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Chemical changes that predispose smoked Cheddar cheese to calcium lactate crystallization

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ABSTRACT

We have observed a high incidence of calcium lactate surface crystals on naturally smoked Cheddar cheese in the retail marketplace. The objective of this study was to identify chemical changes that may occur during natural smoking that render Cheddar cheese more susceptible to calcium lactate crystal formation. Nine random-weight (approximately 300 g) retail-packaged samples of smoked Cheddar cheese were obtained from a commercial manufacturer immediately after the samples were smoked for about 6 h at 20°C in a commercial smokehouse. Three similarly sized samples that originated from the same 19.1-kg block of cheese and that were not smoked were also obtained. Within 2 d after smoking, 3 smoked and 3 control (not smoked) samples were sectioned into 5 subsamples at different depths representing 0 to 2, 2 to 4, 4 to 6, 6 to 8, and 8 to 10 mm from the cheese surface. Six additional smoked cheese samples were similarly sectioned at 4 wk and again at 10 wk of storage at 5°C. Sample sections were analyzed for moisture, L(+) and D(−) lactate, pH, and water-soluble calcium. The effects of treatment (smoked, control), depth from cheese surface, and their interactions were analyzed by ANOVA according to a repeated measures design with 2 within-subject variables. Smoked samples contained signficantly lower moisture and lower pH, and higher total lactate-in-moisture (TLIM) and water-soluble calcium-in-moisture (WSCIM) than control cheeses. Smoked samples also contained significant gradients of moisture, pH, TLIM, and WSCIM, with lower moisture and pH, and higher TLIM and WSCIM, occurring at the cheese surface. Gradients of moisture were still present in smoked samples at 4 and 10 wk of storage. In contrast, the pH, TLIM, and WSCIM equilibrated and showed no gradients at 4 and 10 wk. The results indicate that calcium and lactate in the serum phase of the cheese were elevated because of smoking, especially at the cheese surface immediately after smoking treatment, which presumably predisposes the smoked cheeses to increased susceptibility to calcium lactate surface crystallization.

Key words: Cheddar cheese, calcium lactate, crystal

INTRODUCTION

Naturally smoked cheeses are considered specialty cheeses in the United States and represent an important value-added niche category (US Dairy Export Council, 2007). Smoking is employed for some artisanal cheeses to mimic the smoky character of traditional cheeses that were produced with open wood fires in cheesemaking huts in former times (Bosset et al., 1999). Smoking is also one of the oldest forms of food preservation and was used for this purpose in the making of some traditional cheeses. In the United States today, natural vaporous smoking is used primarily to enhance the flavor, color, and marketing image of cheese, and the practice appears to be growing in popularity, despite concerns that have been raised about the absorption of potential carcinogens by the cheese during exposure to vaporous smoke (Riha et al., 1992; Anastasio et al., 2004; Guillén and Sopelana, 2004; Guillén et al., 2007; Suchanová et al., 2008). Cheddar cheese is among the most popular of the smoked cheese varieties in the United States, and the effects of smoking on the color, flavor, and aging characteristics of Cheddar cheese have been investigated (Riha and Wendorff, 1993; Shakeel-Ur-Rehman et al., 2003).

The composition of woodsmoke is very complex and is known to contain acids, carbonyls, alcohols, phenolics, and other neutral compounds (Lustre and Issenberg, 1969). Many of the fat-soluble compounds present in wood smoke are absorbed into the cheese surface during natural smoking (Guillén and Sopelana, 2004), and presumably the same is true for water-soluble components such as acids, although this has not been investigated in cheese. The brown color that develops at the surface of protein-based foods during smoking is primarily caused by nonenzymatic browning reactions involving amino groups on food proteins and carbonyl compounds in the smoke (Gilbert and Knowles, 1975; Ruiter, 1979). The darkened surface of smoked Cheddar cheese contrasts

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sharply with white crystals of Ca lactate that sometimes form on the surface of Cheddar during ripening, rendering the crystals remarkably bright and easy to distinguish (Rajbhandari and Kindstedt, 2005b). Thus, Ca lactate crystallization has a much greater visual impact when it occurs at the surface of smoked Cheddar cheese than on unsmoked or uncolored cheese. For some artisanal cheeses, Ca lactate crystals may be considered desirable, but most often they are considered a defect that Cheddar cheesemakers seek to avoid (Swearingen et al., 2004).

We have reported previously (Rajbhandari and Kindstedt, 2005a) that some commercially produced smoked Cheddar cheeses in local retail markets appear to experience a high incidence of Ca lactate crystallization. We have also observed a high incidence of Ca lactate crystallization in smoked Gouda cheeses (unpublished data). In an earlier study, we reported that retail samples of smoked Cheddar cheese contained significant gradients of moisture, which were presumed to be the consequence of surface dehydration during smoking (Rajbhandari and Kindstedt, 2005a). Surface dehydration of cheese may occur during natural smoking (Washam et al., 1985), although this is not always the case depending on the method of smoke exposure (Shakeel-Ur-Rehman et al., 2003). It seems possible that dehydration coupled with other possible chemical changes caused by absorption of smoke components may predispose smoked Cheddar cheeses to enhanced Ca lactate crystallization. The objective of the present study was to investigate chemical changes that occur in Cheddar cheese as a result of natural smoking under commercial conditions that may elevate the potential for Ca lactate crystallization.

MATERIALS AND METHODS

Cheese samples for this study were provided by a commercial manufacturer. Cheeses were produced by a milled curd procedure using an automated production line that included enclosed vats (22,727-kg capacity) for coagulating the milk and cooking the curd; an enclosed conveyor series for continuous dewheying, cheddaring, and milling; enclosed mechanical metering of dry salt and automated stirring of salted curd; and block-forming towers that produced 19.1-kg blocks. The blocks were vacuum-packaged and aged for 3 mo before being cut into retail-sized chunks for smoking. One 19.1-kg block was segregated for this study and cut into retail-sized samples (approximately 47 × 60 × 100 mm) weighing about 300 g each. Twelve samples were randomly chosen from this block, 9 of which were assigned to smoking treatment and 3 of which served as a control (not smoked). The 3 control samples were vacuum-packaged and stored at 4°C. The 9 samples that were assigned to smoking treatment were wrapped in an airtight plastic tote bag and transported to a commercial smokehouse. Upon arrival, the samples were removed from the tote bag and placed inside the smokehouse chamber, where they were exposed to natural vaporous smoke at 20°C for approximately 6 h. After smoking, the samples were vacuum packaged and transported with the control samples to the University of Vermont by overnight express mail in an insulated shipping container containing ice packs.

Upon receipt (2 d after smoking), 3 smoked and 3 control samples were analyzed for chemical composition. The remaining samples were stored at 5°C until analysis at 4 wk and 10 wk after smoking. In preparation for the analyses, each cheese sample was sliced into 5 sections that represented 5 different depths (0–2, 2–4, 4–6, 6–8, and 8–10 mm) from the 2 largest (~60 × 100 mm) opposite surfaces, as illustrated in Figure 1. Sections were cut using a wire cutting device, and each pair of sections with comparable depth from the 2 opposite surfaces was combined and grated in a blender to give a composite sample for that depth. Thus, 5 composite samples were prepared that represented 5 different depths from the 2 largest cheese surfaces: 0 to 2, 2 to 4, 4 to 6, 6 to 8, and 8 to 10 mm. The composite samples from the 3 smoked and 3 control cheese samples were analyzed immediately (i.e., d 2 after smoking) in duplicate for moisture, pH, L(+) and D(−) lactate, total Ca, and water-soluble Ca (**WSC**). A second and third set of 3 smoked cheese samples were sectioned and analyzed similarly at 4 wk and 10 wk after smoking, respectively. Moisture content was determined by drying in a forced-draft oven (Thermo Electron, Model 130DM, Winchester, VA) at 100°C for 24 h. Water-soluble Ca was determined using the extraction method described by Metzger et al. (2001). Total Ca and Na in cheese samples and Ca in water-soluble extracts were determined by inductively coupled plasma atomic emission spectrometry. Salt (NaCl) was calculated by multiplying Na content by a factor of 2.54. Cheese pH was measured using a Beckman 50 pH/ISE Meter (Beckman Instruments Inc., Fullerton, CA) by direct immersion of a ROSS combination spear-tip pH electrode (Orion Research Inc., Beverly, MA) into a finely ground sample at ambient temperature. Determination of L(+), D(−), and total lactate was by a colorimetric method (test kit no. 11112821035; Boehringer Mannheim/R-Biopharm AG, Darmstadt, Germany). Lactose in control cheese samples was determined by a colorimetric method (test kit no. 10176 303035). Salt, L(+) and total lactate, and WSC contents were expressed as concentrations