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Effects of milk somatic cell counts on some physicochemical and functional characteristics of skim and whole milk powders

Durmuş Sert,*[1] Emin Mercan,† Serdar Aydemir,‡ and Mustafa Civelek‡
*Faculty of Engineering and Architecture, Department of Food Engineering, Necmettin Erbakan University, Konya 42090, Turkey
†Faculty of Engineering, Department of Food Engineering, Bayburt University, Bayburt 69000, Turkey
‡Enka Dairy and Food Products Industry and Commerce Ltd., Konya 42150, Turkey

ABSTRACT

The aim of this work was to study the influence of milk somatic cell count (SCC) levels on spray-dried milk powders. For this reason, 3 cow milks with different SCC (<300,000, 300,000–700,000, >700,000 SCC/mL) were processed into skim (SMP) and whole milk powder (WMP). The effect of SCC on the physicochemical and functional characteristics of the milk powders and textural properties of set-type yogurts produced from reconstituted milk powders with different SCC was evaluated. A crucial difference was noted between milk powders depending on different SCC. Protein values and ash content of powder samples decreased correlatively with increasing SCC. The hydroxymethylfurfural content of SMP was higher than WMP. We noted an increase in hydroxymethylfurfural content of both SMP and WMP depending on elevated SCC. Solubility index of SMP and WMP was 1.280 to 1.632 and 0.940 to 1.208 mL, respectively; with increasing SCC, solubility index was affected adversely. The highest foam stability was determined in SMP containing >700,000 SCC. Bulk density of SMP and WMP was between 0.682 and 0.708 and 0.660 to 0.685 g/cm^3, respectively. An increase was observed in scorched particle of both SMP and WMP depending on increasing SCC. We found significant differences in particle size distribution of milk powders produced from milk with SCC at different levels. Although WMP had more uniform and big particle structure, SMP had more specific area. A negative correlation was noted between yogurt texture and SCC. Results indicate that milk SCC has negative influences on milk powder quality.
Key words: somatic cell count, milk powder quality, particle size

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[1]Corresponding author: dsert@konya.edu.tr

INTRODUCTION

Mastitis, an inflammation of the mammary gland, is the most prevalent infectious disease of adult dairy cattle (Andrews et al., 2004). Somatic cell count in milk is generally used as an important indicator of mastitis. In the dairy industries of many countries, SCC is widely used for monitoring hygienic milk quality and pricing of raw milk (Suriyasathaporn et al., 2006). The dairy industry has provided a bonus payment program to promote reduced raw milk SCC (Ma et al., 2000).

High SCC causes economic losses in dairy industry. The main reason for economic losses related to elevated SCC is decreased milk yield in cows (Munro et al., 1984; Huijps et al., 2008; Hagnestam-Nielsen et al., 2009). Besides decreasing milk yield, increased SCC in milk adversely affects quality of raw milk and dairy products.

Some studies have shown that an increase in SCC leads to a modification in milk composition. It was reported that elevated SCC results in both decreased protein concentration and casein content (Munro et al., 1984; Lee et al., 1991; Wickström et al., 2009), whereas noncasein nitrogen and whey protein increased (Rogers et al., 1989a; Auldist and Hubble, 1998). Previous studies reported that elevated SCC causes a decrease in the concentration of milk lactose (Miller et al., 1983; Rogers et al., 1989b; Shuster et al., 1991; Auldist et al., 1995) and milk fat (El Deeb and Hassan, 1987; Auldist et al., 1995). Also, SCC changes the mineral balance of milk, and these changes can play significant roles in determining the manufacturing quality of the milk (Auldist and Hubble, 1998). Although high SCC decreases potassium, it increases sodium (Rogers et al., 1989b; Auldist et al., 1995; Chaudhury et al., 1995), and El-Deeb and Hassan (1987) and Lee et al. (1991) showed a decrease in total calcium as SCC increases.

Using high-SCC milk for cheesemaking is associated with decreased curd firmness (Politis and Ng-Kwai-Hang, 1988b) and cheese yield (Politis and Ng-Kwai-Hang, 1988a; Barbano et al., 1991; Auldist et al., 1996b; Klei et al., 1998), increased fat and casein loss in whey (Politis and Ng-Kwai-Hang, 1988a) and clotting times (Lee et al., 1991; Mijacevic et al., 1993), and compromised sensory quality (Munro et al., 1984). Increased SCC in milk caused an increment in fatty acids in the resulting yogurt during storage that may result in a decrease in the shelf life of the product (Fernandes et al., 2007). Oliveira et al. (2002) studied the composition and sensory attributes of yogurt produced with different SCC and reported that sensory quality of yogurt produced from milk with high SCC decreased.

It has been shown that elevated SCC reduced the shelf life and sensory quality of pasteurized milk, mostly by a higher fatty acid rate during storage (Janzen, 1972; Rogers et al., 1989b; Ma et al., 2000). It was also reported that high SCC could lead to poor heat stability of full-cream milk powder and that the sensory properties of such milk powders deteriorated more quickly than those of powder produced from milk with low SCC (Auldist et al., 1996a).

Previous studies have focused on raw milk and other dairy products; very little information exists on the influence of SCC on the quality of milk powders. To the best of our knowledge, no data is available on the possible effects of SCC on particle size distribution in spray-dried skim and whole milk powders. The aim of our study was to investigate the effects of different SCC levels in raw milk on physicochemical and functional properties of skim (**SMP**) and whole milk powder (**WMP**). Moreover, textural properties of yogurts produced from reconstituted SMP and WMP with SCC at different levels was determined.

MATERIALS AND METHODS

Milk Collection

Raw cow milk was supplied from Enka Dairy and Food Products Industry and Commerce Ltd., Konya, Turkey. The Enka Dairy plant is a large-scale company with 5,000 milk producers. Once milk from 50 dairy farms (50–500 cows per farm) is collected in 15 milk collection centers, the milk is cooled to 4°C and transported to processing center with 10-t stainless steel tanks. Each tank contains milk from 150 milk producers (5–20 cows per milk producer). For determination of SCC in milk, 3 samples were taken from each bulk milk tank and analyzed in triplicate for each group. After raw milk analysis, the bulk milk with desired SCC was taken for processing to milk powder. The vast majority of milk was from cross-bred Holstein-Friesian cows. In all farms, milking performed by automatic milking machines in the morning.

Raw Milk Analysis

The physicochemical properties of raw milk (total DM, specific gravity, titratable acidity, fat, ash) were determined according to AOAC method (AOAC International, 2005). The pH was determined by using a 315i/SET pH-meter with a sentix 42 electrode (WTW, Weilheim, Germany). The protein content of milk sample was estimated using a Kjeltech instrument (Kjeltec-8200, Foss Electric, Hillerød, Denmark) by Kjeldahl method (AOAC International, 2005; method 991.20). Fifteen grams of K_2SO_4, 1 g of $CuSO_4 \cdot 5H_2O$, and 5 g of warm milk (38 ± 1°C) were added to digestion tubes and then 25 mL of H_2SO_4 was added slowly. The digestion tubes were placed on the fume ejection system until digest cleared in flask at a temperature of 410°C; it was then cooled to room temperature. Digested samples were distilled with 50% NaOH using Kjeldahl distillation unit where steam was distilled over 4% boric acid (50 mL) containing an indicator for 5 min. The ammonia trapped in boric acid was determined by titrating with 0.1 *N* HCl.

Somatic cell count analyses were carried out with a Fossomatic 90 (Foss Electric) using a previously described method (Gonzalo et al., 1993; IDF, 1995). For the determination of SCC, the milk samples were heated to 40°C in a water bath and held at this temperature for 15 min. Then the samples were processed in the Fossomatic 90. All analyses were carried out in triplicate. Before the experiment the instrument was calibrated by using bovine milk standards of known SCC (between 0 and 2,000 × 10^3 cells/mL) provided by Cecalait (Poligny, France).

Manufacture of Milk Powders

After raw milk analysis, milk was divided into 3 groups based upon SCC status: low (<300,000 SCC/mL), intermediate (300,000–700,000 SCC/mL), and high (>700,000 SCC/mL). First, raw milk groups were preheated (63°C) and standardized (milk fat content: 0.15% for SMP and 3.1% for WMP). Then milk was pasteurized (85°C for 1 min) and concentrated in a falling film evaporator until a concentration of 45% TS was reached. Subsequently, the spray-drying process was conducted in a Spray-Dryer (GEA Niro Atomizer, GEA Process Engineering A/S, Soeborg, Denmark). The inlet and outlet temperatures of the drying air stream were 180 and 70°C, respectively. The drying process, in each condition, was conducted in duplicate. Milk powder analysis were repeated 3 times for each group.