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A new method for the production of low-fat Cheddar cheese[1]

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ABSTRACT

Our objective was to develop an alternative process to produce low-fat Cheddar cheese (LFCC) by combining reduced-fat Cheddar cheese (RFCC) made by a fat-removal process with micellar casein concentrate (MCC) to try to achieve the texture and flavor characteristics of full-fat Cheddar cheese (FFCC). The production of LFCC was replicated 3 times. The MCC was produced by ultrafiltration of skim milk, followed by 3 stages of microfiltration, and the final MCC was spray dried. The LFCC was formulated to achieve 6% fat, 28% protein, and 1.2% salt by a combination of RFCC, MCC powder, salt, and water. The 6% fat target was selected to comply with the FDA standard for a low-fat label claim. The pH of the LFCC mixture was adjusted to 5.3 by lactic acid. Rennet was added to the LFCC mixture, followed by pressing and packaging. Chemical and sensory data were analyzed by ANOVA using the Proc GLM of SAS to determine if any differences in chemical composition and sensory properties were present among different cheeses. Descriptive sensory scores were used to construct a principal component analysis biplot to visualize flavor profile differences among cheeses. The LFCC had 83% less fat, 32% less sodium, and higher protein and moisture content than FFCC. When the cheese texture was evaluated in the context of a filled-gel model consisting of matrix and filler (100% minus percentage of matrix) the LFCC had lower filler volume than FFCC, yet the LFCC had a softer texture than FFCC. The LFCC contained some of the original FFCC cheese matrix that had been disrupted by the fat-removal process, and this original FFCC matrix was embedded in the new LFCC matrix formed by the action of rennet on casein from the continuous phase of hydrated MCC. Thus, the texture of the LFCC was desirable and was softer than the FFCC it was made from, whereas commercial RFCC (50 and 75% fat reduction) were firmer than the FFCC. The sulfur flavor in LFCC was closer to FFCC than commercial RFCC. The LFCC had bitter and grape-tortilla off-flavors that came from the dried MCC ingredient. The commercial RFCC and LFCC made in this study were missing the typical aged Cheddar character (catty, nutty, fruity, brothy, milk fat flavors) found in aged FFCC. Future work to improve the flavor of LFCC made by the process described in this study should include the addition of a flavoring ingredient (e.g., enzyme-modified cheese) to enhance the aged Cheddar flavors and mask undesirable flavors.

Key words: cheese, low fat, micellar casein concentrate

INTRODUCTION

With a rising prevalence of obesity in the United States, individuals are advised to make significant changes in their lifestyle, which includes healthier eating habits. In the Dietary Guidelines for Americans (USDA CNPP, 2010), the recommended fat intake for adults should be less than 35% of total caloric intake. This translates to a maximum of 78 g of fat per day in a 2,000 calorie diet. Although Cheddar cheese is considered a nutrient-dense food providing high protein and calcium to the human diet, it contributes significantly to dietary fat intake. Cheddar cheese contains 9 g of fat per each 28-g serving. Eating smaller amounts of full-fat foods, or substituting a reduced-fat version, is a strategy that can be used to achieve dietary fat reduction. To help consumers meet the dietary guidelines, the cheese industry strives to provide a healthier Cheddar cheese option that has reduced fat. The FDA regulation mandates that food products claiming to be low fat must not contain more than 3 g of fat per reference amount (50 g), whereas reduced fat labeling can be used for food that contains 25% less fat than the regular version (FDA-DHHS, 2002).

Is it easy to make a good quality reduced-fat Cheddar cheese (**RFCC**)? It's technically challenging to produce RFCC with flavor and texture comparable to full-fat Cheddar cheese (**FFCC**). Extensive reviews

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about reduced- and low-fat cheese are available (Drake and Swanson, 1995; Mistry, 2001; Banks, 2004; Johnson et al. 2009), all of which reported poor flavor and texture of reduced- and low-fat cheeses. Some of the flavor defects mentioned included meaty, brothy, burnt, bitterness, low flavor intensity and milk fat flavor. In terms of texture, RFCC is perceived to be firmer, rubbery, waxier, more brittle, as well as less sticky and cohesive than FFCC. Cheeses of 6, 16, and 33% fat were tested at 0.5, 3, 6, and 9 mo of aging by Rogers et al. (2010) and they reported that low-fat cheeses were differentiated from full-fat cheeses by being more springy and firm and this difference widened as the cheeses aged. In addition, they reported that full-fat cheeses broke down more during chewing than the lower-fat cheeses and the degree of breakdown increased with aging. The production of RFCC with up to 75% fat reduction has found some success and is commercially available (Schepers, 2005). However, we did not find any low-fat Cheddar cheese (**LFCC**; which had >82% fat reduction) in the market place. This is because the larger the fat reduction, the more severe the flavor and texture defects in the cheese. This principle was clearly shown by Childs and Drake (2009) through choice-based conjoint analysis and consumer acceptance testing that show flavor followed by texture of cheese are important attributes that determine consumption, and consumer acceptance of a commercial RFCC (75% reduced fat) dropped dramatically due to profound differences in flavor and texture when compared with regular FFCC.

The effect of fat reduction on flavor development in Cheddar cheese was studied by Drake et al. (2010). It was found that flavor differences between FFCC and LFCC were not apparent at 2 wk of ripening, but by 9 mo of ripening pronounced flavor differences were observed. The FFCC had higher brothy, sulfur, and milk fat flavor than LFCC at 9 mo of ripening. In addition, LFCC had higher bitterness than FFCC and developed a burnt rosy flavor that was not detected in FFCC. Likewise, instrumental analysis showed similar key odorants in LFCC and FFCC at 2 wk of ripening, however the key odorants in FFCC and LFCC showed more differences at 9 mo of ripening. It was also reported by Drake et al. (2010) that FFCC and LFCC were composed of identical volatile compounds, but in different concentrations. These differences might be related to differences in microbiological and proteolytic activity during aging that were caused by the difference in fat level and the balance of compounds in the aqueous phase of the cheese. Fenelon et al. (2000a) showed that the rate of growth of nonstarter lactic acid bacteria decreased with lower fat content in cheese, but found a small effect on the starter population throughout 225-d ripening among cheeses with various fat contents. They found lower primary proteolysis in lower-fat cheeses, as reflected in pH 4.6 water-soluble nitrogen as a percentage of total nitrogen, but no differences in secondary proteolysis in cheeses with different fat contents, as reflected in AA nitrogen as a percentage of total nitrogen. Another challenge in the flavor of RFCC and LFCC is the fact that volatile compounds have different threshold levels depending on the environment they are in. Hydrophobic compounds have a higher threshold level in FFCC (less polar) than RFCC or LFCC (more polar) because they are more soluble in the former environment, preventing their release in the headspace (Leksrisompong et al., 2010; Kim et al., 2011).

The effect of fat reduction on the texture of Cheddar cheese can be explained in the context of the filled-gel model, described by Visser (1991). Cheese consists of gel matrix and filler; CN and bound mineral in a cheese serves as the gel matrix, whereas the rest of the constituents are filler. The CN gel matrix determines the solid nature of cheese. The higher the matrix volume, the firmer is the cheese. The reduction of fat in cheese concomitantly increases the protein content in cheese (Bryant et al. 1995; Fenelon et al. 2000a,b; Guinee et al., 2000; Drake et al. 2010), causing an increase in matrix and reduction in filler. This explains the high firmness in reduced-fat cheese. The microstructure difference between FFCC and LFCC produced by removing fat from milk before cheese making is also evident from the scanning electron micrograph, showing a more compact protein matrix per given volume and less open space occupied by the milk fat globules in LFCC than FFCC (Emmons et al., 1980; Bryant et al. 1995).

Many approaches have been investigated to overcome defects in RFCC and LFCC. One approach investigated was use of adjunct culture to improve the flavor in RFCC and LFCC. Fenelon et al. (2002) demonstrated the use of *Lactobacillus helveticus* as adjunct culture, in combination with *Leuconostoc cremoris*, *Lactococcus lactis* var. *diacetylactis* and *Streptococcus thermophilus* to produce RFCC (50% fat reduction), had a higher preference score than the RFCC without adjunct culture. The RFCC with these adjunct cultures showed a higher degree of peptide hydrolysis and greater free AA concentration. However, even the most acceptable RFCC in the study by Fenelon et al. (2002) was still described as having a different flavor profile than typical FFCC, as well as a burnt off-flavor. To improve the texture of RFCC and LFCC, cheese makers try to maximize moisture retention (i.e., increase filler volume) in the curd. This can be done by modifying the make procedure, such as increasing milk pasteurization temperature (Guinee et al., 1998), lowering scald temperature (Banks et al., 1989), washing curd with 22°C water (Johnson and Chen, 1995), milling curd at