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Composition, yield, and functionality of reduced-fat Oaxaca cheese: Effects of using skim milk or a dry milk protein concentrate

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ABSTRACT

The effect of adding either skim milk or a commercial dry milk protein concentrate (MPC) to whole milk on the composition, yield, and functional properties of Mexican Oaxaca cheese were investigated. Five batches of Oaxaca cheeses were produced. One batch (the control) was produced from whole milk containing 3.5% fat and 9% nonfat solids (SNF). Two batches were produced from milk standardized with skim milk to 2.7 and 1.8% fat, maintaining the SNF content at 9%. In the other 2 batches, an MPC (40% protein content) was used to standardize the milk to a SNF content of 10 and 11%, maintaining the milk fat content at 3.5%. The use of either skim milk or MPC caused a significant decrease in the fat percentage in cheese. The use of skim milk or MPC showed a nonsignificant tendency to lower total solids and fat recoveries in cheese. Actual, dry matter, and moisture-adjusted cheese yields significantly decreased with skim milk addition, but increased with MPC addition. However, normalized yields adjusted to milk fat and protein reference levels did not show significant differences between treatments. Considering skim milk-added and control cheeses, actual yield increased with cheese milk fat content at a rate of 1.34 kg/kg of fat (R = 0.88). In addition, cheese milk fat and SNF:fat ratio proved to be strong individual predictors of cheese moisture-adjusted yield ($r^2 \approx 0.90$). Taking into account the results obtained from control and MPC-added cheeses, a 2.0-kg cheese yield increase rate per kg of milk MPC protein was observed (R = 0.89), with TS and SNF being the strongest predictors for moisture adjusted yield ($r^2 \approx 0.77$). Reduced-fat Oaxaca cheese functionality differed from that of controls. In unmelted reduced-fat cheeses, hardness and springiness increased. In melted reduced-fat cheeses, meltability and free oil increased, but stretchability decreased. These changes were related to differences in cheese composition, mainly fat in dry matter and calcium in SNF.

Key words: cheese yield, functional property, pasta filata, reduced-fat cheese

INTRODUCTION

Oaxaca cheese is one of the most popular Mexican cheeses; it is widely used in Mexican dishes, usually melted. It is a pasta filata cheese normally produced from raw milk when manufactured at small dairy plants. The Oaxaca cheese-making process involves curd acidification (until a pH of approximately 5.3 is reached), kneading (in hot water), and stretching. Long, thin strips of curd are formed, which are cooled in chilled water, salted, and cut into segments. The segments are then wound into balls. Only one study has been found in the literature on the chemical composition of Oaxaca cheese, and it is related to the use of fermented cheese whey for its manufacture (Aguilar-Uscanga et al., 2006).

Over the last few decades, because of dietary guidelines and the growing desire for reduced-fat products, the market for reduced-fat cheeses has increased (Childs and Drake, 2009). However, cheeses with reduced fat levels have been found to be associated with deleterious effects on cheese functionality (i.e., resulting in excessively firm and elastic, harder, less meltable cheeses; Rodríguez, 1998; Mistry, 2001).

Reduced-fat cheeses can be produced with part-skim milk, although skimming usually results in a lower cheese yield (Van Vliet, 1991; Shakeel-Ur-Rehman et al., 2003). Furthermore, the addition of casein in the form of milk protein concentrate (**MPC**) is another modern day technology used for the manufacture of these cheeses. The use of MPC results in a higher cheese yield, thus, improving the competitiveness of commodity-type cheese production (Shakeel-Ur-Rehman et al., 2003; Guinee et al., 2006). Milk protein concentrate is spray-dried ultrafiltration retentate obtained from skim milk, with protein contents between 40 and 85%. In MPC, whey proteins and caseins are present in the

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same proportion as in milk (Kameswaran and Smith, 1999). According to these authors, MPC has rennet coagulation properties similar to those of milk.

The aim of the present study is to investigate the effects of lowering the cheese milk fat content by adding skim milk or MPC to whole milk on composition, yield, and functional properties of Oaxaca cheese.

MATERIALS AND METHODS

Cheese Manufacture and Sampling Procedures

Five Oaxaca cheese batches were produced in triplicate (a 5 × 3 randomized complete block design) on 15 consecutive working days, using milk (50 kg) that was obtained the previous day at the Rancho Universitario, Universidad Autónoma del Estado de Hidalgo (Mexico), with mean fat and SNF contents of 3.5 and 9.0%, respectively. One batch was produced with whole milk without any modifications (control batch). For 2 batches, milk was previously standardized to fat percentages of 2.7 ($\mathbf{SM_{3/4\text{-}fat}}$) and 1.8 ($\mathbf{SM_{Half\text{-}fat}}$) by adding skim milk. When needed, the SNF content of the skim milk was adjusted to 9.0% by adding water. For the other 2 batches, 1.5 and 3.0 kg of MPC/100 kg of milk ($\mathbf{MPC_{1.5}}$ and $\mathbf{MPC_{3.0}}$ batches, respectively) were added to achieve cheese milk with approximately 10.0 and 11.0% SNF, respectively (fat content was 3.5% for both batches). The MPC was obtained from NZMP S.A of C.V (Mexico City, Mexico), and contained (per 100 g of MPC) 40 g of protein, 4 g of moisture, 45 g of lactose, 1.2 g of fat, and 9 g of ash. The calculated amount of MPC powder was dispersed in 2 L of milk previously heated to 50°C with an automatic blender at high speed and was manually agitated for 30 min just before adding to milk.

The cheese-making process started with cheese milk pasteurization (63°C for 30 min). After cooling to 35°C, cheese milk was placed in an open vat, and $CaCl_2$ (20 g/100 kg of milk) and a mixture (weight ratio 7:3) of mesophilic and thermophilic commercial lyophilized starter cultures (Lyofast CMS and Lyofast Y, respectively; Sacco, Cadorago, Italy; 1 g of starter mixture/100 kg of cheese milk), previously dispersed in a small amount of pasteurized cheese milk, was added. Then, the cultured milk was incubated in the vat (35°C), with gentle agitation (2 min every 20 min), for the time necessary for the acidity to increase from 0.015 to 0.020% lactic acid. Afterward, microbial liquid rennet (*Mucor miehei*, 1:20,000 strength; Chemostar double-strength chymosin; Rhodia Inc., Madison, WI) was added (15 mL/100 kg), the milk was allowed to set at 35°C for 30 to 45 min, and then the curd was cut for 3 min into 1-cm^3 cubes, which were gently stirred in the whey for 15 min. Afterward, the curd–whey mixture was gradually heated to 38°C (over a 10-min period) while continually stirred, and then was maintained at this temperature for 30 min, with stirring for 5 min every 8 min. The whey was then partially drained (approximately 75% of total volume), and the curd grains were racked to a side of the vat and allowed to set for 15 min. The curd was then cut into 5 rectangular blocks (each weighting approximately 1 kg), which were left in the vat at 38°C (turning every 20 min) until the curd pH reached a value of between 5.2 and 5.4. The remaining whey was then drained and the blocks of curd were transferred to another open vat, hand broken into small pieces, and kneaded in 15 L of hot water at 75°C, for 10 to 15 min, until an elastic and smooth curd was obtained. The curd was then manually stretched and 2 strips were obtained: a short strip (approximately 20 cm long and 5 cm in diameter), which was used for texture measurement, and a long strip (a few meters long and approximately 2 cm in diameter), which was used for the rest of the analysis. Both strips were cooled in chilled water for 10 min, and then removed from the water. Cheese strips were laid out as a single layer on a stainless-steel surface. The strips were left to drain for 10 min and then sprinkled with NaCl (2.0 g/100 g) and covered with a plastic film to prevent excessive drying, at which point, they were left for 16 h at 10°C. The longer strip was then immediately cut into segments of approximately 0.5 kg each, which were wound into a ball shape. All of the balls and the wider strap were weighed, and the values obtained were further used for yield calculations.

All cheeses were stored under vacuum packaging for 3 d at 5°C to simulate the conditions at the retail market stores. Then, pH and functional analysis were performed, and a sample of 250 g of cheese from each manufacturing day was taken for analysis. Samples were blended with a food processor and kept frozen at −18°C until further physicochemical and sensory analysis.

Physicochemical Analysis of Cheese Milk and Cheeses

Infrared spectroscopy with a MilkoScan 5000 (Foss Electric A/S, Hillerød, Denmark) was used for milk fat, protein, lactose, and TS analyses. Milk pH was measured using a pH meter after the sample was homogenized with distilled water (1:5, wt/vol); milk acidity was titrated with 0.10 *M* NaOH using phenolphthalein as the indicator; and specific gravity was determined at 20°C using a manual hydrometer. Furthermore, cheeses were analyzed for moisture, fat, protein, and ash contents following AOAC methods 926.08, 933.05, 920.123, and 935.42, respectively (AOAC, 1999). Water activity