk cow's milk samples were collected throughout the whole area of Bosnia and Herzegovina from randomly selected farms which deliver milk to the dairy industry. The sampling of milk was performed over the period of 2010-2013 (inclusive) through all four seasons (January, April, June, September). The total bacterial count (TBC) was analysed in 52,999 milk samples and the somatic cell count (SCC) in 53,363 milk samples. After analysis, according to the TBC, bulk milk samples were divided into three classes: < 200,000 cfu·mL<sup>-1</sup>, 201,000 – 500,000 cfu·mL<sup>-1</sup> and > 500,000

cfu·mL<sup>-1</sup>, due to the transitional period in which the threshold value for TBC were 200,000. Considering the SCC milk samples were grouped into four classes: < 300,000 mL<sup>-1</sup>, 301,000 – 400,000 mL<sup>-1</sup>, 401,000 – 800,000 mL<sup>-1</sup> and > 800,000 mL<sup>-1</sup>.

### **Determining the total bacterial count and the somatic cell count**

The SCC was determined by the fluoro-opto electronic method of counting (ISO 13366-2:2006) using a Fossomatic minor instrument. The TBC was determined using a Bactoscan FC50 instrument (according to the manufacturer's instructions). The analyses were performed at the Public Institution, Veterinary Institute Bihać.

### **Statistical analysis**

Changes in the hygienic quality of milk over a 4-year period and through the seasons were expressed as percentages of producers as well as amounts of milk in each SCC and TBC class. Changes in proportions were tested by the Chi square test using PROC FREQ of SAS statistical software (v. 9.2; SAS Institute, Inc, 2011). The results are shown graphically in which the class frequencies are represented by bars using a Microsoft Excel program.

### **Results**

As a consequence of the implementation of the milk payment system according to the SCC, the proportion of farms' bulk milk with the SCC < 300,000 mL<sup>-1</sup> significantly increased ( $P < 0.05$ ) through the observed period (Figure 1). Therefore, in the year 2013 the majority of farms' bulk milk (80.72%) belonged to the group with the SCC < 300,000 mL<sup>-1</sup>. Moreover, just 9.46% and 2.37% were classified in the group of hygienically incorrect milk, with SCC 401,000 – 800,000 mL<sup>-1</sup> and > 800,000 mL<sup>-1</sup>, respectively. The proportion of milk with the highest SCC (> 800,000 mL<sup>-1</sup>) in 2010 was almost twofold higher (4.43%) than in 2013 (2.37%). According to these results, the proportion of farms in Bosnia and Herzegovina that produce milk of EU quality significantly increased ( $P < 0.05$ ). The number of farms that produce milk with the SCC < 300,000 mL<sup>-1</sup> increased by 8.5% (Figure 2).

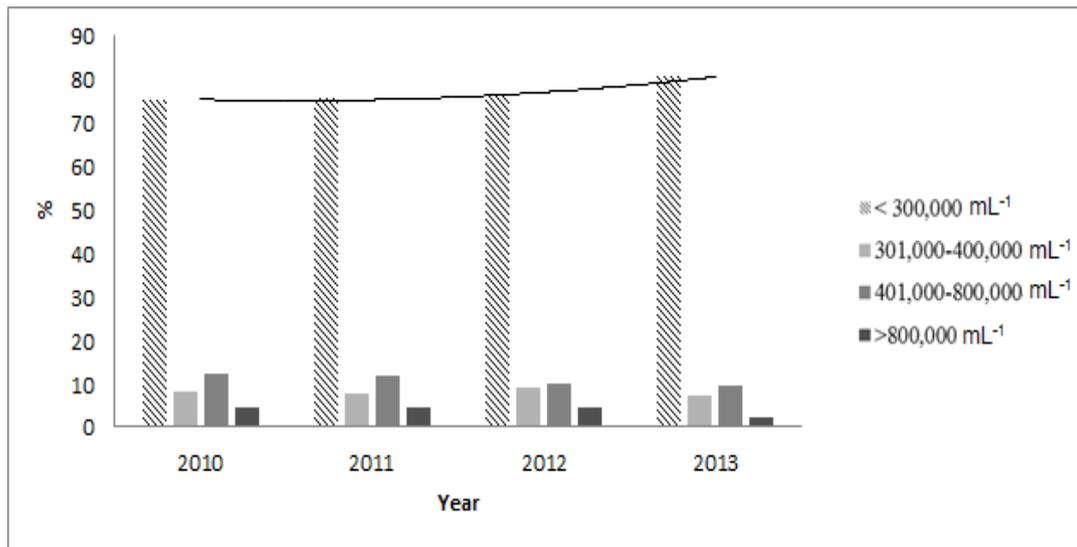


Figure 1. The proportion of farms' bulk milk according to the somatic cell count throughout the period 2010-2013 ( — P < 0.05)

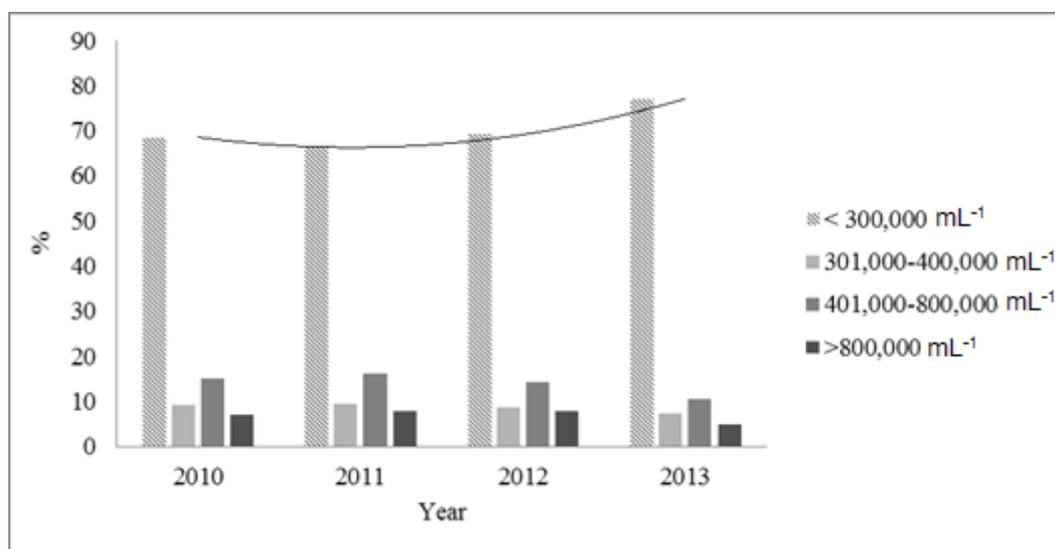


Figure 2. The proportion of the farms, according to the somatic cell count in milk throughout the period 2010-2013 ( — P < 0.05)

The season had a significant effect ( $P < 0.05$ ) on the SCC (Figure 3). Taking into consideration the whole year, in the spring period (April) the proportion of milk with  $\text{SCC} < 300,000 \text{ mL}^{-1}$  was the highest (82.64%), while the proportion of such milk significantly ( $P < 0.05$ ) decreased in September (70.94%). In the autumn the proportion of milk with  $\text{SCC} < 300,000 \text{ mL}^{-1}$  was the lowest (61.93%). The proportion of farms with SCC-high milk ( $\text{SCC} > 400,000 \text{ mL}^{-1}$ ) in autumn was 10.50% higher compared to the spring period (Figure 4).

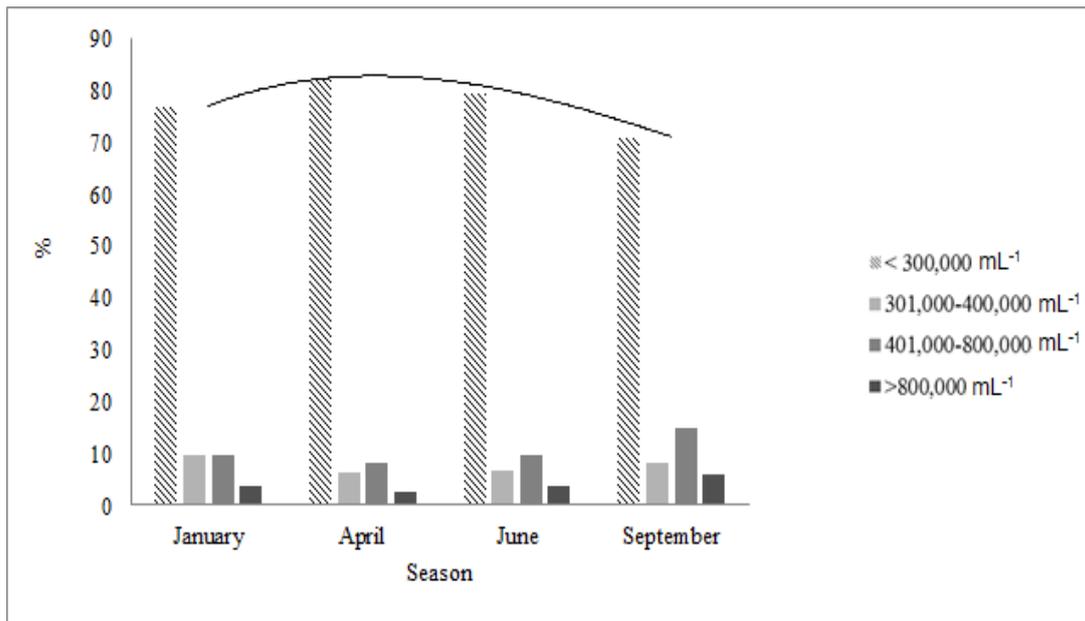


Figure 3. The influence of season on the proportion of farms' bulk milk according to the somatic cell count ( — P < 0.05)

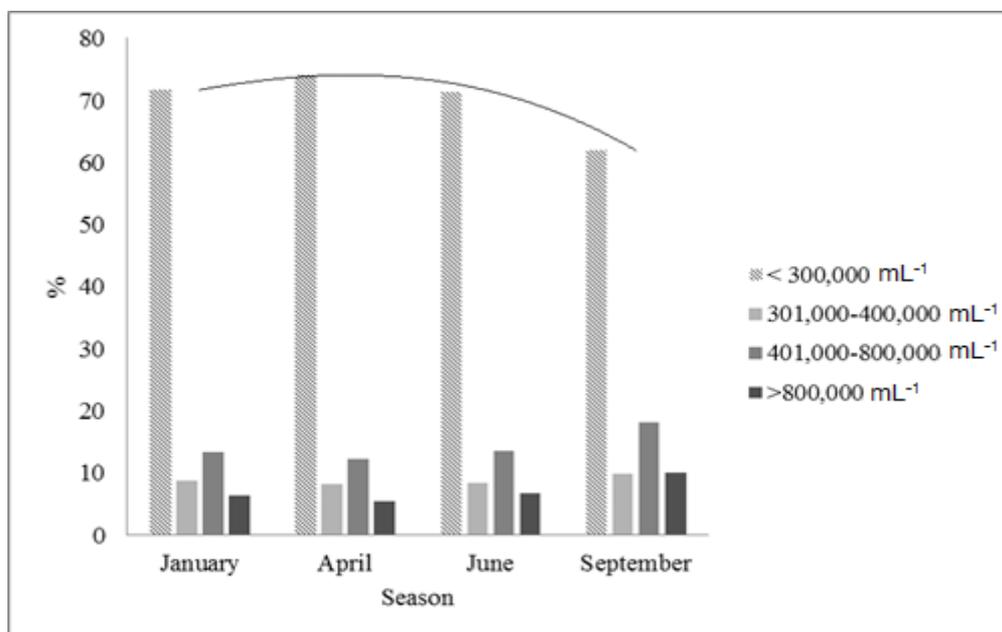


Figure 4. The influence of season on the proportion of the farms, according to the somatic cell count in milk ( — P < 0.05)

Changing the milk payment system in Bosnia and Herzegovina resulted in better hygienic conditions of milking and the regular disinfection of the udder. The implemented hygienic measures in the milking protocol caused a significant ( $P < 0.05$ ) increase of milk with the TBC  $< 200,000 \text{ cfu} \cdot \text{mL}^{-1}$  throughout the 4 year period. The proportion of milk with TBC  $< 200,000 \text{ cfu} \cdot \text{mL}^{-1}$  in 2013 was 10% higher in

comparison to the year 2010 (Figure 5). As well as, the proportion of farms that deliver milk with the TBC < 200,000 cfu·mL<sup>-1</sup> significantly (P < 0.05) increased (Figure 6). A significant decrease (P < 0.05) in the proportion of milk with the TBC < 200,000 mL<sup>-1</sup> during the summer period is presented in Figure 7. The proportion of farms that deliver milk with TBC < 200,000 mL<sup>-1</sup> significantly (P < 0.05) decreased not just in the summer but also in the autumn period (Figure 8).

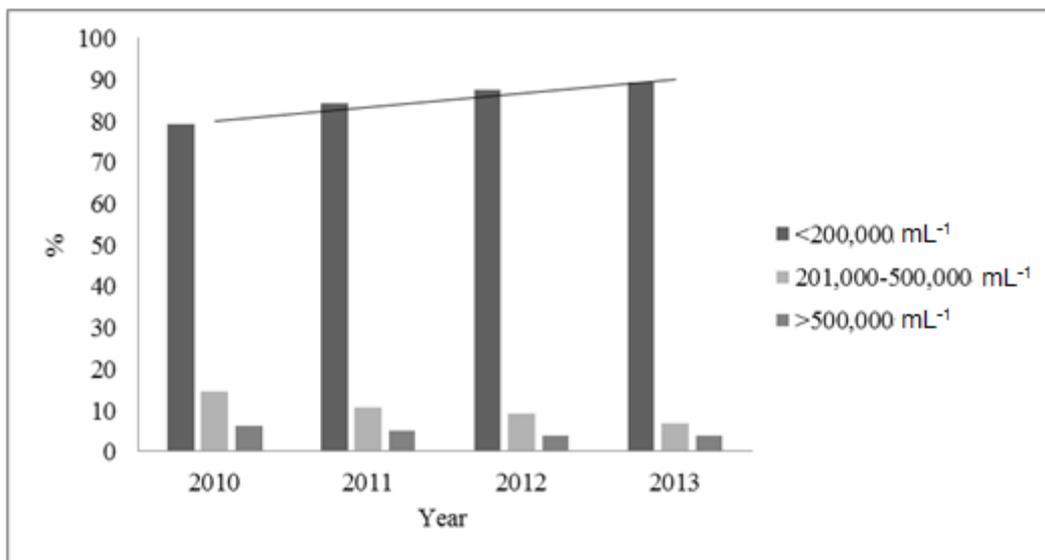


Figure 5. The proportion of farms' bulk milk according to the total bacterial count throughout the period 2010-2013 ( — P < 0.05)

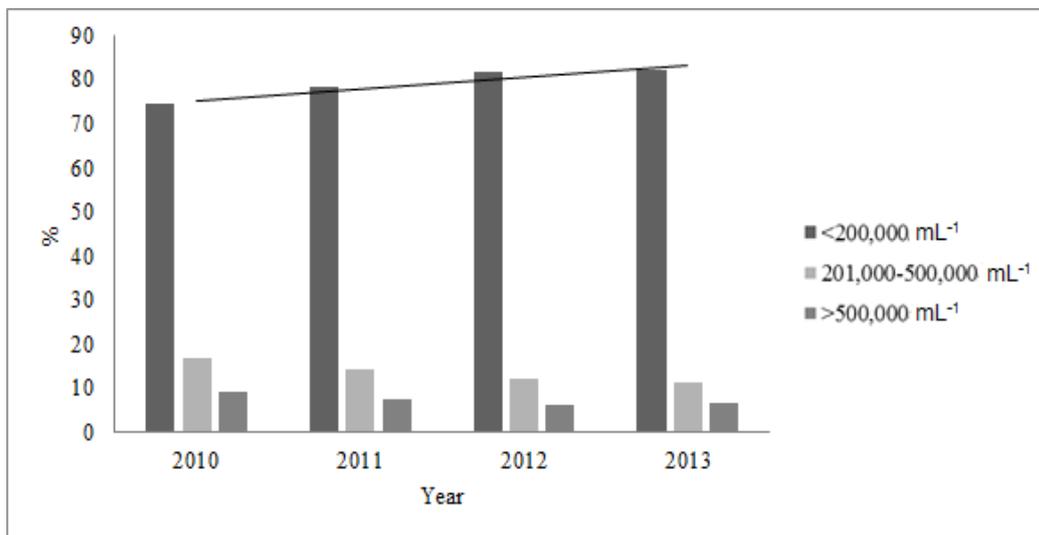


Figure 6. The proportion of the farms, according to the total bacterial count in milk throughout the period 2010-2013 ( — P < 0.05).

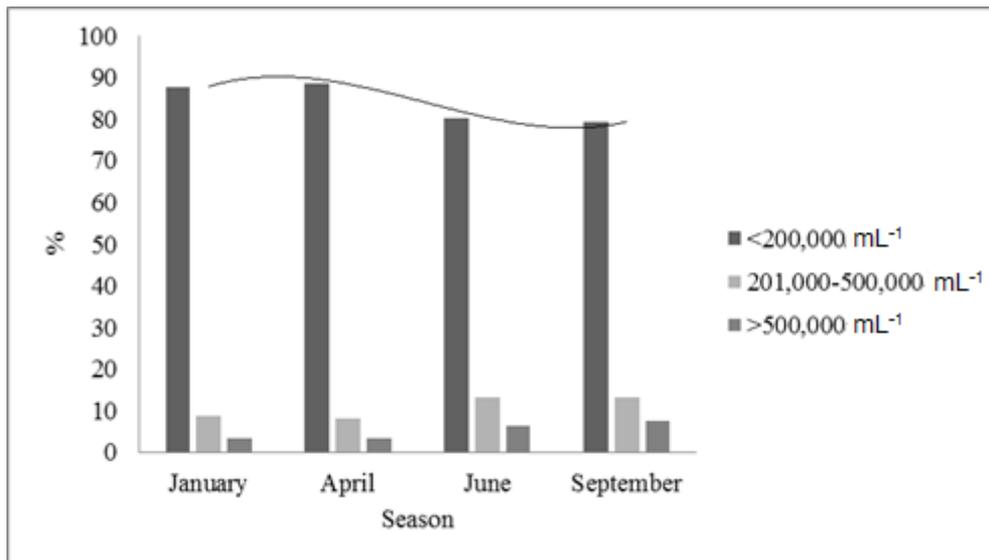


Figure 7. The influence of season on the proportion of farms' bulk milk, according to the total bacterial count ( —  $P < 0.05$ ).

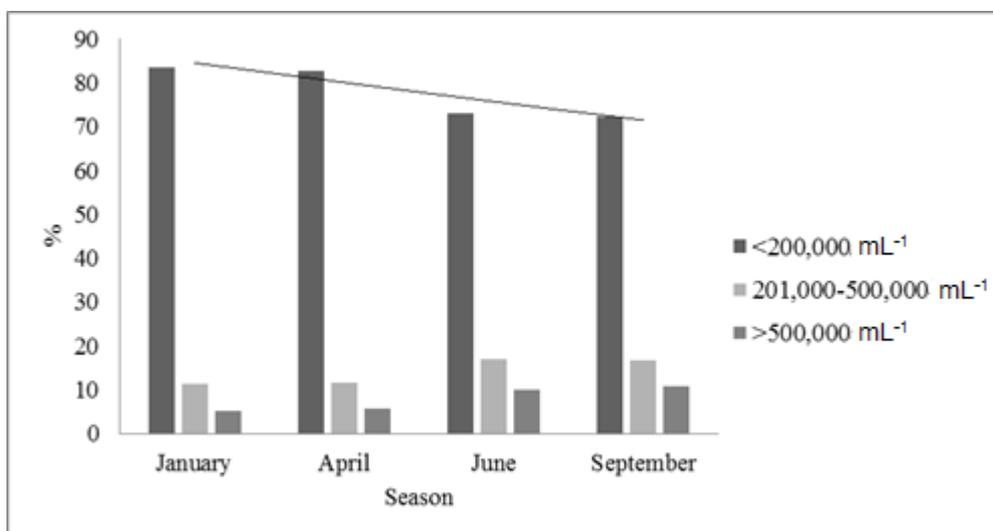


Figure 8. The influence of season on the proportion of the farms, according to the total bacterial count in milk ( —  $P < 0.05$ )

## Discussion

An improvement in the milk quality in Bosnia and Herzegovina due to the changing of the milk payment system, in which the hygienic quality of milk is included, was consistent with some previous research. The changing of the milk payment system in Croatia led to the increase of the proportion of farms' bulk milk with the SCC  $< 400,000 \text{ mL}^{-1}$  (Croatian Agricultural Agency, 2016). In Croatia it is confirmed that before changing the milk payment system, one-third of milk producers delivered hygienically incorrect milk (Kalit and Lukač Havranek, 1998). Nowadays, Croatia delivers approximately 99% of raw milk according to EU standards (Samaržija et al.,

2012). Disinfection before milking has a significant benefit in reducing the number of bacteria which can occur in milk as a consequence of contamination during or after milking (Kalit and Havranek, 2004; Kalit et al., 2015; Pankey et al., 1987).

Besides the reduced sale value of the high-SCC milk for farms, the results of this research could be of an additional importance for Bosnia and Herzegovina. As a country with a long standing tradition of artisanal cheese production, Bosnia and Herzegovina should aim to produce milk with a low number of somatic cells, which will result in the best quality of cheeses. Overall, the cheese made from the high-SCC milk is unacceptable and in direct relationship with the texture and flavour defects due to the poor syneresis, increased moisture content and the higher proteolysis and lipolysis (Chen et al., 2010; Marino et al., 2005; Summer et al., 2015; Vianna et al., 2008;). Moreover, Summer et al. (2015), considering the legal limit of 400,000 SCC mL<sup>-1</sup>, found that the cheese yield is significantly higher for the batches produced from milk with SCC < 300,000 mL<sup>-1</sup> (< 200,000 mL<sup>-1</sup> and 201,000 – 300,000 mL<sup>-1</sup>) in comparison to the batch with SCC 301,000 – 400,000 mL<sup>-1</sup>. This could have a relevant effect on the cheese factory profits, according to the authors' estimation of the decreasing of profits by 46 euro for the cheese batches made from milk with SCC 301,000 - 400,000 mL<sup>-1</sup> compared to batches made from the milk with SCC < 300,000 mL<sup>-1</sup>. Due to this, the aim of the cheese factory should not be to redeem milk just within the legal limit of SCC but milk with the lowest number of somatic cells as possible.

The association between calendar months and SCC was unquestionable while bulk milk SCC was the lowest in the spring period, but the highest in autumn period. These results are in accordance with some previous observations. Ferreira and Vries (2015) found that Florida dairy farms produce milk with a lower SCC during the period from February to April in comparison to the period from August to October, which is specifically for hot, humid weather. Therefore, these conditions should be taken into consideration in the programs for improving the milk quality. O'Connell et al. (2015) observed the lower SCC in bulk milk from February to September, but there were no obvious improvements in the milk quality during the observed period (2007-2011). Archer et al. (2013) stated that in Ireland, bulk milk SCC is the lowest in April and May, and the highest in December and January, because spring-calving predominates in this country. Whereas, in England and Wales, where calving is not connected to the season, bulk milk SCC is the highest in the spring and summer (from April till August). The seasonal increase in bulk milk SCC supplied to dairies can reduce the ability of a country to meet the demand for high quality milk products (Archer et al., 2013).

The environmental temperature affects the number of bacteria in milk due to the faster multiplication of microorganisms in milk at higher temperatures (Albenzio et al., 2002). In Bosnia and Herzegovina, during the observed period, season had a significant effect on the TBC in milk. According to the obtained results the proportion of milk with the TBC < 200,000 cfu·mL<sup>-1</sup> was the lowest during the summer period. Similar findings were made by Matutinović et al. (2011) who researched the influence of season on the microbiological quality of ewe's milk in the sub-Mediterranean part of Croatia. The influence of the season on the sheep milk quality was shown, due to the semi-extensive farming system of the Dalmatian Pramenka, which is strongly affected by climate and environmental conditions.

## Conclusions

The study showed that changing the milk payment system in Bosnia and Herzegovina, whereby in creating the price of milk the somatic cells count and the total bacterial count were included, led to the improvement of the hygienic quality of milk in the observed period (2010-2013). Irrespectively, the season and external factors still affected the hygienic quality of the milk, while in June and September the proportion of milk with a total bacterial count  $< 200,000 \text{ cfu} \cdot \text{mL}^{-1}$  decreased. It can be concluded that consistent appliance of the regulations that determine the quality of milk, leads to the improvement of the hygienic quality of farms' milk, as illustrated in the case of Bosnia and Herzegovina. This kind of milk payment system is important not only for the higher economic benefit of farms, but also for the dairy processing industry profit. This data could also be the basis for estimating the potential advantages/disadvantages of the seasonal processing of raw milk.

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