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Physical properties of pizza Mozzarella cheese manufactured under different cheese-making conditions

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ABSTRACT

The effect of manufacturing factors on the shreddability and meltability of pizza Mozzarella cheese was studied. Four experimental cheeses were produced with 2 concentrations of denatured whey protein added to milk (0 or 0.25%) and 2 renneting pH values (6.4 or 6.5). The cheeses were aged 8, 22, or 36 d before testing. Shreddability was assessed by the presence of fines, size of the shreds, and adhesion to the blade after shredding at 4, 13, or 22°C. A semi-empirical method was developed to measure the matting behavior of shreds by simulating industrial bulk packaging. Rheological measurements were performed on cheeses with and without a premelting treatment to assess melt and postmelt cheese physical properties. Lowering the pH of milk at renneting and aging the cheeses generally decreased the fines production during shredding. Adding whey protein to the cheeses also altered the fines production, but the effect varied depending on the renneting and aging conditions. The shred size distribution, adhesion to the blade, and matting behavior of the cheeses were adversely affected by increased temperature at shredding. The melting profiles obtained by rheological measurements showed that better meltability can be achieved by lowering the pH of milk at renneting or aging the cheese. The premelted cheeses were found to be softer at low temperatures (<40°C) and harder at high temperatures (>50°C) compared with the cheeses that had not undergone the premelting treatment. Understanding and controlling milk standardization, curd acidification, and cheese aging are essential for the production of Mozzarella cheese with desirable shreddability and meltability.
Key words: Mozzarella cheese, physical property, colloidal calcium, whey protein

INTRODUCTION

Low-moisture part-skim pizza Mozzarella is a variety of pasta filata cheese used extensively as a topping on baked dishes in North America. Ingredient cheeses such as Mozzarella must exhibit key physical attributes in both the unmelted and melted states (Lucey, 2008).

Pizza Mozzarella cheese is almost systematically shredded, cut or diced to improve its handling and enhance its meltability (Gunasekaran and Ak, 2002). Shreddability is a broad term that includes physical attributes such as the ease of machinability, the shape and integrity of shreds, the propensity of shreds to mat, and the excessive production of fines during shredding (Childs et al., 2007). Good shredding behavior is observed in a relatively narrow range of textural properties and is not fully understood, or controlled, by cheese manufacturers. Soft cheese usually shows poor shredding characteristics because it sticks to the blade, forms gummy balls of cheese, and produces shreds that tend to mat together. On the other end of the spectrum, firm and dry Mozzarella cheese easily shatters into fines (Kindstedt, 1995). Unfortunately, few methods are available to assess the shredding behavior of cheese. The quality grading of shreds based on visual evaluation has been used by some researchers (Apostolopoulos and Marshall, 1994; Chen, 2003; Ni and Guansekaran, 2004). In an effort to assess the defects observed during the shredding process, Childs et al. (2007) empirically measured the fines production and the adhesion to the blade of cheeses during shredding. These attributes, along with the matting of shreds, are still considered the most common problems, and little is known about the factors that cause them.

Unlike shredding behavior, the physical properties of cheese in its melted state have been studied extensively. When Mozzarella cheese is baked, its quality is associated with extent of flow, stretchability, free-oil formation, blistering, and browning (Gunasekaran and Ak, 2002). Metzger and Barbano (1999) also pointed out the importance of the postmelt texture of Mozzarella cheese in regard to its quality and acceptability. How-

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ever, the postmelt texture of cheese has received little attention from researchers.

More than ever, the growing demand for tailored cheese ingredients requires a better understanding of the effect of cheese-making processing variables on the physical properties and microstructure of cheese. Freshly manufactured Mozzarella cheese exhibits the typical protein fiber orientation and melts poorly. The hydration of the protein matrix and the proteolysis that occur conjointly during the short aging of Mozzarella cheese dramatically change the microstructure and texture of the cheese (McMahon et al., 1999). For control of the baking characteristics, many studies also demonstrated the primary importance of the calcium content in Mozzarella cheese, but most important is the partitioning of the calcium between insoluble and soluble states (Joshi et al., 2003; Johnson and Lucey, 2006; Choi et al., 2008). The effect of the addition of milk ingredients on cheese physical properties has been studied to some degree in full-fat cheeses (Punidadas et al., 1999; Mead and Roupas, 2001) but most interest has focused on low-fat cheeses (Zisu and Shah, 2005; Ismail et al., 2011; Schenkel et al., 2011). Milk ingredients, particularly denatured whey protein (**WP**) concentrate, are widely used in the industrial production of Canadian pizza Mozzarella cheese to increase yield and nutrient value at low cost (Hinrichs, 2001). The aim of the present study was, therefore, to evaluate the effect of adding denatured WP and controlling cheese mineralization through the renneting pH on the shreddability and rheological properties of pizza Mozzarella cheese.

MATERIALS AND METHODS

Milk Standardization

Cheese milk was formulated from (1) raw skim milk (2.5% wt/wt casein), (2) milk protein concentrate (~77% wt/wt casein on a dry basis; 872B, lots L610009 and L610009; Ingrédia SA, Arras, France) rehydrated at 10.1% (wt/wt) casein in water, (3) fresh cream (1.5% wt/wt casein; ~40% vol/vol milk fat), and (4) denatured WP concentrate (~55% wt/wt protein on a dry basis; Agropur, Granby, QC, Canada) rehydrated at 10.5% (wt/wt) protein in water. Casein concentration and fat-to-protein ratio in standardized milk were respectively 3.0% (wt/wt) and 0.85 and the concentration of protein from denatured WP concentrate was fixed to 0 or 0.25% (wt/wt). Total protein concentration in cheese milk with and without added denatured WP were respectively 3.95 and 3.70% (wt/wt). The standardized milk was pasteurized at 74°C for 16 s before cheese making.

Manufacture of Pizza Mozzarella Cheese

Cheese milk (350 kg) was supplemented with calcium chloride (0.0063% wt/wt) and ripened with a direct-in-vat thermophile starter culture (0.104% wt/wt, Easy-Set i420; Chr. Hansen, Milwaukee, WI) until the appropriate renneting pH was reached. Coagulant (Fromase XLG; DSM Food Specialties Inc., Eagleville, PA) was added to the milk (0.0075% vol/wt) at a renneting pH of 6.4 or 6.5. The setting period varied from 8 to 20 min, depending on the gelling behavior. The coagulum was cut and healed for 5 min. Then, the curd-whey temperature was raised (0.2°C/min) to 40°C under low agitation. The whey was drained when the pH decreased 0.5 units below the renneting pH. The drained curd was cheddarized (30 to 60 min) to a fixed pH value of 5.2. The acidified curd was milled and then knitted in hot water (65°C) with a pilot-scale cooker/stretcher (JN-500 CS; Johnson/Nelles Corp., Windsor, WI). The rotational speed of horizontal and vertical screws was respectively 6 and 8 rpm and residence time was approximately 5 min. The cheese reached approximately 55°C at molding. Cheese obtained from the beginning and the end of the cooking/stretching process was discarded. Twelve cheese blocks (26.5 × 9.5 × 9.5 cm) of approximately 2.3 kg each were molded and brined in saturated sodium chloride solution (~24% wt/wt, 4°C) for 4 h. The cheese blocks were vacuum sealed and stored at 4°C. Two vats were available for cheese production and the 4 treatments (2 WP concentrations × 2 renneting pH) were performed from the same batch of milk within 72 h. Cheese productions were repeated 3 times within a month.

Chemical Analysis of Cheese

For compositional analyses, one cheese block was cut in 4 symmetrical parts and one part was finely grated using a food processor. The moisture content was determined by the oven-drying method (Marshall, 1992). Ash was measured by incineration in a muffle furnace at 550°C for 12 h. Water-soluble nitrogen was reported as a percentage of total nitrogen (**WSN/TN%**) to monitor proteolysis of the cheese during aging (Watkinson et al., 2001). The nitrogen content was determined using the macro-Kjeldahl method, and total protein was calculated using a protein conversion factor of 6.38 (Marshall, 1992). The lipid content was obtained by the Mojonnier method (Marshall, 1992). The sodium chloride content was determined using a Chloride Analyzer 926 (Sherwood Scientific Ltd., Cambridge, UK) and the pH of the cheese was measured with an AR15 Accumet pH meter (Fisher Scientific, Ottawa, ON, Canada).