J. Dairy Sci. 101:1–14
https://doi.org/10.3168/jds.2018-14391


# Effects of processing conditions on the texture and rheological properties of model acid gels and cream cheese

**M. Brighenti,*[1] S. Govindasamy-Lucey,†[2] J. J. Jaeggi,† M. E. Johnson,† and J. A. Lucey*†**
*Department of Food Science, and
†Center for Dairy Research, University of Wisconsin, Madison 53706

## ABSTRACT

Manufacture of cream cheese involves the formation of an initial acid-induced gel made from high-fat milk, followed by a series of processing steps including shearing, heating, and dewatering that complete the conversion of the acid gel into a complex cheese product. We investigated 2 critical parameters for their effect on the initial gel: homogenization pressure (HP) of the high-fat cheese milk, and fermentation temperature (FT). The impact of a low (10 MPa) and high (25 MPa) HP, and low (20°C) and high (26°C) FT were investigated for their effects on rheological and textural properties of acid-induced gels. Intact acid gels were sheared and heated to 80°C, and then their rheological properties were analyzed to help understand the effect of shearing/heating processes on the gel characteristics. The effect of HP on fat globule size distribution and the amount of protein not involved in emulsion droplets (i.e., in the bulk phase) were also studied. For cream cheese trials, a central composite experimental design was used to explore the effect of these 2 parameters (HP and FT) on the texture, rheology, and sensory properties of experimentally manufactured cream cheese. Storage modulus (G′) and hardness values of cream cheeses were obtained from small amplitude oscillatory rheology tests and texture profile analysis, respectively. Quantitative spectrum descriptive sensory analysis was also performed. Consistency of acid gels (measured using a penetration test) increased with an increase in FT and with an increase in HP. Although stiffer acid-induced gels were formed at high FT, after the heating and shearing processes the apparent viscosity of the samples formed at high FT was lower than those formed at low FT. For the cream cheeses, significant prediction models were obtained for several rheological and textural attributes. The G′ values at 8°C, instrumental hardness, and sensory firmness attributes were significantly correlated ($r > 0.84$); all these attributes significantly decreased with an increase in FT, and HP was not a significant parameter in the prediction models developed for these attributes. Significant interactions were observed between the HP and FT terms for these prediction models. Higher HP increased the amount of protein adsorbed at interface of fat globules but decreased bulk phase protein content (which may be important for crosslinking this gelled emulsion system). At higher FT temperature, coarser gel networks were likely formed. The combined effect of a coarser acid gel network at high FT, and less bulk phase casein available for crosslinking the acidified emulsion gel with an increase in HP, could have contributed to the lower stiffness/firmness observed in cream cheese made under conditions of both high FT and high HP. Stickiness of cream cheese greatly increased under conditions of high FT and high HP, whereas the sensory attributes cohesiveness of mass and difficulty to dissolve decreased. This study helped to better understand the complex relationships between the initial acid-induced gel phase and properties of the (final) cream cheese.
**Key words:** cream cheese, homogenization pressure, fermentation temperature, texture

## INTRODUCTION

Cream cheese is a soft, fresh, acid-coagulated cheese, and according to its US Standard of Identity should have a minimum fat content of 33% and a maximum moisture level of 55% (Code of Federal Regulations, 2006). In 2015, the production of cream cheese and Neufchâtel cheese in the United States totaled 397 million kg (876 million pounds), which puts it in fifth place in terms of US cheese production by variety/style (IDFA, 2016). Cream cheese has a soft, spreadable texture and a creamy, mildly acidic flavor. Cream cheese is widely used as an ingredient in various types of desserts, cheesecakes, flavored spreads, appetizers, and sauces, in addition to its widespread use on bagels.

Cream cheese has been described as a complex acidified dairy food (Sanchez et al., 1996) and also as an

Received January 4, 2018.
Accepted March 27, 2018.
[1]Current address: Cargill European Food Innovation Center, Havenstraat 84, 1800 Vilvoorde, Belgium.
[2]Corresponding author: rani@cdr.wisc.edu

acidified protein-stabilized emulsion gel (Bot et al., 2007). The manufacturing process of cream cheese involves many steps, including milk pretreatments, slow acidification, acid-induced gelation, shearing/heating of the acid gel, whey separation, and curd treatments (Lucey, 2002). After standardization of the cheese milk to the desired level of fat and solids, pasteurization, and homogenization, the milk is then fermented with mesophilic cultures until pH values of ~4.8 to 4.5 are reached (Fox et al., 2000). The acid-induced gel is then heated and sheared before separation of part of the acid whey, which can be done by centrifugation or by UF (Schulz-Collins and Senge, 2004). The final steps involve treatment of the hot acidified curd, which includes addition of salt and stabilizers, mixing/homogenization, and packaging.

Only a few studies have been done on the effect of manufacturing conditions on the textural and rheological properties of cream cheese. A few studies investigated the effect of heat treatment of cheese milk (Coutouly et al., 2014), final pH of acidification (Coutouly et al., 2014), homogenization pressure (**HP**) of the (acidified) cheese curd (Sanchez et al., 1994a; Wendin et al., 2000; Coutouly et al., 2014), and the rate of cooling of hot cream cheese before it is packaged (Sanchez et al., 1994b). A detailed survey of the texture, rheology, and sensory properties of commercial US cream samples has been reported (Brighenti et al., 2008).

Cream cheese is made from high-fat milk (e.g., 8–14%) that is pasteurized and homogenized. Homogenization of milk reduces the size of fat globules and greatly increases their surface area. As the concentration of native milk fat globule membrane material is not sufficient to cover all of the newly created surface area, homogenized fat globules become coated with proteins, mainly caseins (Walstra et al., 1999; Wilbey, 2002). The casein-covered fat globules behave as active filler particles and thereby increase the effective protein concentration in milk (Fox et al., 2000). Native milk fat globules are considered inert fillers in acid gel networks (van Vliet, 1988). Upon acidification, the casein-covered fat globules become active fillers (van Vliet, 1988) and are incorporated into the gel and reinforce their structure (Guinee et al., 1993). An increase in the HP of milk has been reported to increase the firmness of acid-induced gels containing fat (Balasubramanyam and Kulkarni, 1991; Xiong et al., 1991; Walstra et al., 1999). No studies have been done on the effect of homogenization of cheese milk on the textural properties of the resultant cream cheese.

The fermentation temperature (**FT**) used for the formation of acid-induced gels has a major effect on texture and physical properties (Lucey, 2004). Mesophilic lactic acid bacteria are used as starter cultures, and temperatures ranging from 20 to 30°C are used for the fermentation of cream cheese (Lucey, 2002). Higher FT generally results in coarser acid gel networks (Guinee et al., 1993). At higher FT, hydrophobic interactions are stronger and casein molecules contract. Higher FT also results in faster acidification rates, which depends on the type of starter culture used. With mesophilic fermentations, higher FT usually result in acid-induced gels with higher firmness and (if sheared) higher viscosity (Guinee et al., 1993; Phadungath, 2003).

To our knowledge, the homogenization conditions applied to the cheese milk and the FT used to make the initial acid-induced gel do not yet appear to have been studied for their effect on the texture, rheology, and sensory properties of cream cheese. The objective of this study was to investigate the effect of these 2 processing parameters, HP and FT, on the properties of the initial acid-induced gels. A central composite experimental design was also used to explore the effect of these 2 key parameters (HP and FT) on the texture, rheology, and sensory properties of experimentally manufactured cream cheese. This experimental design would allow us to identify if there was any significant interaction between these 2 processing parameters. It is generally considered likely that the structural properties of the acid-induced gel formed during the initial step (fermentation) of cream cheese manufacture likely affects the textural attributes of the (final) cream cheese (Fox et al., 2000). An objective of this study was to verify if significant relationships were present between the rheological and textural properties of the initial acid-induced gel and those of the final cream cheese.

## MATERIALS AND METHODS

### Acid Gel Study

***Experimental Design.*** For the acid gel study, we prepared combinations of the samples at the highest and lowest levels for both the HP and FT parameters of overall interest in this study to help explore the range of textures that would be created during the complete experimental design used for the cream cheese study. These 4 levels we selected were HP = 10 MPa and FT = 20°C (**LHP-LFT**), HP = 25 MPa and FT = 20°C (**HHP-LFT**), HP = 10 MPa and FT = 26°C (**LHP-HFT**), and HP = 25 MPa and FT = 26°C (**HHP-HFT**). Cream cheese milks (**CCM**) were prepared by combining sweet cream (~35% fat) and skim milk to a fat content of ~11% and a casein:fat ratio of ~0.20. The standardized CCM were heated to ~65°C and homogenized in 2 stages. The pressure for the first stage of homogenization was varied from 10 to 25 MPa, whereas