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Differences Between Cheddar Cheese Manufactured by the Milled-Curd and Stirred-Curd Methods Using Different Commercial Starters

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ABSTRACT

Traditionally, Cheddar cheese is made by the milled-curd method. However, because of the mechanization of cheese making and time constraints, the stirred-curd method is more commonly used by many large-scale commercial manufacturers. This study was undertaken to evaluate quality differences during ripening (at 2 and 8°C) of Cheddar cheese made by the milled-curd and stirred-curd methods, using 4 different commercial starters. Twenty-four vats (4 starters × 2 methods × 3 replicates) were made, with ~625 kg of pasteurized (72°C × 16 s) whole milk in each vat. Fat, protein, and salt contents of the cheeses were not affected by the starter. Starter cell densities in cheese were not affected by the method of manufacture. Nonstarter lactic acid bacteria counts at 90, 180, and 270 d were influenced by the manufacturing method, with a higher trend in milled-curd cheeses. Proteolysis in cheese (percentage of water-soluble N) was influenced by the starter and manufacturing method (270 d). Sensory analysis by a trained descriptive panel (n = 8) revealed differences in cooked, whey, sulfur, brothy, milk fat, umami, and bitter attributes caused by the starter, whereas only brothy flavor was influenced by storage temperature. The method of manufacture influenced diacetyl, sour, and salty flavors.
Key words: stirred curd, milled curd, Cheddar cheese, proteolysis

INTRODUCTION

Cheddar cheese making involves 2 phases—the conversion of milk to curd in the first phase, which is generally accomplished in 24 h, and the transformation of the young "green" cheese into a mature cheese in the second phase. Traditionally, the milled-curd (**MC**) method is used for Cheddar cheese manufacture. The MC method involves the process of "cheddaring" (which involves turning and flipping loaves of warm curd at regular intervals for 1 to 2 h for the development of acid, leading to a fibrous, "chicken breast-like" structure), followed by milling, hooping, and pressing. In the stirred-curd (**SC**) method of manufacture, the curds are continuously stirred after whey drainage, hence eliminating the traditional cheddaring and milling process. The SC method is the method of choice in highly mechanized cheese plants because of its relatively short manufacturing time.

Acidification is one of the most important operations in the manufacture of Cheddar cheese. Starters are added to cheese milk to achieve a uniform and predictable rate of acid production during manufacture. The postcoagulation steps for MC Cheddar are different from those for SC Cheddar; therefore, the development of acidity and the growth rate of starter bacteria may vary. Starter bacteria also contribute to proteolysis during Cheddar cheese ripening through the action of their cell envelope-associated proteinase and intracellular peptidases (Law and Haandrikman, 1997; Singh et al., 2003).

The process of converting young Cheddar cheese into mature Cheddar is governed by the ripening conditions, such as temperature. Cheese-ripening temperature is a major factor controlling bacterial growth and the activity of enzymes in the cheese. Although SC Cheddar is similar to MC Cheddar in composition, it is thought to exhibit a curdy and open texture and is less elastic than MC Cheddar; the characteristic "chicken breast" texture does not develop because of elimination of the cheddaring step. Little or no information is available in the literature that quantitatively compares the ripening of Cheddar cheese made by the MC and SC methods. The objectives of this study were to determine the effect of the method of manufacture on the microbiological, biochemical, and sensory changes during ripening of Cheddar cheese made with different starters, and to determine the influence of ripening temperature on those changes.

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MATERIALS AND METHODS

Cheese Making

Three experimental cheese-making trials were conducted. Four frozen direct vat set starter types (a, b, c, d), each consisting primarily of mesophilic strains of *Lactococcus lactis* ssp. *cremoris* or *Lactococcus lactis* ssp. *lactis*, were obtained from independent starter culture companies (Chr. Hansen Inc., Milwaukee, WI; Rhodia, Madison, WI; Degussa Bioactives, Waukesha, WI; and DSM Food Specialities, Parsippany, NJ). Each starter was used for the manufacture of Cheddar cheese in parallel vats, with the SC method in one vat and the MC method in the second vat. Each starter was used for triplicate cheese-making trials. Each cheese-making trial consisted of 8 vats (4 starters × 2 methods), and each trial was completed over 4 d (one vat milled and one vat stirred with one culture type each day). The order of starter used was randomized. Each vat contained approximately 625 kg (605 L) of pasteurized (72°C × 16 s) whole milk. The milk supply was from the California Polytechnic State University dairy herd, and milk composition was consistent over the cheese-making period. The basic cheese-making protocols for the SC and MC methods are outlined in Figure 1. Chymax (Chr. Hansen, Milwaukee, WI) was used as a coagulant. After salting, the curds were hooped into 18.2-kg Wilson hoops and pressed (0.275 MPa) in a vacuum chamber overnight with the application of 24-mmHg vacuum for the first 60 min. After removal from the press, the cheeses were vacuum-packaged in Cryovac (Sealed Air Corp., Duncan, SC) bags. Three 18.2-kg blocks were obtained from each vat. Two blocks from each vat were ripened at 8°C for 9 mo, and one block was ripened at 2°C.

Compositional Analyses

Total solids in cheese were determined by the microwave oven method (CEM AVC 80 microwave oven, CEM Corporation, Matthew, NC; Marshall, 1992). Protein (total N × 6.38) was determined by the Kjeldahl method and salt by the titrimetric method with a Corning 926 chloride analyzer (Corning, Medfield, MA). Cheese pH was determined with a glass electrode on a slurry prepared by thoroughly blending 10 g of grated cheese with 10 mL of deionized water with a mortar and pestle. Cheeses were analyzed 7 d postmanufacture. All analyses were conducted in duplicate.

Microbiological Analysis

Starter bacteria were enumerated in cheese 1 d postmanufacture and in 90-d-old cheeses on LM-17 agar (Difco Laboratories, Detroit, MI) after incubation for 3 d at 31°C. Starter bacteria were not enumerated on cheeses beyond 90 d of age because nonstarter lactic acid bacteria (**NSLAB**) also grow on LM-17 agar, making starter counts inaccurate (Cogan and Beresford, 2002). The NSLAB in the cheeses (1, 90, 180, and 270 d) were enumerated on Rogosa agar (Difco Laboratories) after incubation for 5 d at 31°C. Cheeses (10 g) were blended with warm 2% sodium citrate, followed by dilution in 0.1% peptone water before pour-plating in duplicate on the respective agars.

Proteolysis

The cheeses were sampled after 7, 90, and 270 d of ripening and frozen at –20°C until analyzed for proteolysis. A water-soluble N (**WSN**) extract of the cheeses was prepared according to the method of Kuchroo and Fox (1982), and the extract was analyzed for total N by the Kjeldahl method to assess primary proteolysis. Reversed-phase (**RP**) HPLC of the WSN extract of 90, 180, and 270-d-old cheeses was performed in duplicate by the method of Farkye et al. (1995) to determine the peptide profiles.

Sensory Analysis

Flavor attributes of 90, 180, and 270-d-old cheeses were evaluated by a trained 8-member descriptive sensory panel, using 17 terms for Cheddar flavor previously identified by Drake et al. (2001). Definitions and references for the Cheddar flavor sensory descriptors have been published previously (Drake et al., 2001). Cheeses (1.5 kg) cut from 18.2-kg blocks were shipped to North Carolina State University by overnight carrier on blue ice gel packs.

Each sensory panelist (6 females, 2 males; ages 22 to 47 yr) had more than 80 h of training on descriptive sensory analysis of Cheddar cheese. Panelists evaluated and scored the descriptors using a 10-point universal intensity scale consistent with the Spectrum descriptive analysis technique (Meilgaard et al., 1999; Drake and Civille, 2003). Prior to sensory analysis, the outer edges (~1 cm) of each block were carefully trimmed and discarded to minimize variability and flavor transfer from packaging. Cheeses were prepared by slicing into 4 × 2 × 2 cm cubes with a wire slicer within 2 h of evaluation. Cheeses were placed into 4-oz (113 g) soufflé cups with lids and tempered to 12°C prior to evaluation. Cheeses were evaluated under white light in a balanced block design by using 3-digit codes. Order of presentation was randomized among panelists. Panelists had access to water and unsalted crackers throughout the evaluation. Panelists evalu-