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Somatic cell counts, chemical composition and coagulation properties of goat and sheep bulk tank milk

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ABSTRACT

This study focused on the need for bulk milk tank somatic cell count (BMTSCC) thresholds and cut-off levels indicating a decrease in milk quality that consequently influences product quantity and quality. First, 226 ewes and 231 goat bulk tank milk samples were collected from different Israeli herds and coagulation properties were determined. Second, soft cheese was produced. No correlation of coagulation properties was found with BMTSCC for sheep milk up to 3264 $\times$ 10^3 and goat milk up to 6452 $\times$ 10^3 cells mL^{-1}. Coagulation properties of goat milk with cell count higher than the latter resulted in a significant decrease in curd firmness. For breeds and management system in Israel, 2500 $\times$ 10^3 cells mL^{-1} is suggested as the cut-off level for sheep and 3500 $\times$ 10^3 cell mL^{-1} for goats. The cell count cut-off level and milk price according to BMTSCC should be tested and then determined for every breed and management and final dairy product.

1. Introduction

Milk quantity and quality from dairy animals are the keys for economic success in dairying. Both are influenced by genetics, environment, husbandry conditions and animal health. The term milk quality refers to the evaluation of the parameters that indicate both the milk's suitability for drinking or for its processing into dairy products and to the health status of the animal or herd that produces this milk (Kelly, Leitner, & Merin, 2011). Milking practices for small ruminants vary from traditional hand milking to most modern computerised milking parlours, with different dairy breeds, herd sizes and milk-yield levels. All sheep milk and most goat milk is used for manufacturing of dairy products. Because of the positive correlation between intramammary infection (IMI) and increase of somatic cell count (SCC) at the gland/animal level, and consequently on the bulk milk tank (BMTSCC) level, the dairy industry for cows' milk introduced a payment scheme based on SCC level and a maximum threshold was set for accepting milk for processing. As a result, the overall milk quality has improved. However, even in cows, the question of how much further should the decrease of BMTSCC be pressed was left open, because there are no clear cut research results on what is the influence of reducing the SCC threshold by 10 $\times$ 10^3 cells mL^{-1} from the current level of ~200 $\times$ 10^3 cells mL^{-1} on the quality of the milk for producing dairy products.

Small ruminant dairying is still more traditional than that for cows' milk, with a high number of farmers who produce a variety of products on the farms. Moreover, in most cases, where the operation is similar to dairy cow farming and the milk is transferred to the dairy, no payment scheme and/or maximum thresholds on milk BMTSCC exist (Pirisi, Lauret, & Dubeuf, 2007).

Studies conducted with goats or sheep that correlate IMI and/or focus only on inflammation (mainly through SCC) with respect to milk and especially products quality are scarce. Most were aimed at the animal level only and were conducted on a large variety of breeds and management systems (Bergonier, de Crémoux, Rupp, Lagriffoul, & Berthelot, 2003; Raynal-Ljutovac, Pirisi, de Crémoux, & Gonzalo, 2007). Among the findings, milk production losses in goats and sheep were mainly blamed on the fact that 10–55% of the animals suffered from IMI in one or two glands (Contreras, Paape, &

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Miller, 1999; Gonzalo, Ariznabarreta, Carriedo, & San Primitivo, 2002; Leitner, Merin, Lavi, Egber, & Silanikove, 2007; Leitner, Silanikove, & Merin, 2008b; Moroni, Pisoni, Ruffo, & Boettcher, 2005). IMI results in an increase in the level of SCC (Bergonier et al., 2003; Contreras et al., 2007; Gonzalo et al., 2002) and in changes in milk composition (Raynal-Ljutovac, Gaborit, & Lauret, 2005; Rovai et al., 2015a; Rovai, Rusek, Caja, Saldo, & Leitner, 2015b), deterioration of milk coagulation properties (Albenzio, Taibi, Muscio, & Sevi, 2002; Leitner, Krifucks, Merin, Lavi, & Silanikove, 2006), and increased enzymatic proteolytic activity that have negative effects on the suitability of milk for cheese making (Giadinis et al., 2012; Gonzalo et al., 2002; Le Maréchal, Thiéry, Vautor, & Le Loir, 2011; Marti-De Olives, Le Roux, Rubert-Aleman, Peris, & Molina, 2011; Rovai et al., 2015a,b). In addition to IMI caused mainly by bacteria, which results in an increase of SCC in cows, an increase in sheep and goats SCC was also recorded that was due to physiological characteristics that occur from mid-lactation (Bianchi et al., 2004; Raynal-Ljutovac et al., 2007). Thus, due to the different dairy breeds and management systems, bacteria species involved, time in lactation and different end products, local calibration standards for BMTSCC determination are required.

Two principles should be considered when decisions are made regarding BTMSCC: (i) safety—all animals that are milked into the bulk milk tank should have no clinical symptoms, with particular emphasis on the absence of potential zoonotic microorganisms and (ii) economics—the quality of milk should be considered regarding its suitability for maximised economic value of the final product.

The objectives of this study were focused on the need for SCC thresholds and a cut-off level for bulk milk tanks under intensive management systems of sheep and goats that: (i) indicate a decrease in milk quality that might influence its economic potential and thus should be considered in a payment scheme and (ii) determine the BMTSCC threshold levels for milk, based on data collected and published (Leitner et al., 2008b), over which it is possible that if clinically infected glands were milked a public safety issue may be posed.

2. Materials and methods

2.1. Milk sampling and analysis

Samples from 226 ewe and 231 goat bulk milk tanks (BMT) were collected from Israeli herds from all over the country during two seasons: October–December 2013 and February–April 2014 (some farms were sampled 1–3 times at different seasons). The samples were collected during loading of the delivering tank from the farm to the dairy. The samples were immediately transferred in an ice box to the Israel Cattle Breeders Association central laboratory (Caesarea, Israel) and were analysed for gross composition: fat, protein, lactose and urea content by the Milkoscan FT+ and SCC by the Fossomatic FC (Foss Electric, Hilleröd, Denmark). Once a week 20–30 samples were collected according to the SCC levels and transferred in an ice box to the Dairy Science Laboratory at the Agricultural Research Organization (A.R.O), the Volcani centre for clotting parameters analyses. Rennet clotting time (RCT) and curd firmness (CF) after 60 min were tested using the Optigraph© (Ysebaert, Frepillon, France) as described earlier (Leitner et al., 2008a).

2.2. Cheese yield

A second experiment was conducted to confirm that the Optigraph results are a reliable measure to evaluate cheese yield. The cheeses were produced from 6 ewe and 8 goat BMT samples, which were collected at 14 farms. The milk was transferred to the laboratory as described above. For cheese manufacturing, six 1 L stainless steel containers were placed in a thermostatically controlled water bath. Milk was preheated in the containers for 25 min at 30 °C. Then Maxiren 600 (DSM Food Specialties BV, Delft, The Netherlands) at 0.089 g L^{-1} was added to each container and was held for 60 min until cutting into 0.8 cm cubes with stainless steel knives. The cut curd was left to stabilise for 10 min and then temperature was raised to 40 °C and cooked for additional 25 min with gentle stirring. The curd was poured into perforated moulds and turned over after 10 min. The cheese was pressed at ~45 g cm^{-2} for 24 h at 4 °C and weighed for yield calculation.

2.3. Statistical analyses

Correlation models of several parameters were performed using SAS Proc Corr (SAS Institute Inc., 2009 Version 9.2, Cary, NC, USA). Data are presented as means and SEM. No significant differences were found between time of sampling in each season and within herds and therefore statistical analyses were done over sampling time.

Because each parameter is not linear, further analyses were conducted on groups (gr) where sheep or goats were arbitrary sorted into 4 groups (~25% each) according to each parameter tested and SAS Proc Univariate procedure was applied. The influence of milk constituents and SCC levels on RCT and CF was analysed using the Proc GLM procedure of SAS Proc Univariate procedure with the general form. In a further iteration the highest SCC group was divided into 2 subgroups and analysed. In the model RCT or CF = gr SCC + gr Fat + gr Protein + gr Lactose + gr Urea + season + gr SCC*season + gr Fat*season + gr Protein*season + gr Lactose*season + gr Urea*season were analysed, where: gr SCC, gr Fat, gr Protein, gr Lactose and gr Urea = parameter level as described in Table 1 (for SCC; for other parameters data not shown), Season = period when milk was taken, October to November or January to April. For goats, the highest SCC group was divided farther into two groups.

3. Results

No significant differences were found between the two collecting seasons for any of the milk constituents and SCC neither for goat or sheep. Therefore results are combined for both seasons (Table 1). Goat milk BMTSCC ranged from 165 × 10^3 to 6452 × 10^3 cells mL^{-1} and sheep milk from 237 × 10^3 to 3264 × 10^3 cells mL^{-1}. Correlations between coagulation properties RCT or CF, milk constituents, urea and SCC of goat milk are presented in Table 2. Significant positive correlations were found for fat and protein with RCT and CF. Positive correlation was found between SCC and RCT, but not with CF. The individual BMTSCC versus CF are presented in Fig. 1, showing a random distribution. Correlations between coagulation properties RCT or CF and sheep milk constituents, urea and SCC, are presented in Table 3. Significant positive correlations were found for fat and protein with RCT and CF, while positive correlation was found between SCC and RCT,

Table 1
Samples of bulk milk tank somatic cell count (BMTSCC) arbitrary sorted to 5 levels for goat milk (n = 231) and sheep milk (n = 226).

Group	Goats		Sheep	
	n	BMT SCC (×10^3)	n	BMT SCC (×10^3)
1	58	165–1576	56	237–827
2	65	1577–2055	55	828–1263
3	51	2056–2473	53	1264–1722
4	39	2474–3000	30	1723–2000
5	17	3001–6452	25	2001–3264