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Improving quality characteristics of reduced and low fat Turkish white cheeses using homogenized cream

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ABSTRACT

The effects of cream homogenization on the biochemical, textural, sensory and microstructural characteristics of reduced and low fat Turkish white cheeses were analyzed over a 90d storage period. The total solids content, milk fat, salt and free fatty acid concentration all increased in the reduced and low fat cheeses made from homogenized cream relative to controls. Additionally, hardness was significantly lower in the cheeses obtained from homogenization, despite gradually decreasing in all the samples during storage. Micrograph analyses revealed a protein matrix in the control cheeses that was compact with a small number of unevenly dispersed fat globules. In contrast, the micrographs of cheeses from the homogenized treatment group revealed a larger number of fat particles dispersed in the casein matrix. Cheeses with homogenized cream had improved flavor, odor, texture and appearance. Generally, the data obtained from this study demonstrate that cream homogenization pre-processing improves the quality characteristics of reduced and low-fat Turkish white cheeses. This finding is important for the cheese industry owing to the great demand for reduced-fat dairy items by the consumer. Our data suggests that employing a process using homogenized cream would eliminate many undesirable textural qualities commonly found in lower-fat cheeses.

1. Introduction

Turkey has a long tradition of producing a great variety of fermented dairy products and cheeses. White cheese is the most popular white-brined traditional Turkish cheese and is a major component of the Turkish diet. White cheese has been manufactured on an industrial scale in Turkey for a long time; 243,000 tons are produced annually in Turkey (Hayaloglu, Guven, Fox, Hannon, & Mcsweeney, 2004; Oner, Karahan, & Aloglu, 2006). In almost all parts of Turkey it is produced from raw and heat-treated, unhomogenized ewes' or cows' milk, or a blend of the two (Akın, Aydemir, Kocak, & Yildiz, 2003). It is a soft cheese with a salty and acidic taste; typically it has 20–25% milk fat and is brine-ripened (4–5 °C) for three months (Akalın & Karaman, 2011). According to Turkish Food Standards (TS, 2006), white cheese is classified based on the lowest fat content in the dry matter, therefore the full-fat cheese is 45% fat, reduced fat or regular fat is 30%, half-fat is 20% and low-fat is less than 20% fat.

In Turkey and elsewhere, there is increasing interest in low-fat dairy products because of the increasing rates of obesity worldwide. However, reduced-fat cheeses continue to be less acceptable to consumers than their full-fat counterparts due to their deficiencies in texture and flavor. Homogenization may help improve low-fat cheeses' appeal because it can be applied to partially replace fat in reduced-fat foods. Milk homogenization increases the fat content in cheese by lowering the amount of fat lost to the whey, and increases the moisture content of the cheese by increasing fat emulsification and lipolysis in certain cheeses (Madadlou, Mousavi, Khosrowshahi Asl, Emam-Djome, & Zargaran, 2007; Poduval & Mistry, 1999; Rudan, Barbano, Guo, & Kindstebt, 1998; Tunick et al., 1993).

Homogenization of milk, however, can adversely alter milk's protein network, modifying the general structure (Nair, Mistry, & Oommen, 2000). This led to the concept of selective homogenization, where only the cream portion of the milk is homogenized. Preliminary studies in cheese production suggest that selective homogenization may improve the textural characteristic qualities of some low-fat cheese varieties. Reduced-fat cheddar cheese texture and body were improved using homogenized cream (Metzger & Mistry, 1994, 1995). Poduval and Mistry (1999) found that selective homogenization resulted in smaller fat globules and less free oil in reduced-fat Mozzarella cheese. Homogenized cream in low-fat Iranian white cheese altered the cheese microstructure,

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yield and functional characteristics, improving texture, flavor and appearance in these cheeses (Madadlou et al., 2007). No studies have analyzed the effect of cream homogenization on reduced and low fat Turkish white cheese. Therefore, the aim of this study was to investigate the effect of cream homogenization on the biochemistry, microstructure, texture and sensory properties of reduced and low-fat Turkish white cheeses during ripening.

2. Materials and methods

2.1. Treatment groups

Our study included two control groups and two treatment groups, with three repetitions for each: control samples of reduced-fat cheese made from unhomogenized cream (CRF); control samples of low-fat cheese (CLF) made from unhomogenized cream; treatment samples made with homogenized cream, reduced-fat cheese (HRF) and low-fat cheese (HLF). Each cheese batch was manufactured using 2000 L of skim milk. Reduced-fat and low-fat cheeses were manufactured using current standards for skim milk fat content, 1.5% and 0.75%, respectively. For the control groups, CRF and CLF, unhomogenized cream was then used and homogenized cream was used for the HRF and HLF treatment groups. All groups were then cooled, brined and aged in an identical manner.

2.2. Materials

Fresh bovine milk containing 3.45% milk fat and cream containing 38% milk fat were obtained from and processed at one of the largest dairy product manufacturers, Pınar Dairy Products Company (Izmir, Turkey). White cheese production was carried out using standard instruments and equipment (homogenizer, pasteurizer, etc.) in the Pınar Dairy Products Company facility. Two cheese cultures were used as starters, a lyophilized direct-to-vat single culture containing *Lactobacillus casei* subsp. *casei* (Danisco Co., France) and a freeze-dried mixed culture containing *Lactobacillus-lactis* subsp. *lactis* and *Lactobacillus lactis* subsp. *cremoris* (Redi-set, Danisco Co., France). A sachet of lyophilized culture was used for each batch. The activated redi-set starter culture was added to cheese milk at a volume of 0.5%; and added liquid calf rennet (Ecoren 200, Maysa, Istanbul, Turkey) was diluted to a strength of 1:16,000. The liquid rennet was diluted at a ratio of 1–40 with cold water before use and then added to the milk.

2.3. Homogenization and cheese making

The cow's milk containing 3.45% milk fat was skimmed and standardized to 1.5% and 0.75% milk fat, with either homogenized or unhomogenized cream. The cream containing 38% milk fat was split into four batches, two of which were homogenized (55 °C, 20 MPa) in a one-stage APL homogenizer (Oakland, California). The third and fourth portions (control cream) were pumped through the homogenizer (55 °C) under no pressure. All milk was pasteurized (74 °C, 15 s) in an HTST system (APV, Germany) and cooled to 33 °C. The milk was inoculated with starter cultures and supplemented with a $CaCl_2$ (Commercially available) solution (0.02% w/v). Milk was then held at 33 °C for 15 min for starter maturation (until pH 6.30), followed by the addition of liquid calf rennet. Curd set for 65–75 min and was, then, cut into approximately 1 cm cubes with vertical and horizontal knives. Curd settled, then, for 30 min, mixed for 15 min to facilitate whey expulsion, and was transferred into the blocking machine. Post-blocking, curds were molded in polyethylene blocks (300 g) and the spontaneously expulsed whey was moved along the conveyor. Cheese blocks were left to cool (+4 °C) until internal pH dropped to 4.75. Cheese blocks were, then, immersed in a brine solution (15% NaCl, w/v, 15 °C) for 5 h and cooled (4 ± 2 °C) for ~8.3 h. Cheese was extracted from the blocks, packaged in vacuum-sealed pouches (BK3550, Cryovac, Sealed Air Corporation) and stored (4 ± 2 °C) for ripening (90 days).

2.4. Analyses

The chemical composition of ingredient milk was characterized from aliquots of the milk used to make the cheeses. All chemical and textural analyses of cheese samples were determined on 1, 15, 30, 45, 60 and 90 days of storage. Cheese microstructure was evaluated on day 30. All analyses were performed in triplicate.

2.4.1. Chemical analyses

Ingredient milk was analyzed for dry matter, fat, lactic acid and protein (TS, 1994) using the standard methods employed in Turkey. Milk pH was measured using a pH meter (combined glass calomel electrode, Bechman Zeromatic). The concentration of dry matter, fat, salt, titratable acidity (lactic acid %), total nitrogen (TN), water-soluble nitrogen (WSN), ash, total free fatty acids (FFA) and the cheese pH were determined according to the methods described by Renner (1993) and TS (2006). Ripening index was calculated as (WSN/TN) × 100.

2.4.2. Microstructure

Cheese microstructures were characterized using electron microscopy (SEM) (JSM 6060 LV, Jeol, France). Samples were prepared for SEM following a modified method from Hayat (1981) and Khosrowshahi, Madadlou, Mousavi, and Emam-Djomeh (2006). Cores taken from the middle of the cheese (~1 cm^3) were placed in glass bottles, fixed overnight at room temperature in 3% (v/v) glutaraldehyde buffered with a 0.1 M sodium phosphate buffer (pH 7.2) and washed four times in the buffer solution. The specimens were post-fixed for an hour in 1% (w/v) osmium tetroxide, washed four times in buffer and dehydrated in a graded alcohol series. Dried specimens were mounted using double-sided carbon tape, coated with thin gold layer (Polaron SC 502 sputter coater, Quo-rum Technologies, New Haven, UK) and examined using SEM. Representative micrographs were selected for visual presentation of each group's matrix (1000x).

2.4.3. Textural analyses

Texture profile analyses (TPA) were conducted using a two-bite test on a Texture Analyzer (TA-XT plus, Stable Micro Systems, Godalming, UK). Characteristics that are consistent with sensory evaluation parameters were determined: hardness, adhesiveness, cohesiveness, gumminess, chewiness and springiness (Al-Otaibi & Wilbey, 2006; Bourne, 1978). Cylindrical samples (23 mm diameter, 20 mm height) from each cheese were cut, covered in airtight plastic wrap to avoid moisture loss and equilibrated to assay temperature (25 °C). Each cut sample was compressed, 80% of original height, and a test speed of 1 mm s^{-1} was used. Texture analysis values are the mean of three replicates.

2.4.4. Sensory analyses

Organoleptic assessment of the cheeses, during the ripening period, was carried out by, an experienced 9-member panel (4 female, 5 male) (Akalın & Karaman, 2010). Sensory analyses were performed according to the Turkish Standard method for white pickled cheese, TS 591 (TS, 2006). 30 g samples at ambient temperature (20 ± 2 °C) were presented unlabeled to panelists along with palate cleansers. Samples were evaluated for flavor (5–35), odor (5–10), texture (5–35), and appearance (5–20).