Wisconsin center for dairy Research

annual report 2002

Wisconsin

Center for Dairy Research

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CDR Annual Report

Published March 1, 2003, by the Wisconsin Center for Dairy Research.

Our annual report is a technical overview of CDR funded research and other Center activities during fiscal year 2002. This document was prepared for organizations funding CDR and for fellow dairy researchers. Although it describes projects in progress and interpretations of data gathered to date, it is not a peer-reviewed publication.

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CDR's Cheese Industry Team

Alto Dairy
Bel/Kaukauna
Conagra
Chrs. Hansen Labs
Dairy Management Inc(DMI)
Foremost Farms
DSM Food Specialties Inc.
Grande Cheese
International Flavors and Fragrances (IFF)
Kraft Foods Technology Center
Land O' Lakes Inc
DFA/Plymouth Cheese
Rhodia Inc.
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Wisconsin Milk Marketing Board (WMMB)

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Our Mission Statement

The Wisconsin Center for Dairy Research will serve as a national leader in strategic research to improve the competitive position of the dairy industry by linking Center/University faculty, staff, students and the dairy/food industries to address key issues resulting in transfer of technology and communication of information.

Contents

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Chapter One

Interim reports

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Relationship between cheese melt profiles and chemical/textural/sensory properties

Personnel
Chen, Carol; Muthukumarappan, K.

Funding
Dairy Management, Inc.

Dates
3/16/2000 to 12/31/2002

Objectives
1. To characterize the effect of selected manufacturing protocols on cheese melt profiles.

2. To correlate cheese melt profile characteristics to chemical/textural/sensory properties.

3. To develop strategies based on correlations that enable cheesemakers to design manufacturing practices which result in specific melt/flow characteristics for food application systems.

Development and application of a cheese shred/texture map delineated by cheese rheological, sensory and chemical analysis

Personnel
Chen, Carol

Funding
Wisconsin Milk Marketing Board

Dates
7/1/2000 to 12/31/2002

Objectives
1. To develop a shred/texture map of cheese based on rheological, sensory and chemical measurements.

2. To define manufacturing protocols of Cheddar and mozzarella tailored for shredding.

Identification of physical/chemical changes in shredded cheese over time

Personnel

Chen, Carol

Funding

Dairy Management, Inc.

Dates

3/16/2000 to 12/31/2002

Objectives

1. To characterize physical/chemical/sensory characteristics over time of shredded cheese in consumer-sized packages.

2. To determine the effect of flow agents on the physical/chemical/sensory projects of shredded cheese.

Analysis of the economic impact of cheese defects

Personnel

Smukowski, Marianne; Wendorff, Bill

Funding

Dairy Management, Inc.

Dates

7/1/2001 to 12/31/2002

Objectives

The purpose of this study is to collect data concerning cheese defects and to examine the financial consequences to manufacturers in the cheese industry. This study will identify the most common defects and assist the industry in correcting these defects

1. Survey cheese manufacturers for specific defects

2. Assess economics of the industry-wide impacts of the specific defects

3. Extrapolate data based on tonnage

Technical and economic development of a milk refinery

Personnel
Etzel, Mark

Funding
Dairy Management, Inc.

Dates
3/16/2000 to 12/31/2002

Objectives
1. Determine the technical capabilities of various MF systems from different suppliers for the separation of casein from milk serum proteins (i.e., how complete and clean is the separation) and the efficiency of subsequent UF concentration of the serum proteins.

2. Determine the throughput, yield, and recovery of the ion exchange chromatography step as a function of feed stream properties and target protein fractions.

3. Determine the technical properties and opportunities for use of casein concentrates (liquid or dry), and casein and milk serum protein fractions as dairy ingredients in non-cheese applications.

4. Determine the costs (capital, fixed, variable, operational, etc.) for the MF/UF and ion exchange chromatography aspects of fractionation and concentration of the milk protein streams.

5. Determine the potential market and utilization of milk refinery products (i.e., opportunities).

Alpha-lactabumin production for clear bottled drinks and nutraceutical

Personnel
Etzel, Mark

Funding
Dairy Management, Inc.

Dates
1/2/2001 to 12/31/2002

Objective
Produce alpha-lactalbumin of a purity and absence of denatured protein, denatured protein, suitable for use in development of clear, bottled drinks and nutraceutical beverages.

Relating rheological properties to cheese functional performances

Personnel

Lucey, John , Foegeding, Allen, S. Gunasekaran, Johnson, Mark E, McMahon, Donald

Funding

Dairy Management Inc.

Dates

January 2002 to December 2004

Objectives

1. To develop molecular-based mechanisms and models to explain the functional performances involved in meltability.

2. To develop molecular-based mechanisms and models to explain the functinal performances involved in machinability of cheese.

3. To develop an information piece (short booklet or workshop) that provides detailed descriptions of a range of cheese functional properties in terms that both industry and researchers could understand.

Understanding and controlling the calcium equilibrium in cheese

Personnel

Lucey, John A, Johnson, Mark E.

Funding

Dairy Management Inc.

Dates

July 2002 to June 2004

Objectives

1. To determine the impact of changes in the Ca equilibrium on the textural and rheological properties of these cheeses.

2. To identify changes in the proportions of bound and soluble Ca in cheese during ripening.

Developing pH-sensitive biodegradable smart hydrogels using whey protein concentrate

Personnel

Sundaram Gunasekaran

Funding

Dairy Management, Inc.

Dates

7/1/2001 to 6/30/2003

Objectives

The overall objective is to develop new biodegradable smart hydrogels using whey protein concentrate (WPC).
Hypothesis: Whey protein-based hydrogels exhibit a pH-sensitive swelling behavior. Therefore, they can be used as carrier matrices for pH-sensitive controlled delivery applications.

1. To develop new pH-sensitive hydrogels using whey protein concentrate and characterize their swelling behavior as a function of swelling medium and gel preparation conditions.

2. To determine the release kinetics of some model biologically active substances from whey protein-based hydrogels in various pH media.

Model development for manipulation of rheological properties of cheese

Personnel

Gunasekaran, Sundaram

Funding

Dairy Management, Inc.

Dates

3/16/2000 to 6/30/2002

Objectives

1. Develop a model that defines physical and functional properties (melt, stretch, end-use properties, etc.) by rheological and other measurements at room and elevated temperatures that are related to typical industry measurements and ultimate cheese use. This model will establish a defined target for cheese makers to reach which is crucial for tailor-making of specified cheeses.

2. Validate the model(s) developed for their applicability using cheeses manufactured with specific make parameters to manipulate certain functional properties.

Improving lactose refining technology by controlling crystallization

Personnel
Hartel, R.W.

Funding
Dairy Management Inc.

Dates
July 2002 to June 2005

Objectives
1. To provide a better understanding of the mechanisms and kinetics of lactose nucleation (both primary and secondary).

2. To define the important compositional and operating parameters that influence lactose nucleation in commercial whey products.

3. To determine the importance of growth rate dispersion on commercial lactose refining operations and develop methods for minimizing these effects.

4. To provide economically viable operating parameters for commercial lactose refining operations that enhance the quality (color, purity, and particle size) and consistency (on a day to day basis) of lactose crystals produced.

Crystallization kinetics of calcium lactate

Personnel
Hartel, Richard

Funding
Dairy Management, Inc.

Dates
7/1/2001 to 12/31/2002

Objectives
The primary objective of this project is to investigate the factors that influence crystallization kinetics of calcium lactate. We will study crystallization kinetics in model solutions, in expressed cheese serum and on the surface of cheese itself. The effects of various storage conditions (temperature, temperature fluctuations, etc.) and chemical composition (calcium and lactate content, pH, other salts, other constituents of importance in cheese, etc.) will be evaluated.

Development of Parmesan cheese flavor using selected bacteria

Personnel

Johnson, Mark; Steele, James; Lindsay,Robert

Funding

Dairy Management, Inc.

Dates

7/1/2001 to 12/31/2003

Objectives

1. Define and verify the chemistry of flavors produced in Parmesan cheese made with specifically selected adjunct lactic acid bacteria that provide flavor notes known to characterize high quality, aged Parmesan cheese. Hypothesis: By correlating chemical and sensory data from experimental Parmesan cheese, we will be able to identify and establish commercially viable starters and adjunct lactic acid bacteria and cheese manufacturing methods to produce Parmesan cheese with intensified flavors.

2. Construct derivatives of *Lactobacillus helveticus* CNRZ32 that overexpress specific esterase activity. Hypothesis:We believe that esterase activity, i.e. production of specific esters, provides specific desirable flavor notes in Parmesan cheese. The lactobacilli used as starters for Parmesan cheese lack sufficient esterase activity to adequately develop full, aged Parmesan flavor.

Use of whey proteins in pasteurized processed cheese products

Personnel

Lucey, John

Funding

Dairy Management, Inc.

Dates

7/1/2001 to 6/30/2003

Objectives

1. To determine the influence on the rheological, textural, and sensory properties of pasteurized processed cheese products.

2. To investigate the influence of denaturation and further processing treatments on whey products when they are subsequently incorporated into processed cheese products.

Biochemistry of full and reduced fat Cheddar shred ripening

Personnel

Rankin, Scott

Funding

Dairy Management, Inc.

Dates

4/15/2001 to 12/31/2002

Objectives

Characterize the effects of gas composition (CO2, N2, CO2/N2 blends) and light exposure on the biochemical, microbial, and textural ripening indicies of MAP packaged
Cheddar cheese shreds. An understanding of the degree to which MAP storage variables influence cheese ripening will enable processors to start to select conditions condusive to optimal ripening and storage quality.

Mother liquor for production of lactose and a calcium-based product

Personnel

Smith, Karen

Funding

Dairy Management, Inc.

Dates

3/16/2000 to 12/31/2002

Objectives

1. Evaluate microfiltration (MF) system and centrifugation for ability to remove calcium from DLP.

2. Initial determination of feasibility of separating calcium from DLP.

3. Determine the composition and type of calcium product produced from DLP.

4. Compare resulting calcium from DLP product with currently available dairy calcium products.

5. Produce acceptable products containing calcium ingredients from DLP.

Development of information manuals on controlling whey flavor

Personnel
Smith, Karen

Funding
Dairy Management, Inc.

Dates
7/1/2000 to 12/31/2002

Objectives
1. Develop two manuals: a) Manual for whey producers (cheese makers) on how they can affect whey flavor and minimize problems.b) Manual for whey handlers that outlines methods for handling whey which minimize flavor problems.

New starter systems for accelerated ripened Cheddar cheese

Personnel
Steele, Jim; Broadbent, Jeff

Funding
Dairy Management, Inc.

Dates
7/1/2000 to 12/31/2002

Objectives
1. Determine bitter taste thresholds for casein derived peptides in a cheese model system.

2. Define the contribution of *Lactobacillus helveticus* CNRZ32 peptidases to the hydrolysis of casein derived bitter peptides.

3. Construct food-grade *Lactococcus lactis* S2 derivatives with enhanced activity of peptidases demonstrated to be important in hydrolysis of bitter peptides.

4. Develop a food-grade, genetic system for proteinase gene exchange in industrial strain of *Lactococcus lactis*.

Production of intensely flavored Cheddar-type cheeses by adjunct cultures

Personnel
Steele, Jim

Funding
Dairy Management, Inc.

Dates
3/16/2000 to 12/31/2002

Objectives
1. Construct strains of *Lactobacillus casei* which produce elevated levels of diacetyl.

2. Construct strains of *Lactobacillus casei* which over-express a bacterial lipase known to enhance cheese flavor.

3. Manufacture processed cheese from Cheddar cheeses having significantly elevated levels of free fatty acids or furanones and pyrazines.

Control of annatto cheese colors in whey products

Personnel
Wendorff, Bill; Lindsay, R. C.

Funding
Dairy Management, Inc.

Dates
1/1/2001 to 12/31/2002

Objectives
Hypothesis: The annatto-based off-colors in dry whey products are caused by the adsorption of annatto colorants onto protein or protein-lipid particles, and these off-colors can be minimized by oxidative bleaching and/or processing to disrupt and remove the adsorptive complexes.

1. Determine the quantitative binding capability of commercially-important forms (native, denatured, and delipidated) of whey proteins for annatto cheese colorants.

2. Devise commercially-applicable methods to minimize or eliminate annatto off-colors in dry whey products.

Mechanisms for intensifying and modulating cheese flavor: A global approach

Personnel

Steele, James L.

Funding

Dairy Management, Inc.

Dates

1/1/2001 to 12/31/2003

Objectives

The overall objective of this project is to assemble a comprehensive database on the metabolic potential of *Lactobacillus helveticus* CNRZ32, an important cheese flavor-enhancing bacterium, for modulating and intensifying cheese flavor development. Based on our previous experience in cheese flavor research, it is our hypothesis that genome sequence analysis of CNRZ32 is the most expedient method to identify many of this bacterium's genes encoding enzymes involved in cheese flavor development. Because of their similarities, it is also our hypothesis that this knowledge can be applied to other important lactic acid bacteria.

Specific objectives:

1. Determine the nucleotide sequence of the *Lactobacillus helveticus* CNRZ32 genome

2. Assemble a comprehensive database of CNRZ32 genes likely to be involved in modulating or intensifying cheese flavor.

Chapter Two

Final reports

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“Whey Refinery” for producing proteins for beverages and nutraceuticals

Personnel
Etzel, Mark R.

Funding
Dairy Management Inc.

Dates
March 2000 to December 2002

Objectives
Purified whey proteins are uniquely suited for use in clear bottled drinks and nutraceutical foods for enhancing infant nutrition, suppressing appetite, treating diseases such as phenylketonuria, and other applications. The objective of this project is to develop a “whey refinery” technology to economically manufacture purified whey proteins suitable for new uses and novel applications in beverages and nutraceutical foods. Specifically, we will:

1. Develop and demonstrate an ion exchange process to produce purified alpha-lactalbumin, beta-lactoglobulin, lactoferrin, lactoperoxidase, and κ-casein glycomacropeptide from a single stream of whey

2. Test the purified whey proteins for purity, activity, and/or clarity after heat treatment.

Summary
We developed and demonstrated the operating conditions and solution chemistries needed to purify alpha-lactalbumin, beta-lactoglobulin, immunoglobulins, lactoferrin, lactoperoxidase, and κ-casein glycomacropeptide from a single stream of whey. We collaborated with Amersham Biosciences, the world-leader in process chromatography systems, and a large dairy processor to implement this technology at process scale. Using an economic analysis, we refined the process to increase the return on investment. We conducted successful pilot trials and scale-up to production is ongoing.

We collaborated with three companies to utilize the process for κ-casein glycomacropeptide manufacture in developing a new product for children with the disease phenylketonuria (PKU). Glycomacropeptide is the only known protein that is naturally free of the amino acid phenylalanine.

We developed procedures to test for clarity of clear white grape juice after addition of glycomacropeptide or alpha-lactalbumin and pasteurization. We tested a commercially-available sample of alpha-lactalbumin and found it to have unacceptably high turbidity in this application. A commercially-available sample of glycomacropeptide was found to work better, but was still had an unacceptably high turbidity. Our samples of alpha-lactalbumin and glycomacropeptide had the lowest turbidity.

Publications

"Production of κ-Casein Macropeptide for Nutraceutical Uses," U.S. Pat. 5,968,586 (1999).

"Isolating β-Lactoglobulin and α-Lactalbumin by Eluting from a Cation Exchanger Without Sodium Chloride," U.S. Pat. 5,986,063 (1999).

"Production of Kappa-Casein Macropeptide," Int. Pat. Appl. WO9918808A1 (1999).

"Production of Kappa-Casein Macropeptide," Eur. Pat. Appl. WO9918808A1 (1999).

"Kappa-Casein Macropeptide Isolation from Cheese Whey Using Ion Exchange Chromatography," S. Dermawan, M.S. Thesis, Univ. Wisconsin, Madison (1999).

"Production of Substantially Pure Kappa-Casein Macropeptide," U.S. Pat. 6,168,823 (2000).

"Commercial-Scale Chromatographic Fractionation of Whey Proteins," in "The Importance of Whey and Whey Components in Food and Nutrition: Proceedings of the 3rd International Whey Conference, Munich 2001," p.83.

One M.S. thesis (S. Doultani) and three publications in preparation.

Presentations

"Capture of Lactoferrin from Whey Using Packed Bed Chromatography," Kelowna, Canada, April 18, 1999.

"Chromatographic Capture of Proteins from Milk," Recovery of Biological Products IX, Whistler, Canada, May 19, 1999.

"Chromatographic Capture of Proteins from Milk" Am. Chem. Soc. Natl. Mtg., San Francisco, CA, March 29, 2000.

"Chromatographic Fractionation of Whey Proteins," Grande Cheese, Lomira, WI, October 26, 2000.

"Whey Refinery Prototype for Protein Fractionation," Am. Dairy Prod. Inst. Annu. Mtg., April 23-25, 2001, Rosemont, IL.

"Commercial-Scale Chromatographic Fractionation of Whey Proteins," International Whey Conference, Munich, Germany, September 12-14, 2001.

"Fractionation/Separation of Dairy Proteins," DMI Whey and Dry Milk Ingredients Forum, Phoenix, Arizona, January 9-10, 2002.
"Milk Refinery Concepts: Medical Proteins for Functional Foods," Babcock Associates Meeting, Madison, Wisconsin, February 28, 2002.

"Fractionation/Separation of Dairy Proteins," Ross Products Division, Abbott Laboratories, Columbus, Ohio, March 14, 2002.

"Milk Refinery Concepts: Medical Proteins for Functional Foods," Whey Short Course, Madison, Wisconsin, May 7, 2002.

"Milk Refinery Concepts: Value-Added Proteins for Functional Foods," Proliant, Hilmar, California, July 26, 2002.

Outreach

"CALS Scientist Puts the Squeeze on Whey for Valuable Proteins," *CALS Press Service*, October (1999).

"Diamond in the Rough: The Cinderella Story of Whey Protein Ingredients," *Dairy Field*, February (2000).

"Fractionation Boosting Fortification Potential of Whey Proteins," *The Cheese Reporter*, March (2000).

"Advanced Whey Ingredient Technologies," *Innovations in Dairy*, May (2000).

"Research Trends in Healthful Foods," *Food Technol*. 54(10): 45-52 (2000).

"Glycomacropeptide: A Dairy Protein for PKU Diets," *PKU News* 12(2): 3 (2000).

"Whey Cool," *Discover Wisconsin: America's Dairyland* (30 min. TV show), October (2000).

"Dry Dairy Ingredients Provide Proteins Similar to Human Breast Milk," *Doitwithdairy*, October (2000).

"A New Way to Separate Whey Proteins?" *Food Engineering*, December (2000).

"Divide and Conquer: Fractionating Whey Proteins for Profit," *Dairy Dimensions*, 2: 1-2 (2000).

"Fractionating Valuable Peptides from Whey," *Dairy Pipeline* 12(4):1-4 (2000).

"Powder Helps Those with PKU'" Wisconsin State Journal, August 9, 2001.

"Medical Foods From Milk," CALS Press Service, July 19, 2001. (http://www.cals.wisc.edu/media/news/07_01/medical_foods_milk.html)

"Glycomacropeptide (GMP) Update," *PKU News*, 14: 2 (2002)
.
"Whey Points The Way To More Effectively Using Milk As A Raw Material," *Dairy Dimensions*, 2002.

Determination of the relationship between galactose and lactic acid content of sweet whey and their effects on the spray-drying process

Personnel

Wendorff, W. L,Smith, Karen and Rao, Rae Dawn

Funding

Dairy Management Inc.

Dates

July 2001 to June 2002

Objective

To determine the relationship between galactose and lactic acid content of whey and its effect on spray drying.

Summary

Lactic acid and galactose present in whey are thought to contribute to problems such as stickiness and agglomeration that occur during the spray-drying process. To address this problem, our study focused on characterizing the variability of lactic acid and galactose in different whey streams under different storage conditions.

Two phases were carried out in this study. Initially, commercial sources of Cheddar, mozzarella, and cottage cheese whey were surveyed for differences. Whey samples were pulled at the time of draining and stored for 24 hours under ideal ($4^{O}C$) and abuse ($37.8^{O}C$) temperatures. Levels of galactose and lactic acid were periodically measured over this time period. The elevated storage temperature caused increases in lactic acid and galactose levels in the Cheddar and mozzarella whey over time, however lactic acid and galactose content of the cottage cheese whey remained constant regardless of storage time or temperature. Storage at ideal temperature resulted in no change in galactose or lactic acid levels over a 24-hour period. Variation in the extent of galactose and lactic acid produced in Cheddar and mozzarella whey was observed.

To further investigate this aspect, the next phase was completed to look at differences that may result from using different starter cultures in cheese production. Cheddar and mozzarella cheese were produced on a bench-top scale according to the Center for Dairy Research's standard make-sheets to produce subsequent whey samples. For each make, a single culture was used for production. Mozzarella cheese was produced using one of the follow cultures: *Streptococcus thermophillus, Lactobacillus helveticus*, or *Lactobacillus delbrukii ssp. bulgaricus*. Cheddar cheese was produced using either *Lactococcus lactis ssp. lactis* or *Lactococcus lactis ssp. cremoris*. Whey was pulled at draining and was stored as previously explained. Differences in lactic acid and galactose production were noted between culture types. *L. helveticus* produced significantly more lactic acid than the other 4 cultures in the temperature-abused whey.

L. lactis ssp. lactis did not produce any galactose in the abused whey. On the other hand, the 3 thermophilic cultures produce the highest concentrations of galactose in the temperature-abused whey. *L. lactis ssp. cremoris* produced some galactose when the whey was temperature-abused. There were no significant concentrations of galactose produced when whey was stored at 4ºC. Findings from this study help define which whey streams could potentially give more difficulty when spray-drying. Also, culture selection for cheese production may be adjusted to decrease lactic acid and galactose levels in whey.

This study also demonstrates the importance of storing whey at low temperatures prior to processing. Results from this study may be used to help minimize levels of lactic acid and galactose present in whey and thus improve quality of spray-dried whey.

Publications/Presentations

Results will be published in Rae Dawn's M.S. Thesis and a manuscript will be submitted to J. of Food Protection. Information will also be disseminated in our whey processing short courses and cheese conferences.

Texturization of butter and butter spreads

Personnel

Hartel, Richard W.

Funding

Dairy Management Inc.

Dates

April 2000 to June 2002

Objectives

The primary objective of this project is to understand how to control lipid crystallization rates during texturization of dairy spreads in order to influence the rheological properties. Specifically, the objectives are:

1. To determine the effects of processing conditions in the Gerstenberg and Agger texturizer unit on crystallization of milkfat in dairy-based spreads.

2. To correlate the rheological properties of these products to their crystalline structure, based on processing conditions, types of fats mixed together and storage conditions.

Summary

Optimal control of formation and stabilization of water-in-oil emulsions requires a good understanding of the mechanisms and kinetics of the crystallization behavior of the fats. Quality parameters, such as spreadability, hardness and firmness, are governed to a large extent by crystallization of the lipid phase in these spreads. The formulation and the processing conditions must be closely matched to provide the right type and extent of crystallization at the moment of emulsification, otherwise a spread with poor qualities will be produced. In this project, the onset of crystallization during emulsion formation in dairy-based spreads was studied.

Milkfat components used in this study were anhydrous milkfat (AMF), a high-melting milkfat fraction (HMF) and a low-melting fraction (LMF). To better understand the effects of various triacylglycerol (TAG) species on stabilization of emulsions, several other lipid components were prepared. In particular, sunflower oil was used to dilute mixtures of HMF and LMF. General composition (TAG content) of each lipid class was determined by GC analysis.

Water-in-oil emulsions (20% NaCl in the aqueous phase) without added emulsifier were prepared by mixing in a 1 L lab-scale batch reactor with agitation and temperature control. Aqueous phase contents between 10 and 70% were studied, with most experiments done at 20%. The lipid mixtures were melted at 80°C in the reactor and the desired amount of aqueous phase added. The mixture was cooled statically (no stirring) to a point just above the critical temperature for the lipid mixture. The critical temperature is defined as the point where massive crystallization takes place upon slow static cooling.

Once the temperature had reached a point just above this critical temperature (typically 20 – 30°C), the batch was cooled rapidly by switching coolant circulation in the jacket of the vessel to a refrigerated water bath (at temperatures from 6 to 20°C). Intense agitation was applied during this cooling step to promote emulsification and lipid crystallization at the same time. The emulsion was then allowed to set statically for another 20 minutes, filled into containers and cooled (statically again) to 0°C. Secondary crystallization took place during static cooling to storage temperature.

The following measurements were made:

Chemical composition

TAG analysis was performed by GC to identify the primary TAG in each lipid material used for emulsification.

Microstructural images

Polarized light microscopy was used to obtain images of the emulsion and lipid crystals during formation and storage of the spread. A small amount of sample was placed on a microscope slide and compressed slightly with a cover slip. Transmission microscopy with crossed polarizer lenses allowed imaging of the lipid crystals, water droplets and air bubbles.

Solid fat content (SFC)

SFC of each sample was measured at 0°C using a Bruker Minispec NMR. SFC of the bulk fats was measured after tempering to ensure complete solidification. Solid fat contents of emulsion products were measured directly in the NMR, even though SFC cannot be read directly due to the presence of the aqueous phase. A relative SFC was calculated by taking into account the relative extent of the aqueous phase.

Textural properties

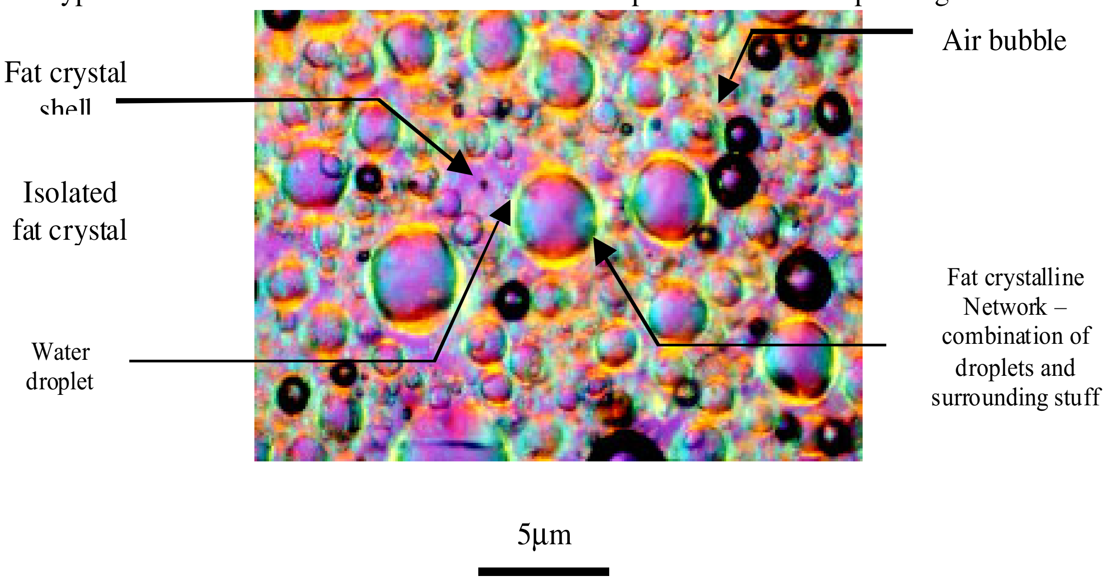
All measurements of the physical properties of the spreads were made using the TA-TX2 Texture Analyzer. Hardness was defined as the force necessary to penetrate the product at 0°C with a 12.7 mm diameter probe to a depth of 10 mm. Firmness was defined as the force necessary to penetrate the product at 22°C with a 50 mm diameter probe to a depth of 10 mm. Spreadability was measured by using matched 45° cones to generate squeezing flow of the spread. The force required to compress the product to a depth of 24 mm was used to calculate a normalized spreadability (relative to a maximum force of 500 N).

Proper emulsification (many, small water droplets) required careful coordination of the rate and extent of crystallization of the lipid mixture at the moment when the emulsion was being formed. Stabilization of the emulsion required that the proper amount of crystalline material formed at the point when the droplets were being sheared. If crystallization occurred too slowly, there was insufficient crystalline matrix to stabilize the droplets and coalescence of the droplets occurred. If crystallization occurred too rapidly, a crystalline shell formed around the droplets and the shearing action was insufficient to break them down into sufficiently small sizes. Thus, the choice of lipid components and process conditions must be matched during emulsification to produce spreads with the desired properties.

Microstructural analysis of emulsion formation

Figure 1 shows a polarized light microscope image of a product emulsion where the different elements of the spread can be seen. Water droplets, ranging in size from a few microns up to 50 µm, are surrounded by a lipid crystalline network comprised of fat crystals on the surface of the water droplets and a crystalline network between the droplets. A large portion of the lipid phase remains in the liquid form. A few air bubbles are also evident, depending on how easily air was incorporated during mixing. In general, air incorporation was minimal.

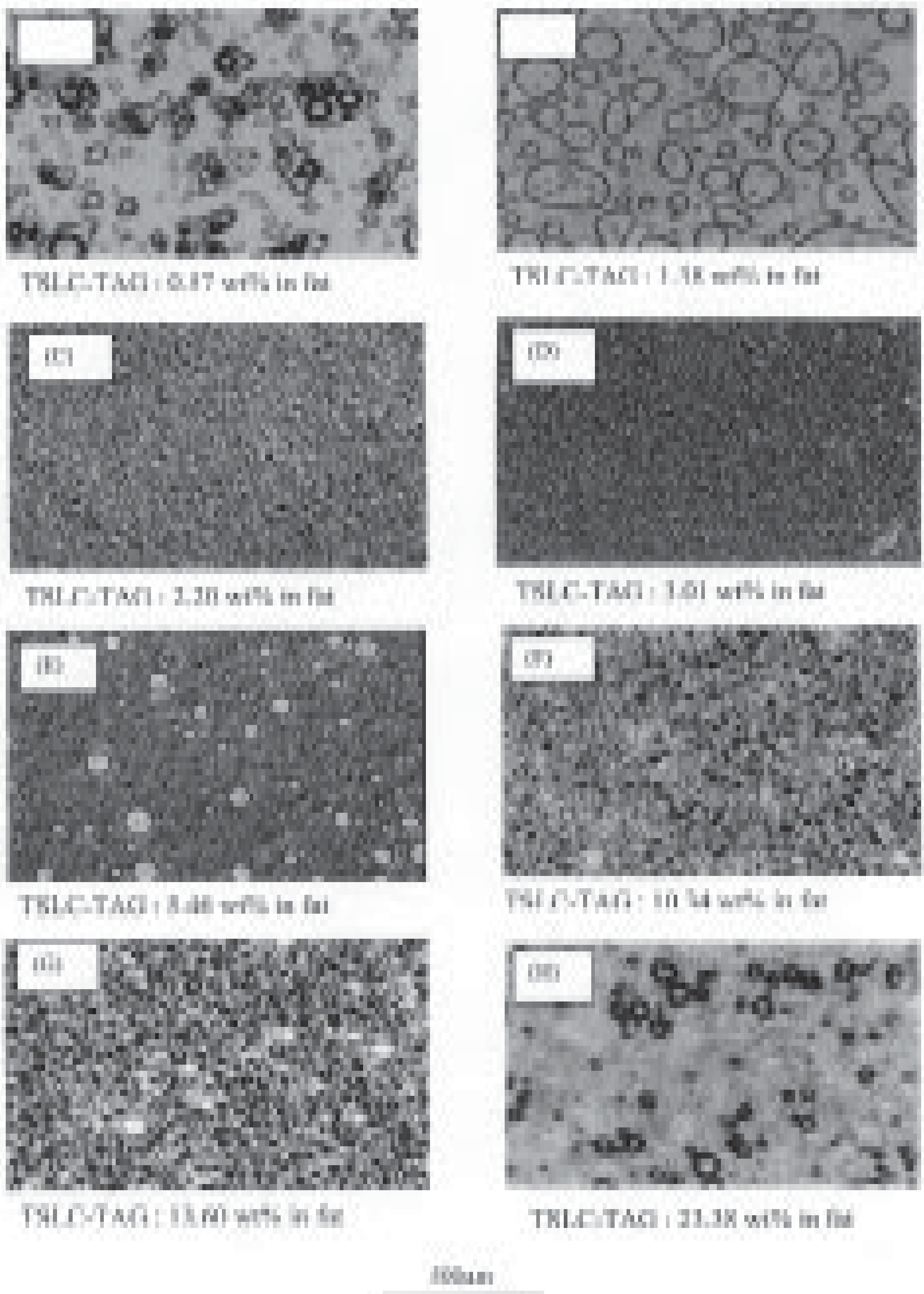
Figure 1. Typical microstructure of water-in-oil emulsion – polarized microscope image



Lipid phase composition

Coating of the emulsion droplet surface with fat crystals during emulsification was critical to stabilizing water droplets. To coat the surface, a certain portion of high-melting fat was required. This amount of high-melting fat was dependent on the amount of water dispersed in the emulsion. Figure 2 shows the effects of increasing the amount of trisaturated long-chain (TSLC) TAG in a mixture of HMF and LMF, with different levels of HMF, on emulsification with 20% aqueous phase (20% NaCl solution). At levels of TLSC less than 2%, there was insufficient high-melting fat crystallized to stabilize the emulsion. Shear forces broke the water droplets to smaller sizes, but without the fat crystals to stabilize the small droplets, coalescence occurred and larger droplets reformed. Between 2 and about 5% TSLC TAG were needed in this case to stabilize the water droplets and maintain a small size. When TLSC TAG level increased above about 5%, water droplets increased in size again since the shear forces were not able to break the droplets down to small size with the solidified fat coating their surface. The correct level of TSLC TAG was dependent on the aqueous phase content since small droplets were obtained with 7.1% TLSC TAG and 40% aqueous phase, whereas less aqueous phase resulted in larger droplets. Our preliminary experiments suggested that the ratio of water content to TSLC TAG should be in the range of 6 to 22, although further experiments might narrow this range considerably.

Figure 2. Effects of TSLC TAG concentration and water content on microstructure formation (fat matrix: HMF + LMF; aqueous phase: 20%)
TSLC TAG – trisaturated long chain triacylglycerols



Process timing

Emulsion formation follows well-defined steps under the conditions of these experiments, as long as the proper amount of high-melting lipid is used. In the first 2 minutes of shearing, water droplets were observed breaking down and coalescing. That is, under these conditions, lipid crystallization was not sufficient within the first two minutes to stabilize the droplets. However, at about 2.5 minutes, lipid crystallization occurred at a sufficient level to stabilize small droplets and a fine emulsion was formed. Agitation for an additional 15 minutes had essentially no effect on droplet size. All of the emulsification was completed within a period of a minute or two coincident with lipid crystallization.

Starting temperature

The temperature of the lipid phase prior to cooling is critical for controlling lipid crystallization at the point of emulsification. As noted above, the temperature of the lipid phase should be just above the critical temperature prior to emulsification to ensure proper timing of crystal formation. If the temperature was too high, crystallization was delayed and coalescence of water droplets occurred. If the temperature was too low, crystallization occurred before emulsification began and the emulsion could not be broken down into smaller droplets. Thus, lipid temperature and process timing are critical to obtaining the desired emulsification.

Cooling rate

To evaluate the effects of cooling rate on emulsion formation, water bath temperature was adjusted from 2 to 20°C during emulsification. The bath temperature controls the rate of cooling at the point of emulsification. In Figure 3, cooling rates associated with bath temperatures between 6 and 9°C gave the finest emulsions. Lower bath temperatures (2°C) caused crystallization that was too fast so that the finest droplets could not be formed. Bath temperatures higher than 10°C resulted in cooling rates that were too slow so that crystallization occurred too slowly and coalescence of water droplets was apparent. In a continuous texturizer, the cooling rate is governed by the cooling profile along the length of the unit. In continuous systems, cooling profile will need to be matched against the rate of crystallization for a given system.

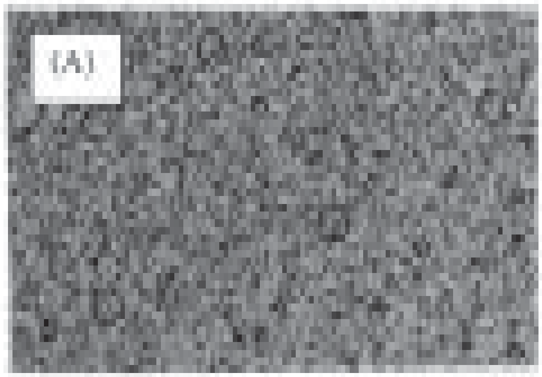
Agitation rate

The shearing process during emulsification is also important for proper emulsion formation. In general, higher shearing rate led to smaller water droplets as long as crystallization of the lipid was closely matched for the system.

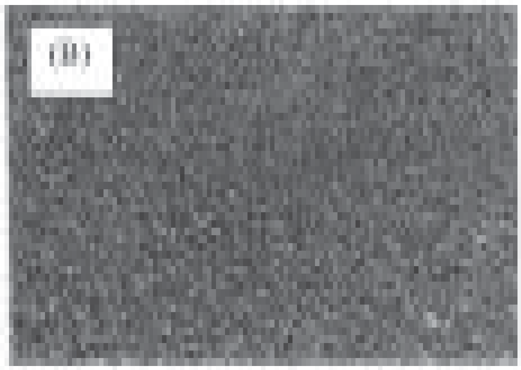
Physical properties of spreads

The amount of high-melting fat available to crystallize at the surface of the water droplets determines how well each droplet is dispersed and ultimately affects the consistency of the final spread product. Figure 4 shows the effect of aqueous phase volume on consistency of spreads made with AMF. In this case, the spreadability goes through a maximum at about 40% aqueous phase volume although firmness continues to increase across the entire range. Hardness was not affected by emulsion phase, since it is more a function of the second-

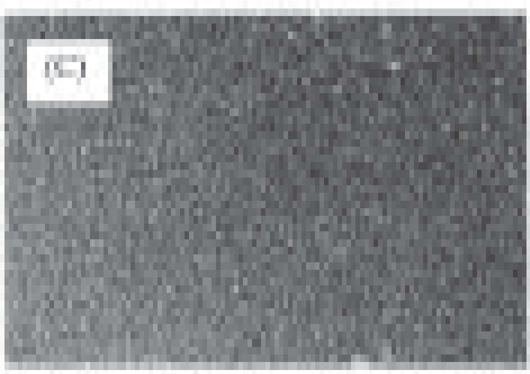
Figure 3. Effect of coolant temperature on microstructure formation (fat matrix: AMF80%+LMF60% with fixed water content)



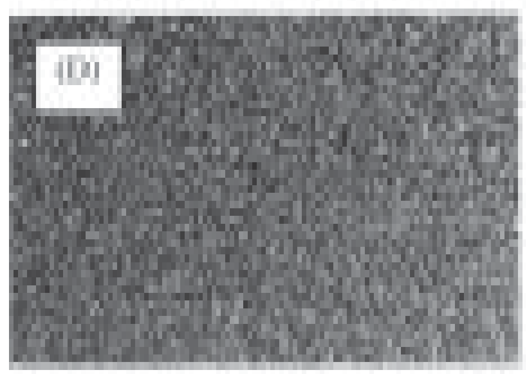
(A) Coolant temperature: 2℃
Very hard and can not spread.



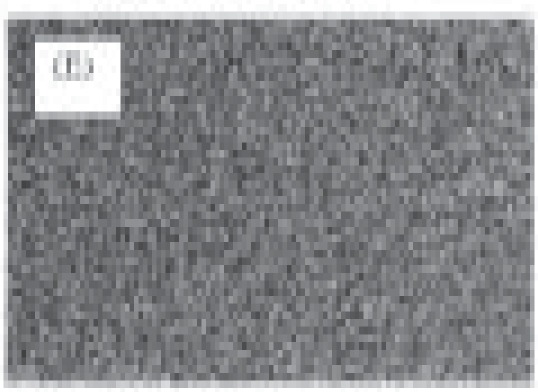
(B) Coolant temperature: 6 ℃
not too hard, can spread.



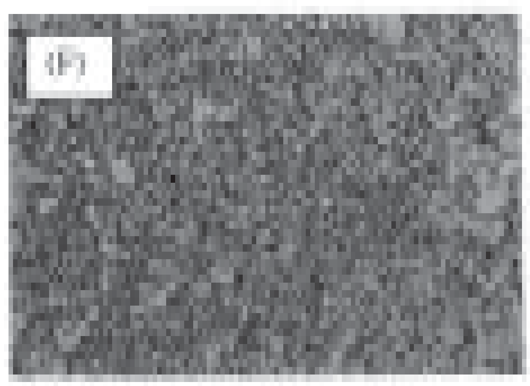
(C) Coolant temperature: 9 ℃
not too hard, can spread.



(D) Coolant temperature: 12 ℃
not too hard to spread.



(E) Coolant temperature: 16 ℃
Hard and can not spread.



(F) Coolant temperature: 20 ℃
Hard and can not spread

300µm

Figure 4. Effects of water content on microstructure formation (fat matrix: 20%HMF + 80%LMF, TSLC TAG fixed at 7.1%)

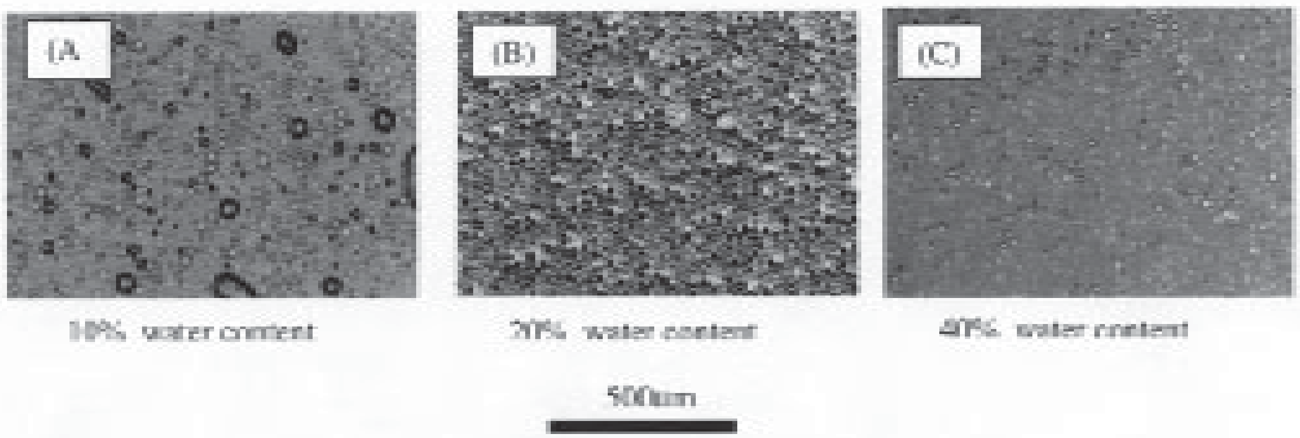
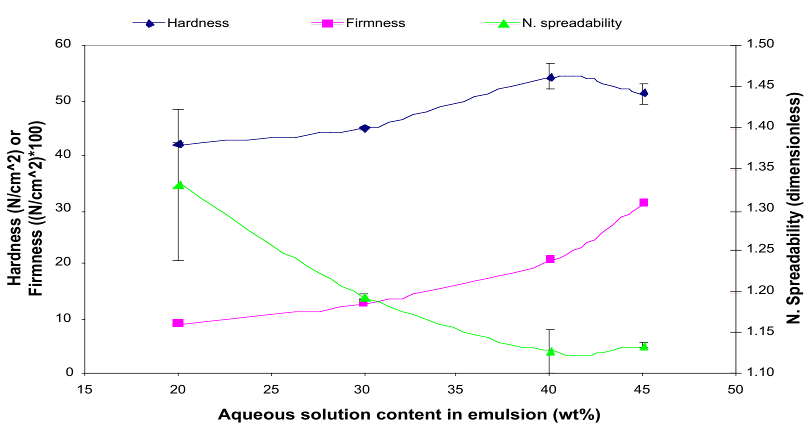


Figure 5 Textural properties vs. water content in mixture
(fat matrix: 50% AMF + 50% LMF)



ary crystallinity formed at low temperatures. Interestingly, a mixture of 50% AMF and 50% LMF has different behavior (Figure 5), with spreadability decreasing as aqueous phase volume increased. This product was also less firm due to the lower solid fat content.

Effect of high-melting TAG

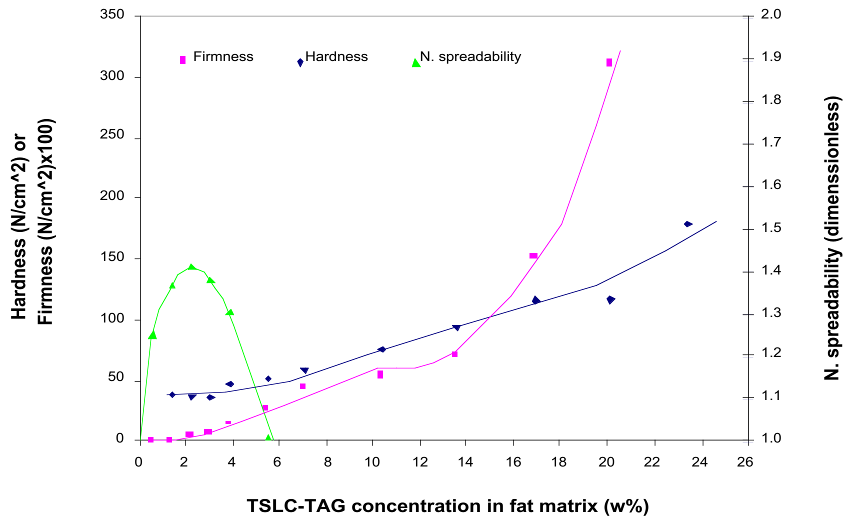
For a spread made with a blend of HMF and LMF at 20% aqueous phase, the amount of TSLC TAG had a significant effect on consistency of the final product (Figure 6). In this case, spreadability reached a maximum when the TSLC TAG content was about 2%. Higher and lower levels of TSLC TAG caused a decrease in spreadability. Subsequent experiments with model lipid systems documented that the effects of TSLC TAG on the physical properties of the spreads were highly system specific. Further work is necessary to clearly document these effects.

Effect of middle-melting TAG

The middle-melting TAG crystallize during the cooling stage and provide the secondary structure for holding together the water droplets. Disaturated long-chain (DSLC) TAG content of the lipid phase was varied to determine the effects of these structure-building components on textural properties. Increased levels of DSLC TAG in the range of 10 to 20% caused a significant increase in firmness of the spreads, only a slight increase in hardness and a substantial decrease in spreadability. Formation of too much of a secondary network structure caused substantial forming and decrease in spreadability.

Solid fat content (SFC)

Figure 6. Texture properties vs. TSLC-TAG concentration in fat matrix of (HMF + LMF) with 20% aqueous phase



Since the NMR readings on the emulsion do not necessarily represent true SFC readings, the relationship between relative SFC of the emulsion and equilibrium SFC of the bulk fat (by the IUPAC tempering method) was developed for different spread products. This relationship is shown in Figure 7. A linear relationship between the relative SFC of the spread product and the true SFC of the bulk lipid was found. However, values of SFC for the bulk fat were always higher than those found in the spreads. For comparison purposes, the relative SFC of the spread was compared against consistency parameters.

Correlation between firmness and hardness

Figure 7. Relation between SFC and NMR reading
(Varied milk fat matrixes with 20% (wt) aqueous solution)

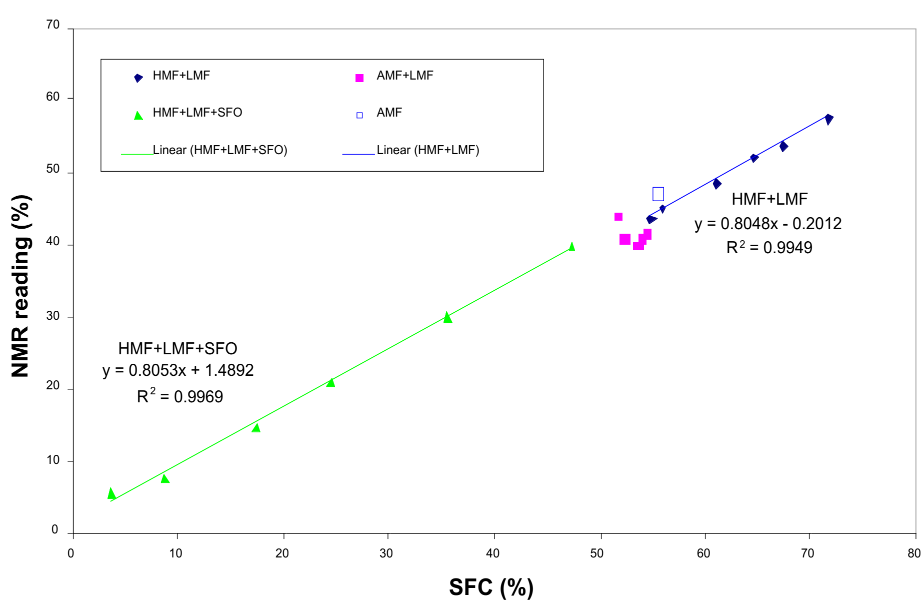
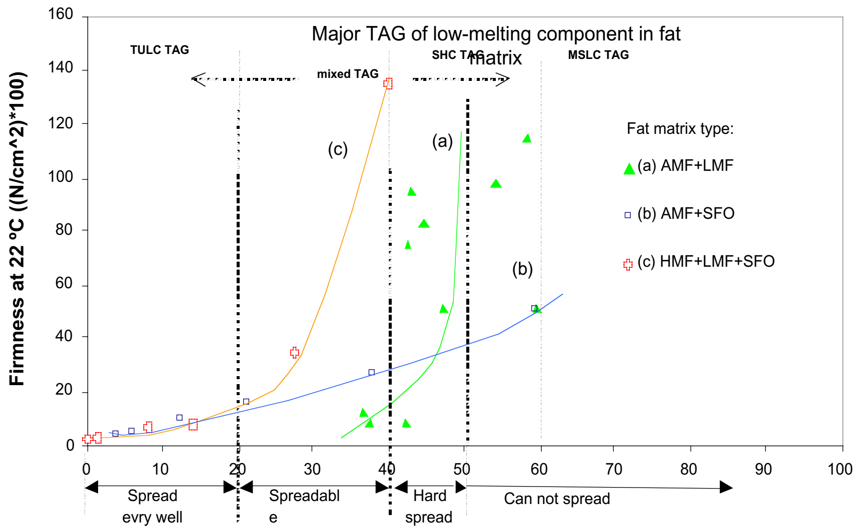
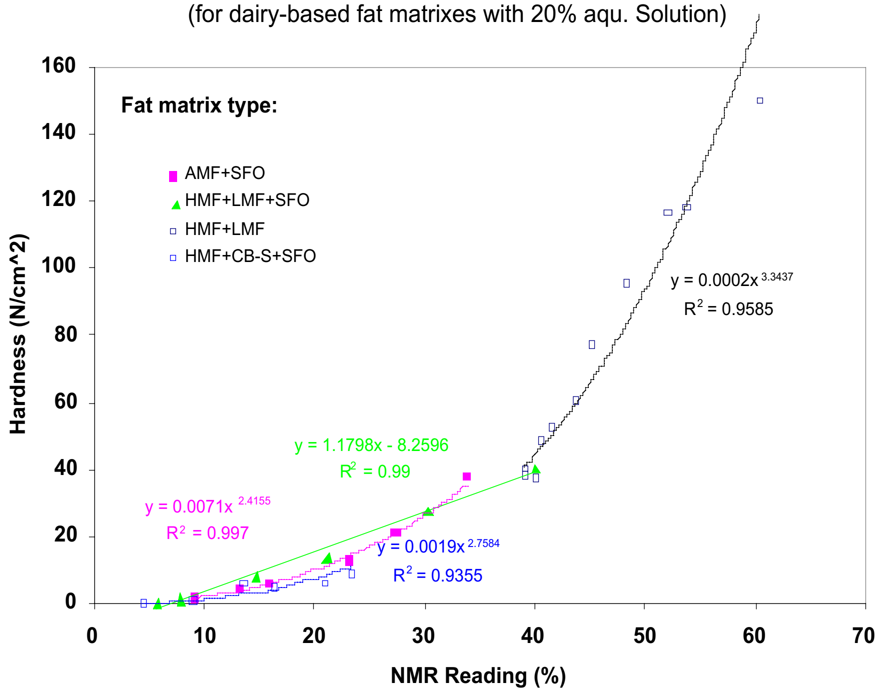


Figure 8. Firmness vs. Hradness
(for dairy-based emulsions with different fat matrix types)



The firmness values (at 22°C) of spreads made from various blends of AMF, HMF and LMF were compared against the hardness values (at 0°C), as shown in Figure 8. Some general relationships can be observed, although further work is needed to fully clarify these results. First, there is no direct correlation between the two consistency measures. Firmness is measured at 22°C and hardness at 0°C and different TAG have crystallized at these temperatures, which provides different rheological properties. Note that the mixture of AMF and LMF gives spreads in the range that are hard to spread. However, mixtures of HMF and LMF can give spreadable properties, especially when diluted with sunflower oil. AMF can also give good spreads when diluted with sunflower oil. In these products, it is the composition of the middle-melting TAG that gives this behavior since these TAG crystallize predominantly between 22 and 0°C.

Figure 9. Hardness vs. NMR Reading
(for dairy-based fat matrixes with 20% aqu. Solution)



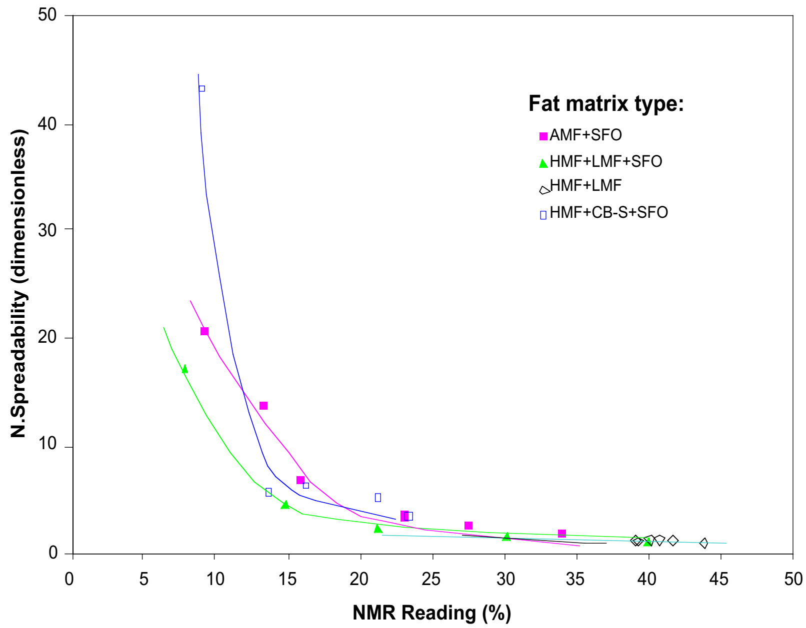
Correlation between rheological properties and SFC

In Figures 9-11, the relationships between the rheological properties and the relative SFC of the spreads are shown. For hardness, there is a reasonable correlation with SFC. However, spreadability and especially firmness to not correlate very well with SFC at all, indicating the effects of specific TAG on rheological properties.

Conclusion

In dairy-based spreads, there are several structural aspects that must be controlled (through proper formulation and process conditions) to attain the desired physical characteristics. The microstructural elements necessary for good spread properties can be summarized as follows.

Figure 10. Normalized Spreadability vs. NMR Reading
(for dairy-based fat matrixes with 20% aqu. Solution)



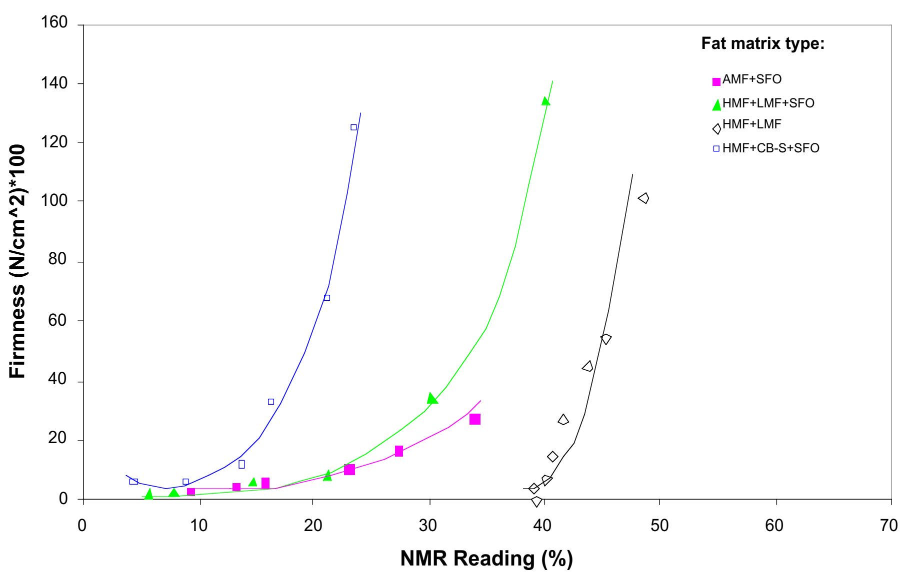
Water droplets

Water droplets form the core of the emulsion and the size and distribution of water droplets is critical to proper texture. A fine dispersion of water droplets is needed to give the desired hardness and spreadability. Careful control of lipid crystallization during emulsification is needed to ensure a fine water droplet dispersion.

Lipid crystal shell around water droplets

A shell of high-melting TAG on the surface of the water droplets is critical to stabilization of fine droplets. The extent and rate of crystallization of the few percent of high-melting TAG is critical during emulsification.

Figure 11. Firmness vs. NMR Reading
(for dairy-based fat matrixes with 20% aqu. Solution)



Lipid crystal network

A three-dimensional network of middle-melting TAG, in conjunction with the high-melting TAG shell, is necessary to give the desired physical properties.

Liquid oil phase

The oil phase acts as dispersant for the fat crystals and water droplets. Sufficient oil phase is needed to provide the desired spreadability.

Isolated fat crystals

If isolated fat crystals form in the matrix during emulsification, these act against the desired properties. These isolated fat crystals disrupt the homogeneity of the emulsion and cause loss of consistency.

Air bubbles

Too many air bubbles also are a negative factor in spread consistency. A high level of air incorporation leads to fractured and crumbly spread products.

Controlling both the formulation and processing conditions during emulsification is critical to obtaining spreads with the most desirable physical properties. However, our understanding of the relationships between TAG composition and end product characteristics is extremely limited. Based on the results of this project, the PI has been awarded a USDA Competitive Grants Program research grant (in 2002) to continue study on the specific effects caused by individual TAG on properties of spreads.

Publications/Presentations

- Shi, Y., Liang, B. and R.W. Hartel, Texturization of Water-in-Oil Based Spreads, poster presentation at Amer. Oil Chem. Soc. Annual Conference, Montreal, Canada (May, 2002).
- several manuscripts in preparation

Development of a meltability test for process cheese

Personnel

Gunasekaran, S., Hwang, C.H. and Ko, S.

Funding

Dairy Management Inc

Dates

July 2000 to July 2002

Objectives

To develop an automated cheese meltability test device and procedure that is quick, the test should be conducted within a very short time; easy , the test should be conducted easily, without requiring undue demand on operator time and/or skills; and low cost.

Summary

The UW Melt Profiler was designed to be used inside a convection oven. Due to poor convective heat transfer in the oven this procedure requires over 15 min per test. We eliminated the convection oven as the heat source, and installed direct conduction heating via foil heaters embedded inside the top and bottom metal plates. These metal plates (4-mm thick; 90-mm diameter) are in constant thermal contact with cheese sample as shown in Figure 1 and hence the sample is heated fairly quickly. Thermocouples were used to continuously monitor and control the temperature of both the cheese sample and heating plates to ensure that the sample is not scorched. To minimize any possible convective cooling to the surrounding, a shield was installed around the sample. Not requiring an oven to perform the melt test also reduced the overall cost and space requirements. In addition, the sample was more easily accessible for temperature sensing and visual observation as needed. We made cheese temperature

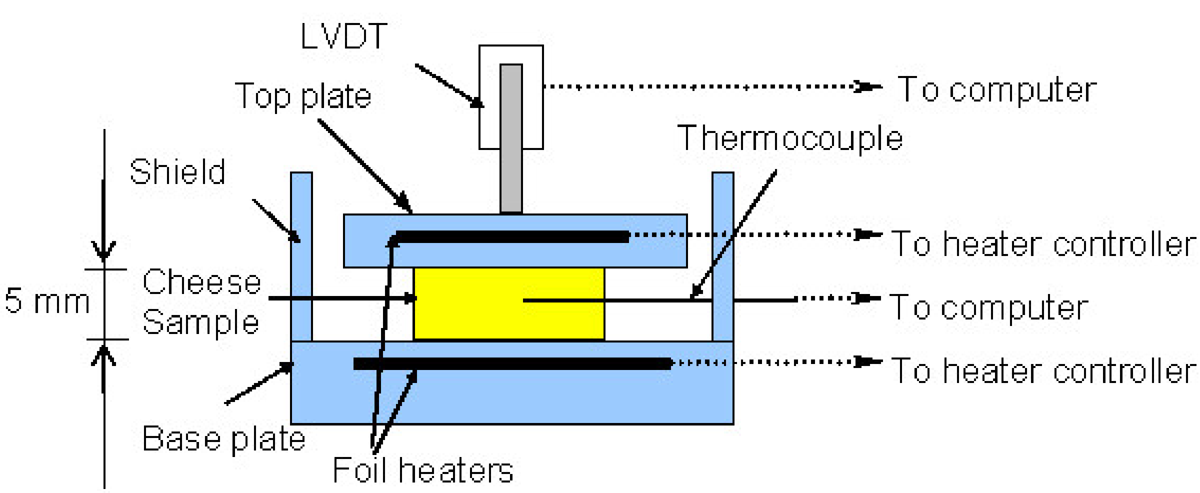


Figure 1. Schematic of the modified UW Melt Profiler device showing foil heaters embedded in the top and bottom plates for conduction heating of the cheese sample.

measurement an option needed only when parameters other than melt/flow are important. This further simplified the UW Melt Profiler test procedure under direct conduction heating. The new and old procedures are referred henceforth as “conduction test” and “convection test”, respectively.

As in the case of the convection test, a linear variable differential transducer was used for measuring sample flow (change in sample height with time). The mass of the top plate plus the LVDT rod was 87.68 g, which corresponds to an applied constant force of 0.86 N. The added mass, compared to the 70 g used in the convection test, comes from modifications needed to incorporate the foil heater.

Non-contact sensing of cheese flow

The use of LVDT to monitor the flow of melted cheese meant two things. Due to force applied on the sample for LVDT sensing, it is not possible to study the flow of cheese under gravity as would happen during melting of cheese in typical foods such as pizza. Also, the plate interferes with non-contact monitoring of cheese flow, which stymies testing multiple samples simultaneously.

However, when the top plate is not used, the test is no longer of the squeeze flow type, and in fact, reduces to that of the Schreiber test with conduction heating. Nonetheless, this was pursued because the industry would be more willing to adopt this test and can readily relate to test results. Therefore, the sample was heated by the bottom plate and was allowed to flow without any external applied force. The sample flow was monitored by two non-contact sensing techniques using: 1) a computer vision system 2) a laser deformation sensor.

The computer vision system was set up using an electronic camera and an image acquisition plug-in board. The change in cheese melt spread area was recorded continuously during melting under gravity.

The laser deformation sensing system consisted of a laser sensor, a controller, and a plug-in data logger. Initially, the laser light was used to monitor the sample height. But, due to the interference by the melting fat there was excessive noise in the signal. Therefore, the length of the sample spread at a certain location on the sample was recorded as the sample traveled under the stationary laser beam.

The computer vision system and laser sensing system are schematically illustrated in Figures 2 and 3, respectively.

Multi-sample testing

The laser sensor system described above lends itself readily for multi-sample testing. We replaced the bottom stationary heating plate (described previously) by a rotating plate (34-cm diameter; rotating speed=1.1 rpm) electrically heated from below by adapting a commercial pizza cooker, as shown in Figure 4. The rotating plate can hold up to 12 samples (each 30 mm in diameter) when placed equally spaced about 2 cm from the outer edge of the plate. The laser beam was positioned at the sample center. Due to the circular movement of the plate, the laser beam traverses an arc across the sample center, which is very close to the sample diameter. The changes in sample spread length were recorded continuously over time via a data logger.

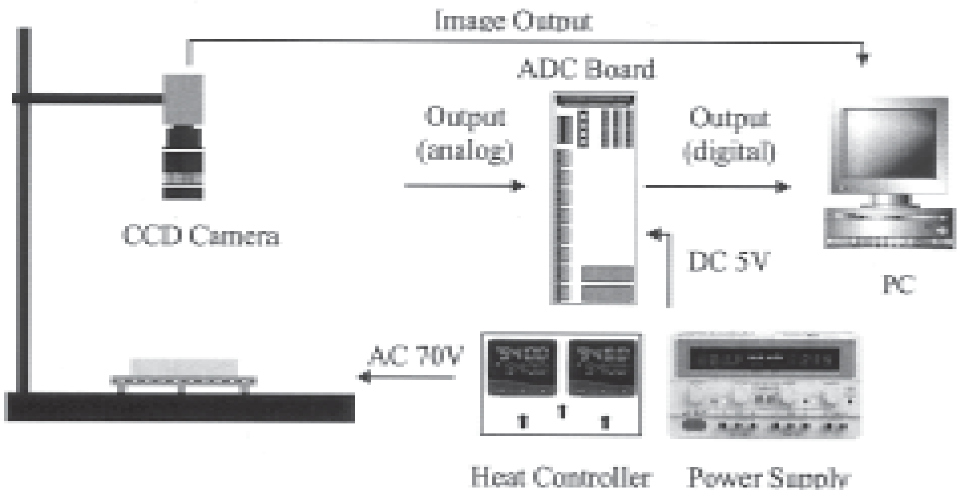


Figure 2. Schematic of the non-contact cheese flow measurement system using a computer vision system in conjunction with the conduction heating bottom plate. Associated components for temperature control and cheese melt spread area measurement are included.

The laser scanning speed was set at 100 point/s and total testing time was less than 5 min for test. The removable rotating pan was easily cleaned minimizing total test time. Additionally, this design can be improved with multiple laser beams (or by beam splitting) to traverse across the sample in a raster fashion to obtain a more representative measurement of the cheese spread.

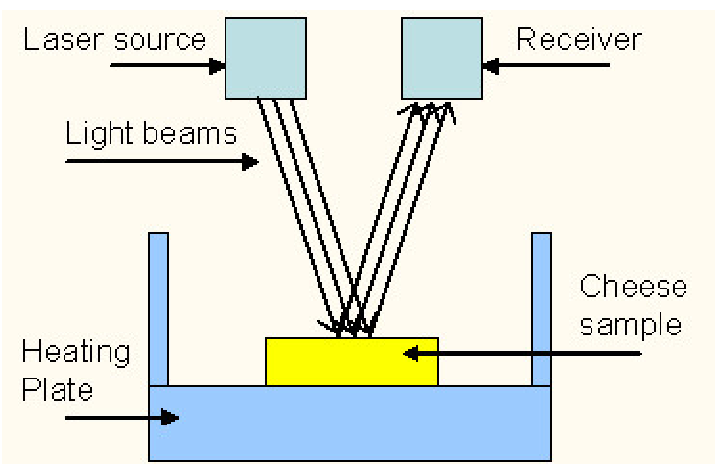


Figure 3. Schematic of the non-contact cheese flow measurement system using a laser sensor in conjunction with conduction heating bottom plate.

Experiments

Three process cheeses of different melt characteristics were obtained from local cheese plants. The process cheeses were labeled as Hi-melt (high melt), Med-melt (medium melt), and restricted melt. They were tested using all the melt test systems described above. The conduction and convection tests were conducted at 50ºC, 60ºC, 70ºC, and 80ºC. The non-contact test with the computer vision system was performed at 70ºC and the multi-sample test was performed at 80ºC. The disk-shaped (30-mm diameter; 5-mm thick) samples used for all melt tests.

For comparison purposes, the modified Schreiber test was conducted by placing the sample on a stainless steel plate and heating it in an oven at 120ºC±1ºC for 5 min. The spread area of the melt was determined using the computer vision system described above. All the tests were replicated.

Conduction test melt profile

Melt profiles of Hi-melt, Med-melt, and restricted process cheeses obtained using the conduction test are presented in Figure 5. The melt profiles obtained is similar to the typical melt profile obtained in the convection test. The profile indicates that the Hi-melt cheese flows the best. The restricted melt cheese barely moved at 70ºC test temperature, therefore the restricted melt cheese was not used for some tests. The softening point (T_{SP}), melt end point (t_{EP}), and average melt flow rate (AFR) determined for the process and natural cheeses are presented in Figures 6, 7, and 8, respectively. The trends of all three parameters are the same regardless of the test method (i.e., method of heating). However, the absolute values are significantly different. As expected the t_{EP} values were smaller for the conduction test than for convection test almost by a factor of 4 to 5 at 50 ∞C test temperature (Figure 8). The advantage of shorter test time decreases with increasing test temperature, especially for process cheeses. Another interesting observation is that the t_{EP} values for the conduction test were fairly independent of the test temperature. The melt flow does not trail off in the conduction test as long as in the convection test. This is also clear from the substantially higher AFR measured in the conduction test (Figure 7). This could be at least partly due to the higher applied force in the conduction test. As in the case of t_{EP}, the difference between conduction and convection test AFR values for the process cheeses decreased with test temperature more so than for the natural cheeses. The T_{SP} values tended to be higher with the higher test temperature (Figure 6) as previously reported for other cheeses. Also, the T_{SP} determined by the conduction test was higher than the corresponding values determined by the convection tests. This is an indication that higher heating rate accelerates the melt transition in natural and processed cheeses. However, the exact nature of this effect is not clear.

Non-contact and multi-sample measurements

The diameter and area of the melted process cheese spread measured by the vision system and the laser sensor are plotted in Figures 9 and 10, respectively. The area of spread of cheese melt under conduction heating compared well with the corresponding area measured by the Schreiber test data in terms of the expected trend (Figure 9). However, the spread areas were substantially larger when the samples were heated by conduction. This is

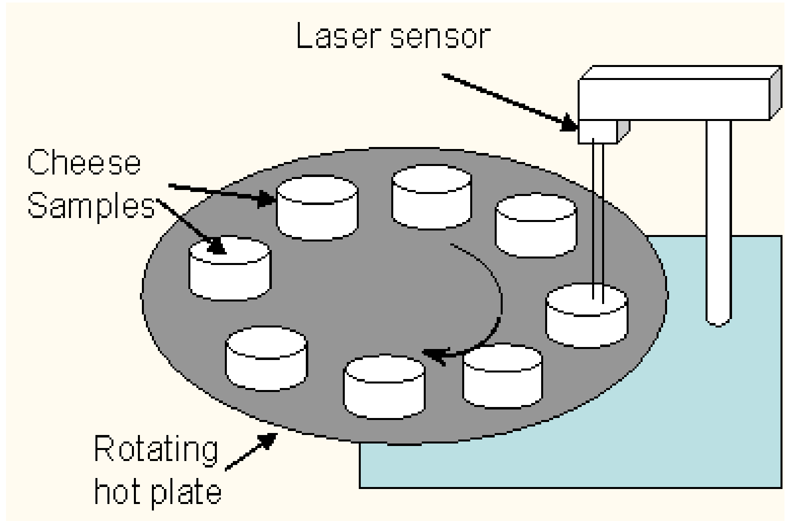


Figure 4. Multi-sample testing system with laser non-contact cheese flow sensor.

Figure 5. Typical cheese melt profiles obtained for Hi-melt, Med-melt, and restricted melt process cheeses in the conduction test.

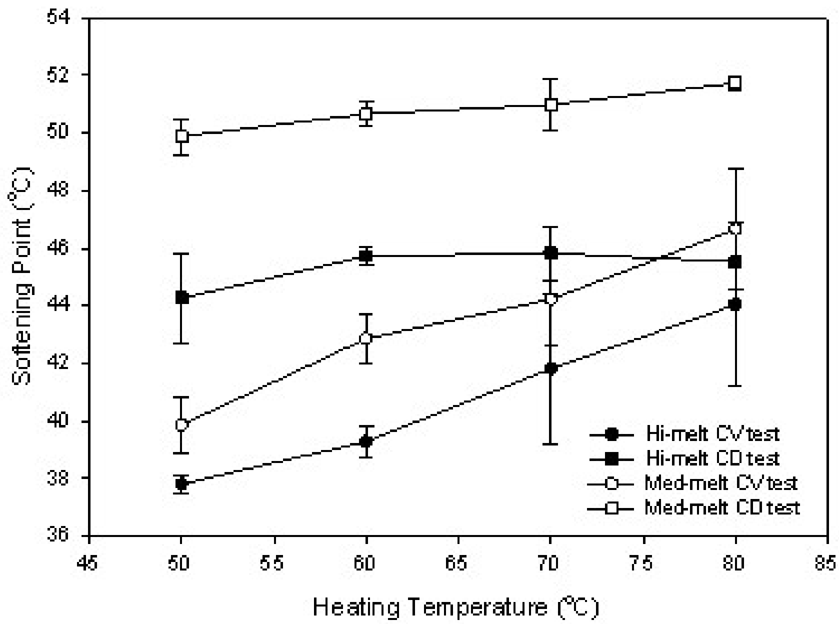


Figure 6. Softening points determined for process (top) and natural (bottom) cheeses in the conduction (CD) and convection (CV) tests.

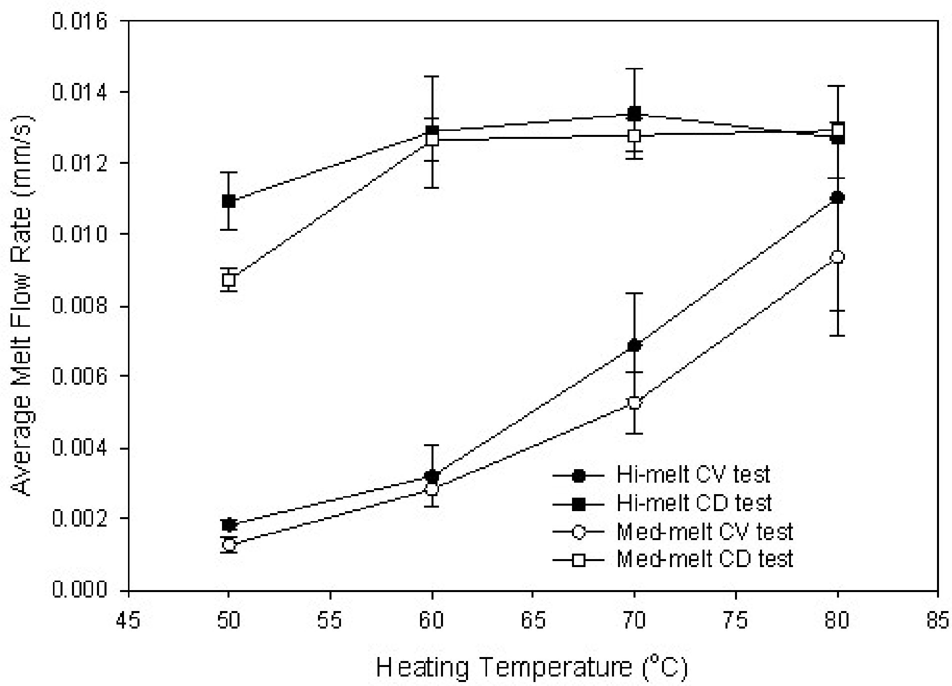


Figure 7. Average flow rate determined for process (top) and natural (bottom) cheeses in the conduction (CD) and convection (CV) tests.

particularly remarkable considering the temperature used in the conduction tests was less than the oven temperature used in the Schreiber test. This can potentially help distinguish small differences in melt/flow properties of the samples.

The multi-sample test results using the laser sensor also indicate a higher spread diameter for the Hi-melt cheese than for the Med-melt cheese. However, the data variability between tests could be a concern (Figure 10). This is because the laser scan measures the spread length across the sample at one location, which can vary from sample to sample. Problems arise, similar to those experienced with the original Schreiber test. Multiple measurements across the sample should improve the quality of test results.

Conclusions

Conduction heating improves the speed and ease of cheese melt profile measurements. When measured at the same temperature, the softening point and average flow rate of process and natural cheeses were higher and varied to a greater extent among different cheeses in the conduction test than in the convection test. Thus, the possibility of distinguishing between samples whose melt/flow properties is closer than what is possible with the convection test. The conduction test was further modified with non-contact cheese flow sensing and multi-sample testing. These modifications would allow instrument measured cheese melt/flow properties for routine quality assurance tasks in the industry.

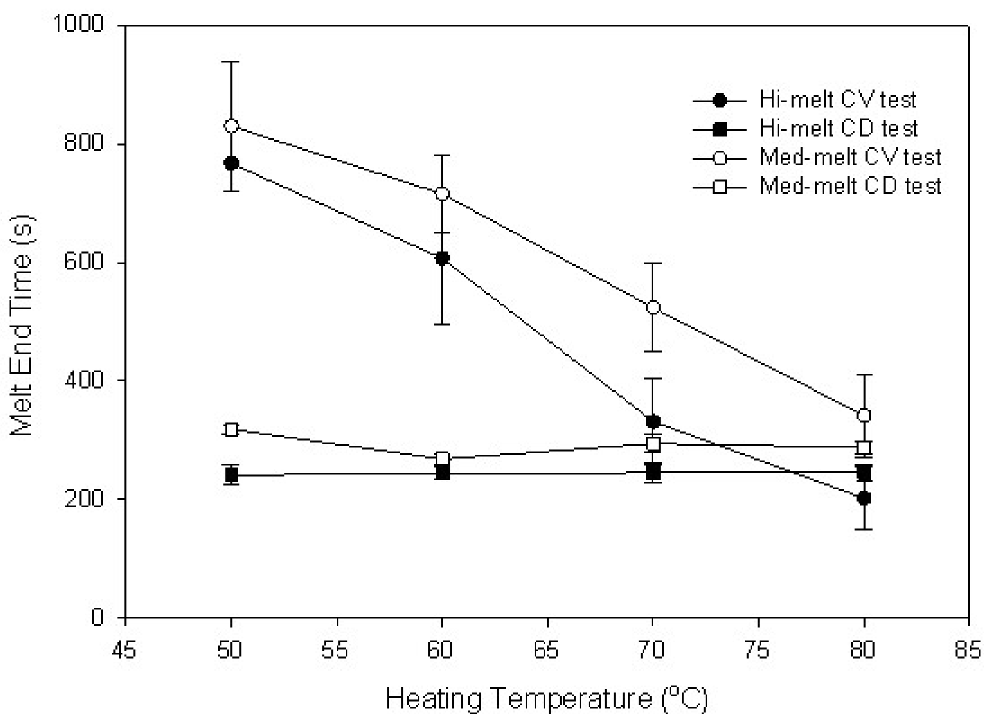


Figure 8. Melt end time determined for process (top) and natural (bottom) cheeses in the conduction (CD) and convection (CV) tests.

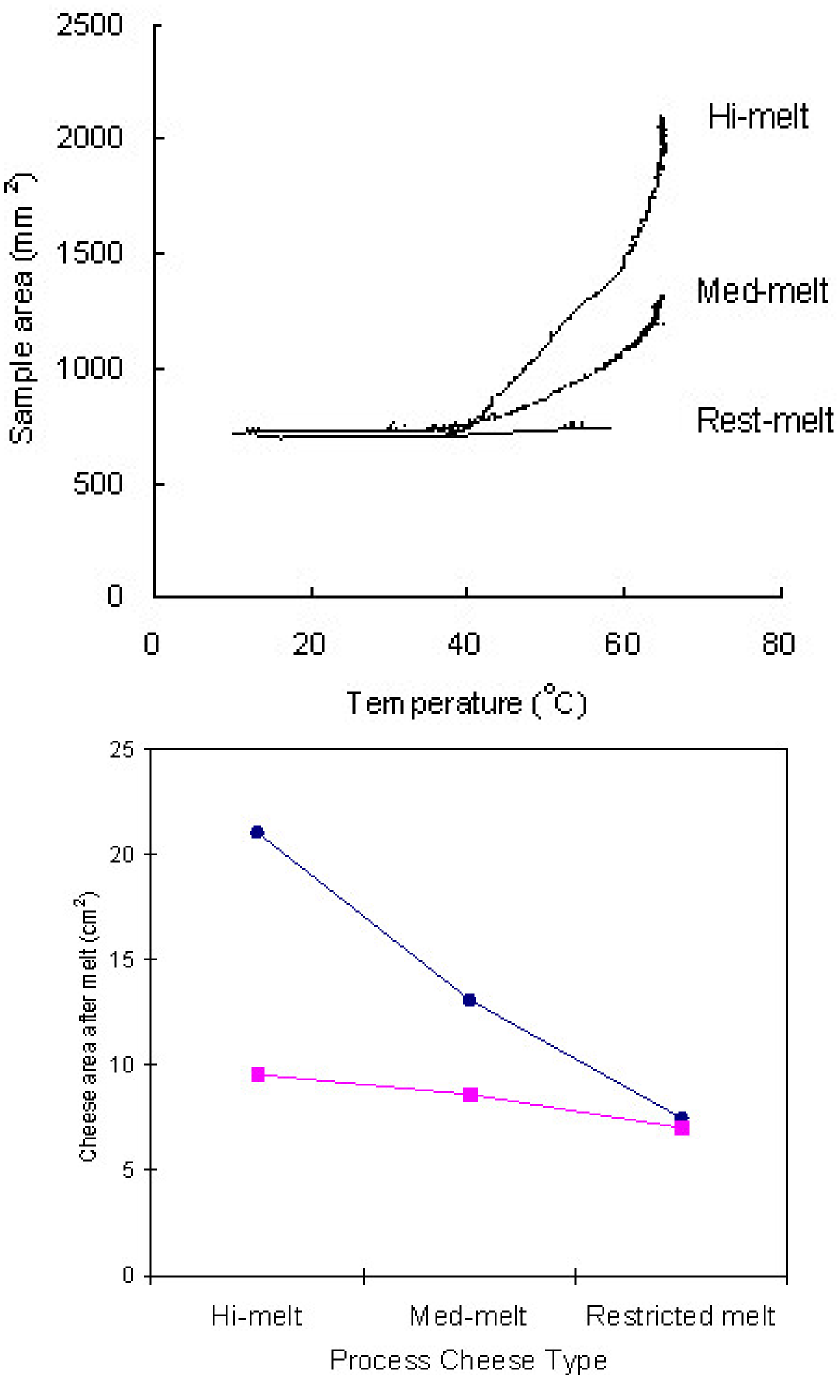


Figure 9. The cheese melt spread area measured by the computer vision system at 70 ºC as a function of temperature (top) and comparison with Schreiber test data (bottom).

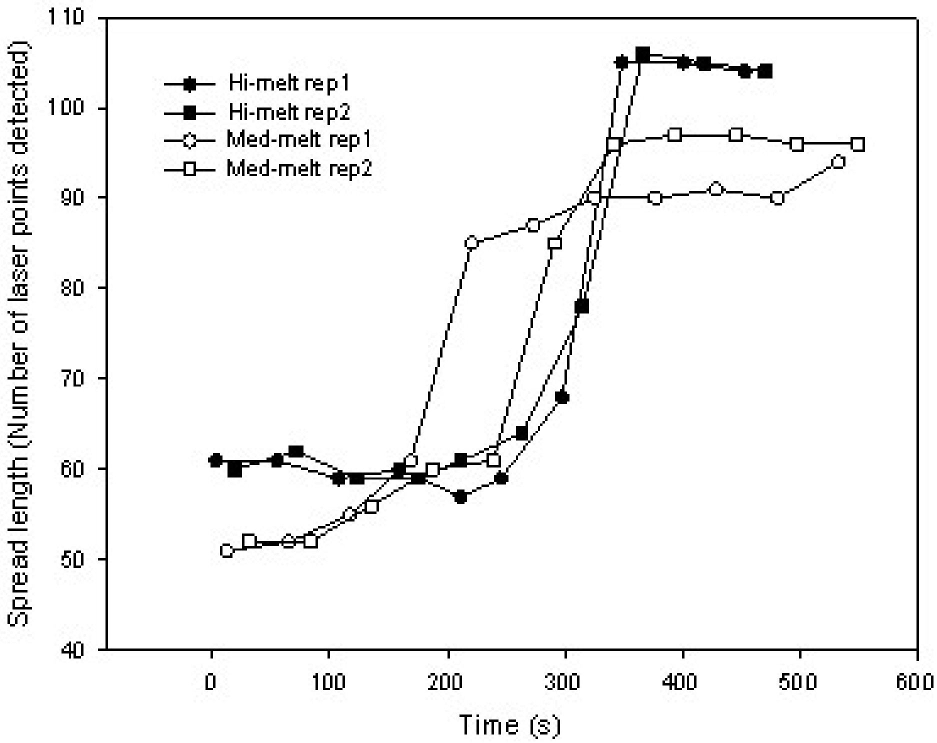


Figure 10. Cheese melts spread length vs. time of heating by the multi-sample non-contact laser sensing system performed at 80 ºC.

Publications/Presentations

Gunasekaran, S. C-H. Hwang, and S. Ko. 2002. Cheese melt/flow measurement methods – Recent development. Australian Journal of Dairy Technology 57(2):128-133.

Large amplitude nonlinear viscoelastic behavior of mozzarella cheese during twin-screw extrusion

Personnel

Gunasekaran, S., Giacomin, A.J., Osswald, T.A., Johnson, M.E. and Yu, C.

Funding

Dairy Management Inc.

Dates

April 2000 to December 2001

Objectives

1. Investigate the fundamental rheological behavior of Mozzarella cheese under large strain rates developed in a twin-screw extruder.

2. Study the effect of process variables/extrusion parameters on cheese properties.

Summary

The pasta filata process of heating and stretching of cheese curd is typical of many Italian cheese varieties such as mozzarella cheese. Curd is heated in hot water to a molten state and kneaded until it becomes an appropriate viscoelastic mass, a process which imparts unique characteristics to pasta filata cheeses. Mechnical mixers with single or twin screws are widely used for mixing. Both the heat treatment and large shear treatment are important to obtain the final properties of the cheese. To control this process better we need to know how to characterize the thermomechanical treatment (heat and large shear) and how these treatments affect rheological and other properties of the cheese.

We fabricated an open-channel twin-screw extruder similar to the cooker-stretcher used in mozzarella cheese manufacturing. This scaled down unit was designed following the specifications obtained from the Viking Machine & Design, Inc. De Pere, WI.

Characterization of thermomechanical treatments

Figures 1 and 2 show the dynamic development of the filled section (and the occurrence of the steady state) and the associated power consumption for a typical run, respectively at each of the five screw speeds and at barrel temperature 55 ºC. It is obvious that extrusion of cheese at each screw speed shows three distinct stages, first the filling stage, during which the transport rate at the feeding end exceeds the output of the stretcher, and the length of the filled section is increasing. Second is the short steady state when the filled section, the power consumption and the output are relatively constant. And finally, the emptying stage, during which the output eventually exceeds the transport rate of the feeding section when the feeding of the curd is stopped. The steady state stage could be extended if the feeding of the curd is continued at the same rate; however the amount of curd needed is beyond the capacity of this project.

At the highest screw speed, the maximum filled section length was the shortest (Fig. 1). However, there appears to be a region where the maximum filled section length is almost independent of the screw speed. The reason for this is not clear, given the approximate measurement of the filled section it is probable that this region may not exist. The time from the onset of curd addition to the beginning of steady state decreased with screw speed: 15, 10, 6, 4, and min respectively for 15, 20, 25, 30, and 40 rpm. However, the duration needed to extrude the remaining cheese curd (~10 min) was independent of the screw speed. This is typical of "starve-fed" extrusion processes in which the steady state output is set by the feeding rate and is independent of the screw speed because the extruder is operated at less than 100% of its volumetric capacity.

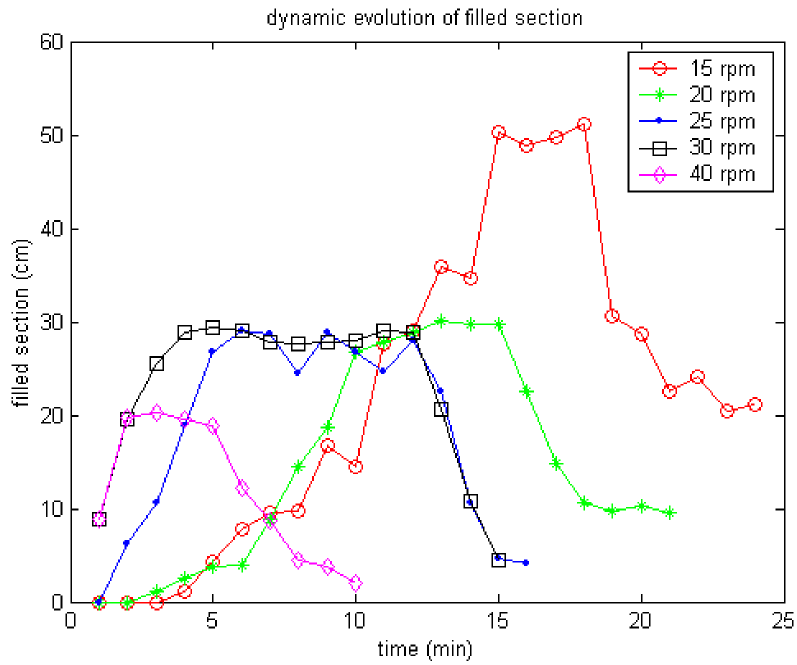


Fig. 1 Dynamic evolution of filled section at 55°C barrel temperature and at different screw speeds.

The power consumption (Fig. 2) rises rapidly as the screw flights behind the die begin to fill, especially when the screw speed is high. In our extruder, the diameter of the mold is so large that it offers no resistance to mass flow. This is a major difference between the stretcher-cookers used for cheese stretching and the typical extruders, in which the pressure build-up behind the die is significant. Therefore, during cheese stretching pressure flow can be neglected, only drag flow produced by the screw root and flights is important. As expected, power consumption increased with the screw speed.

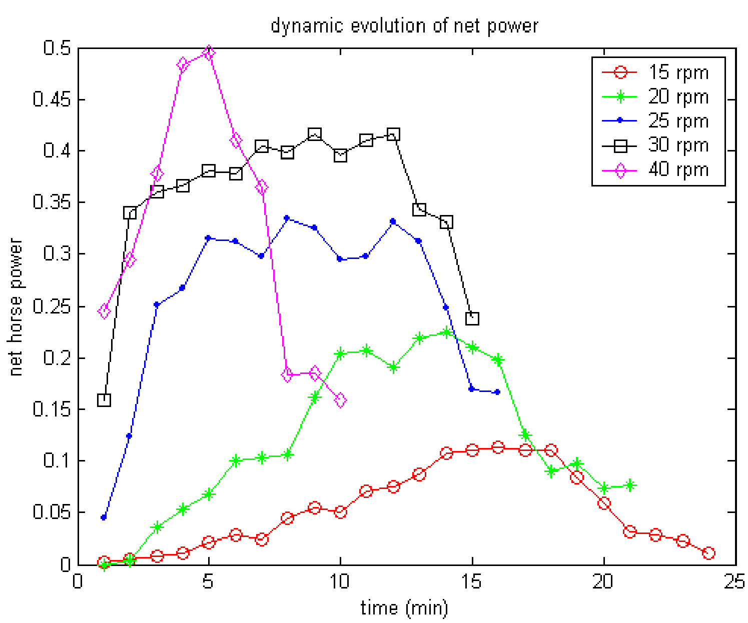


Fig. 2 Dynamic evolution of power consumption at 55°C barrel temperature and at different screw speeds.

The mean residence time in the stretcher is determined by the volume filled with material (filled section) and the actual throughput rate. Therefore the mean residence time decreases with the screw speed. Since at longer residence time more heat will be transferred from the barrel to the material, we would expect a higher exit temperature at a lower screw speed. For the barrel temperature of 62 °C, the exit temperatures of the cheese at

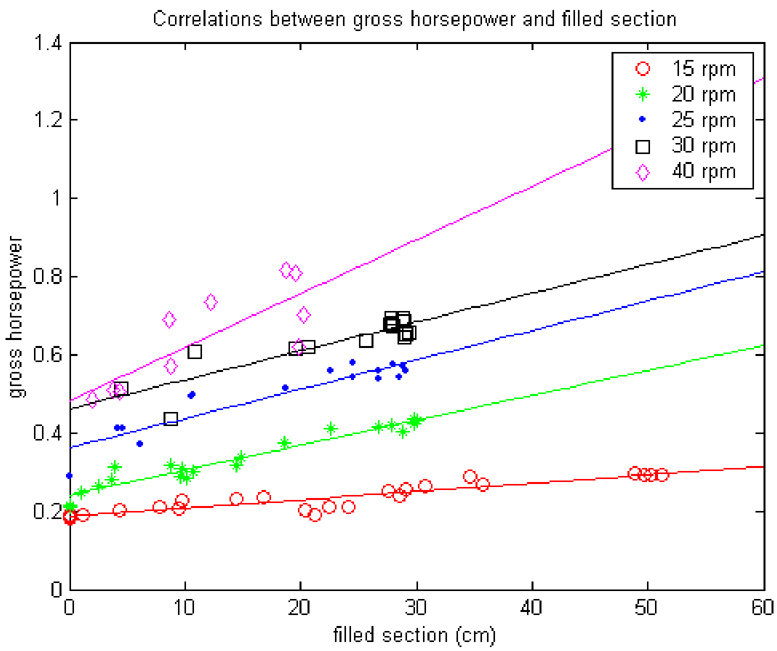


Fig. 3 Correlations between filled section length and gross horse power consumption at 55°C barrel temperature and at different screw speeds.

screw speeds 15, 20, 25, 30 and 40 rpm were 61.0 ºC, 59.7 ºC, 58.6 ºC, 57.4 ºC and 55.3 ºC, respectively.

During actual operations, the stretching of cheese curd is a continuous process, therefore the stretcher chamber is fully filled most of the time. The starve-fed condition may not hold. It is necessary to estimate power consumption for this case. Assuming the average shear stress acting on cheese curd during the process is s the power consumed is determined by:
Power = A x s x screw speed ? filled section length
where, A is a constant which can be determined experimentally for the given stretcher-cooker.

Therefore, if we plot horse power (HP) vs. filled section length (FSL), a linear relation would be expected. From this plot (Fig. 3) both average shear stress and the power consumption for filled channel could be estimated. Although some scatter is observed due to the approximate measurement and control of FSL and feeding rate, good linear correlations exist for screw speeds, especially when screw speed is small. By extrapolating to the full length of the stretcher channel we can estimate the power requirement for continuous operation of the stretcher at each screw speed are as follows.

Screw speed = 15 rpm: HP = 0.0021*FSL + 0.1865; R^2 = 0.938
Screw speed = 20 rpm: HP = 0.0064*FSL + 0.2413; R^2 = 0.937
Screw speed = 25 rpm: HP = 0.0075*FSL + 0.3620; R^2 = 0.846
Screw speed = 30 rpm: HP = 0.0074*FS + 0.4622; R^2 = 0.765
Screw speed = 40 rpm: HP = 0.0137*FSL + 0.4818; R^2 = 0.746

Apparently the dynamic process of stretching should also depend on the thermal conditions, that is to say the barrel temperature. Therefore we presented the HP vs. FSL plot at 25 rpm for 3 barrel temperatures, 55 ºC, 62 ºC and 72 ºC (Figure 4). The differences between barrel temperature and exit temperature increased with the barrel temperature (Table 1), but at higher screw speed this difference is less significant. It is perhaps due to a combination of the deep channel geometry and the generally lower residence time at higher temperatures, both of which limit the amount of thermal energy that can be transferred to the melt. At higher screw speed, the difference in residence time due to different barrel temperatures is less significant, thus led to a more uniform temperature differences. We also determined that the power consumption decreased appreciably as the melt temperature increased. The changes in power consumption reflect directly the changes in shear stress acting on the cheese during the process. They depend on the rheological properties of the cheese, which is a complex viscoelastic material. As expected, thermomechanical treatment had influenced the rheological properties of the cheese curd significantly so that the power consumption is a strong function of the barrel temperature.

As above the linear regression was used to determine whether the power consumption was correlated with the length of filled section for different barrel temperatures. Again, reasonably good fits were achieved.

Screw speed = 25 rpm
Barrel temperature = 55 °C:HP = 0.0075*FS + 0.362 $R^2 = 0.846$
Barrel temperature = 62 °C:HP = 0.0057*FS + 0.272 $R^2 = 0.819$
Barrel temperature = 72 °C:HP = 0.0036*FS + 0.244 $R^2 = 0.894$

Screw speed = 40 rpm
Barrel temperature = 55 °C:HP = 0.0137*FS + 0.482 $R^2 = 0.746$
Barrel temperature = 62 °C:HP = 0.0098*FS + 0.379 $R^2 = 0.765$
Barrel temperature = 72 °C:HP = 0.0077*FS + 0.347 $R^2 = 0.754$

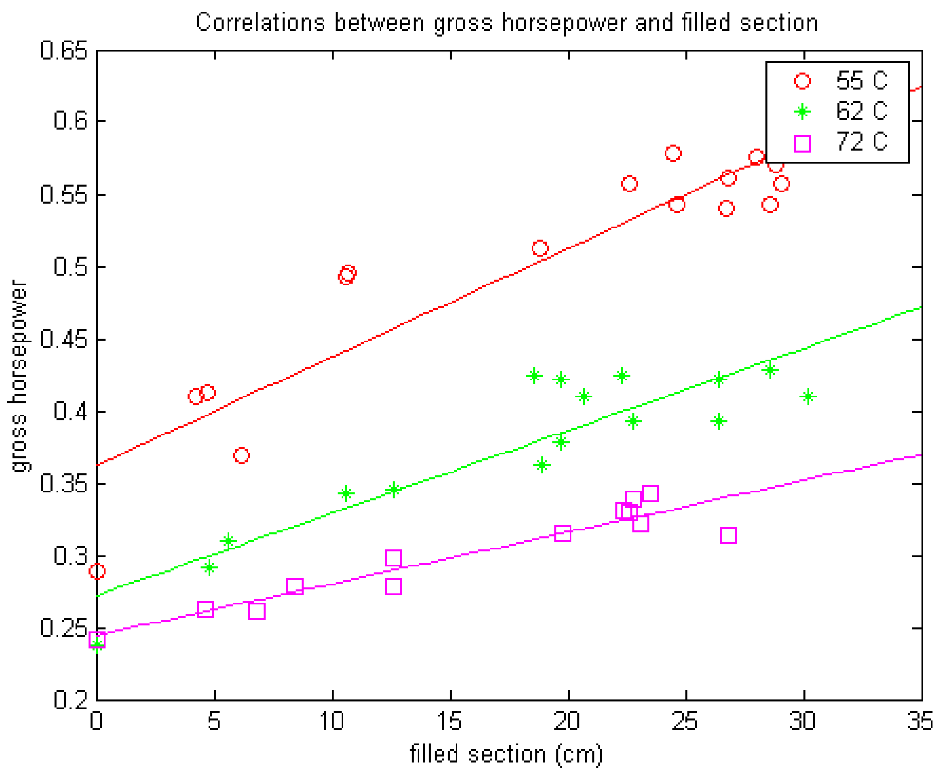


Fig. 4 Correlation between gross horse power consumption and filled section length at different barrel temperatures at 25 rpm

Table 1. Difference between exit temperature and barrel temperature

RPM	Barrel Temperature (°C) 55	62	72
25	2.4	3.4	4.8
40	6.4	6.7	7.2

System analysis

In thermomechanical processes, it is important to identify system variables that characterize the process independent of scale. Although screw speed and barrel temperature are the manipulated variables in these experiments, they are not system variables. According to Mulvaney et al. (1997), most important system variables for the stretching of mozzarella cheese are SME (specific mechanic energy) and TE (temperature of curd mass at exit). The SME is indicative of the shear stress for the treatment therefore it characterizes the mechanical treatment and the TE is indicative of the total thermal treatment. Fig.5 shows how SME increases with the screw speed. This change in mechanical treatment as the screw speed changes may affect the development of fibrous structure of the cheese and its functional properties. However, since cheese is viscoelastic, to analyze the effects of the mechanical treatment it is also important to know the ratio of the strain energy (represented by SME) is imparted to the cheese which is stored as elastic, or recoverable energy, and how much is dissipated as flow which is also contribute to the exit temperature. Mulvaney et al. (1997) proposed that development of a fibrous structure would be enhanced by viscous flow. The data in Fig. 5 show large deviation from average in the 3 runs, it is mainly due to the difficulties in reproducing runs on different days without automatic control of the curd feeding rate.

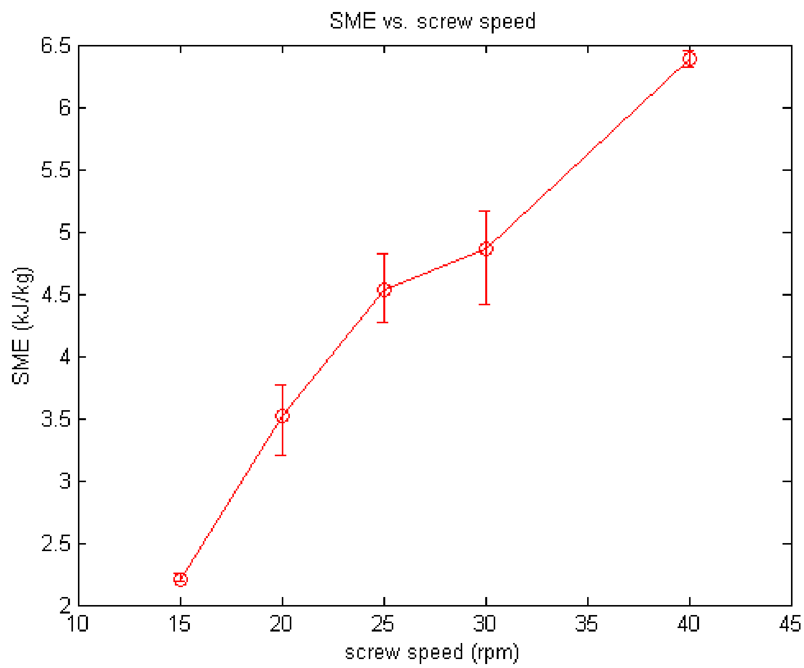


Fig. 5 Effect of screw speed on SME (specific mechanical energy) at 55°C barrel temperature

Figures 6 and 7 show how the cheese exit temperature and SME varied with changes in barrel temperature, respectively. Clearly, the main result is that an increase in barrel temperature resulted in a linear increase in the exit temperature and a significant decrease in SME. At higher screw speed, the exit temperature is lower than that at lower screw speed for the same barrel temperature. This may be caused by the shorter residence time at higher screw speed which led to less heat was transferred into the material. As to the SME, higher temperature changes the rheological properties of the cheese, therefore it affects the SME. As it suggests that SME depends on both screw speed and barrel temperature, different combination of screw speed and barrel temperature may create the same SME and can be considered equivalent in term of mechanical treatment of the cheese. This shows the need for close control of the thermomechanical processes based on system variables instead of operating variables.

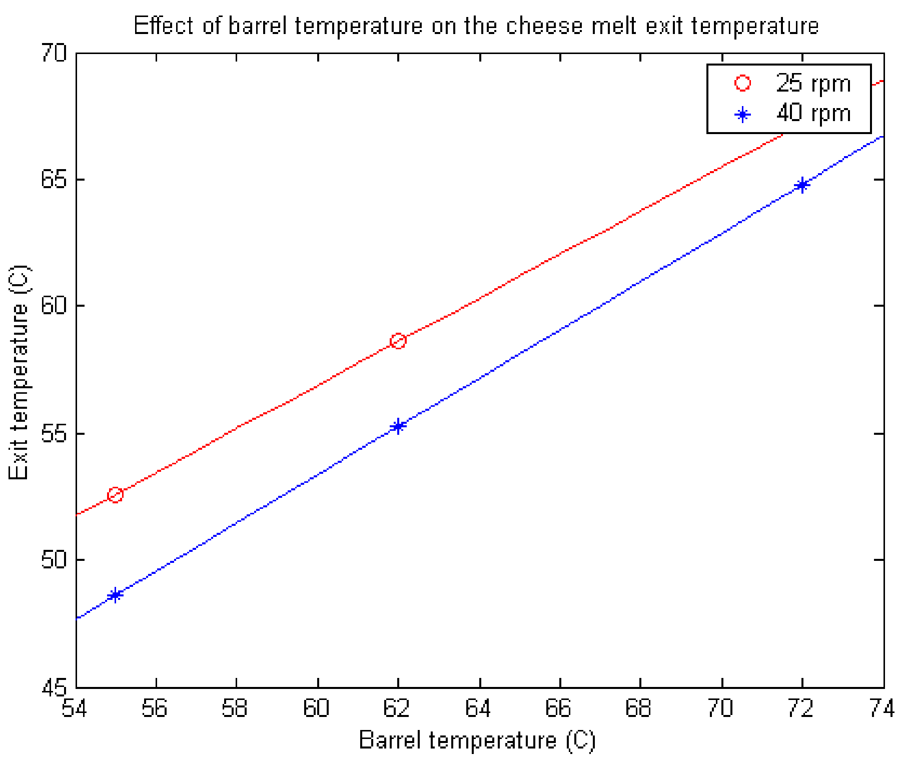


Fig. 6 Effect of barrel temperature on exit temperature of cheese at to screw speeds.

Melt rheological properties

It is extremely difficult to obtain on-line rheological data for stretching process, especially for such a complex viscoelastic material as cheese, since its rheological

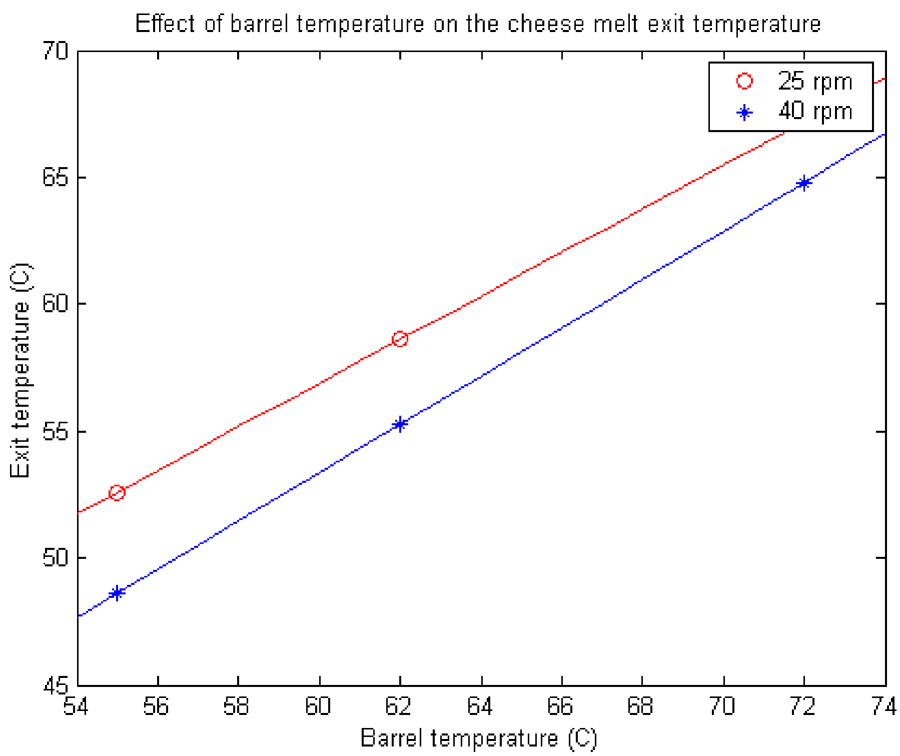


Fig. 6 Effect of barrel temperature on exit temperature of cheese at to screw speeds.

properties are strongly affected by temperature and shear rate. However, it is very important to get at least some qualitative estimate of what the rheological properties of the cheese curd melt within the stretcher chamber might have been in order to analyze the process more accurately. Therefore, Mozzarella cheese samples for each screw speed were subjected to frequency sweep tests at 50, 60 and 70 °C at 1 day after extrusion. These temperatures covered the temperature range used in these stretching experiments. The G' (shear storage modulus) and h' (real part of the dynamic complex viscosity) for a simple sample extruded at 30 rpm was shown in Fig. 8. Results are similar for the other screw speeds as well.

Apparently viscoelastic properties of the cheese are strongly affected by both temperature and frequency in range of interest for stretching Mozzarella cheese. In real operation screw speed is proportional to the steady state shear rate, which is qualitatively represented by the frequency in SAOS tests.

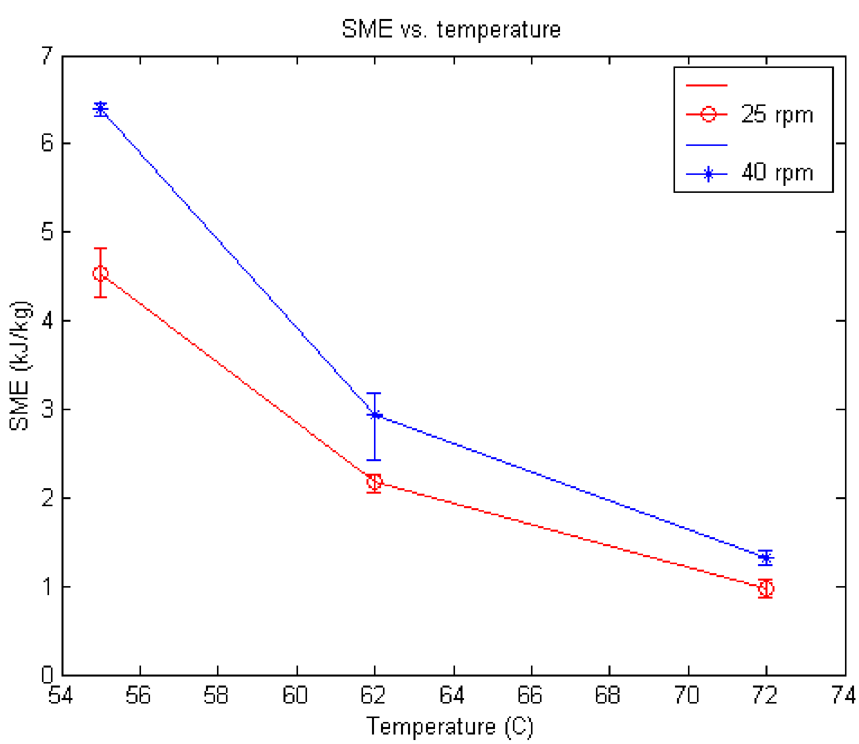


Fig. 7 Effect of barrel temperature on SME (specific mechanical energy) at two screw speeds.

The G' represents the elastic energy which is stored during the process and h' represents the energy which is dissipated as heat. From Fig. 8 we can see that the amount of stored energy would be increased as the screw speed increases and as the temperature decreases. This suggests that when extrusion is carried on at low temperature and high screw speed, the material produced would be more elastic, favoring

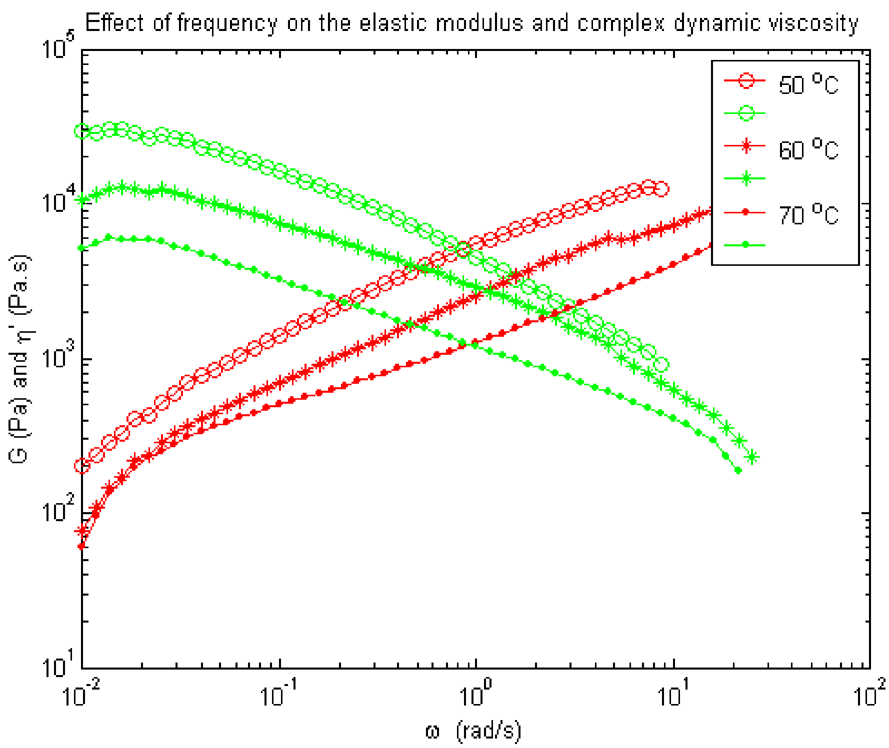


Fig. 8 Dynamic rheological data (storage modulus, G' and a component of dynamic viscosity, η') as a function of frequency (ω) for cheese samples extruded at 30 rpm and 55°C

energy storage during mixing; on the contrary extrusion at high temperature and low screw speed would promote viscous flow and perhaps results in less mechanical degradation of the casein molecules. Also, because higher temperatures resulted in lower G' and h', higher screw speed could be used at higher temperatures while still maintaining low shear stress, which also means low SME, as shown in Fig. 7, operation at 72°C and 40 rpm had almost same SME value as operation at 62°C and 25 rpm.

Effects of thermomechanical treatment

The initial elastic modulus, G_0 represents the ideal elastic behavior of the cheese at small strains and short time, and is supposed to directly relate to the network structure of the cheese. It was proposed that G_0 is related to the number of temporary physical cross-links in the cheese. The plot of G_0 vs. SME and TE is given in Fig. 9. It can be seen that G_0 is higher at higher exit temperature (when SMEs are equally small) or higher SME (when temperatures are equally small). The dependence of G_0 on temperature appears to be more sensitive than that on SME. Fig. 9 suggests that a more elastic network structure can be imparted to Mozzarella cheese with relatively low energy input at higher temperature, but higher energy inputs are required to obtain an equivalent G_0 at lower temperatures.

Effects of thermomechanical treatments on compositional properties
The thermomechanical treatments during stretching process strongly affect cheese moisture content (MC) and fat-in-the-dry matter (FDM) but not the cheese pH, salt and calcium contents (Renda et al., 1997). In general, cheese MC and FDM decreased as the mixer speed increased. However, as we mentioned above screw speed is not system variable, we need to know how composition of cheese will be affected by changes in system variables such as SME and TE. The relation between MC and

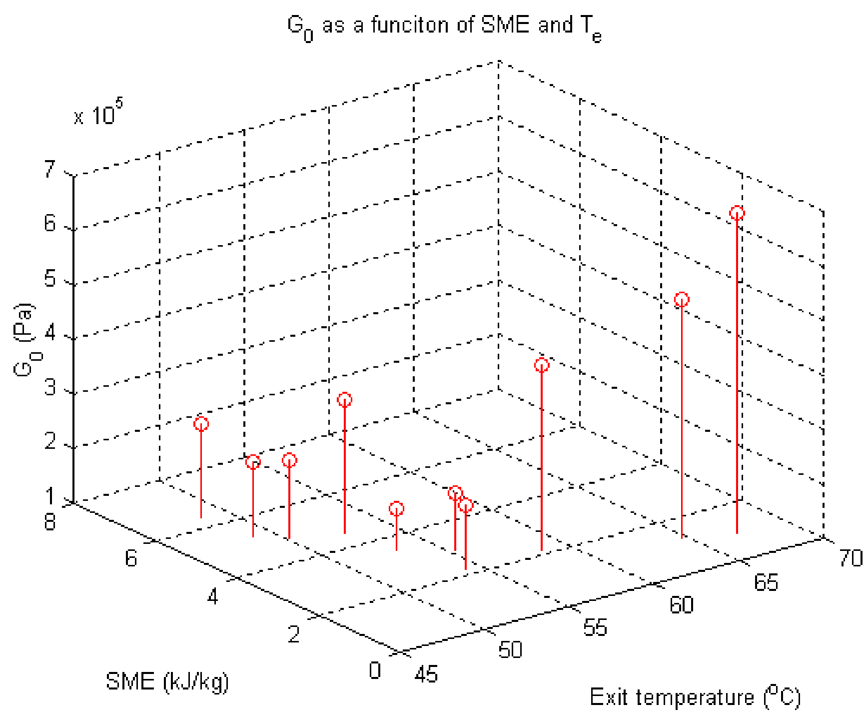


Fig. 9 Effects of TE (cheese curd exit temperature) and SME (specific mechanical energy) on G0 (initial elastic modulus)

SME and TE were obtained by a linear and second-order regression analyses, respectively with reasonable fits:

MC (%) = -0.5167*SME + 49.1697 R^2 = 0.781

MC (%) = -0.0081*TE^2 + 1.059*TE + 13.7523 R^2 = 0.687

The 2nd order polynomials were used to characterize the relations between FDM and TE and SME.

FDM (%) = -0.0215*TE^2 + 2.313*TE – 21.557 R^2 = 0.544

FDM (%) = -0.4043*SME^2 + 3.168*SME + 34.873 R^2 = 0.592

These fits for FDM are not as good as those for moisture content. It might be because FDM is more sensitive to changes in experimental conditions. However, it can be said that there exists optimal SME and TE values for maximizing fat content, which will lead to less fat loss and higher cheese yield. This is reasonable because fat distribution in the cheese significantly depends on the thermomechanical treatment, under optimum conditions fat globule will be most uniformly dispersed and distributed in the protein network so that largest fat content can be achieved.

Publications/Presentations

Yu C and S Gunasekaran. 2002. Modeling of melt conveying in a deep-channel single screw cheese stretcher. J. Food Engineering (submitted).

Other manuscripts and a Ph.D. thesis are under preparation.

Chapter Three

Applications

annual report 2002

Whey Applications Research Program

Personnel

Kimberlee J. Burrington, coordinator, Karen Smith, PhD, researcher, Kathy Nelson, research specialist

Funding

Wisconsin Milk Marketing Board, Dairy Management, Inc.

Dates

January 2002 to December 2002

Objectives

1. Enhance the value of whey-derived ingredients by providing technical support to the whey processing industry. Provide processing and applications support for whey, permeate, lactose, whey protein concentrate, whey protein isolate, and whey protein fractions.

2. Conduct industry directed whey applications projects, which evaluate the functional attributes of specific whey ingredients in finished food systems. Areas of food applications for whey ingredients are dairy and bakery products, beverages, soups, sauces, meats, nutraceuticals, and infant formula.

3. Initiate development of a pilot plant facility which provides the ability to conduct whey processing projects with industry, for the evaluation of existing and new processing conditions. The pilot plant should be able to process whey from the cheese vat to the spray dried ingredient.

Summary

This year completed the fifth year of the Whey Applications program. In 2002, the Whey Applications program was contacted by 31 Wisconsin-based companies and 96 national companies, consisting of whey processors, ingredient suppliers, end-users, equipment manufacturers, ingredient companies, associations, government organizations, universities, and the press. Contacts were increased by 31% over last year.

Whey applications were developed and presented at the following events, seminars, and companies: two USDEC Mission Groups, Dairy Farmers of America, WMMB Board Members visit, Heinz, Sara Lee, Tyson Foods, WI Whey Utilization Short Course, and IFT. Applications development focused on energy bars, sports drinks, confections, batters and breadings, and pizza crust. One specific project, Development Of Foods For The PKU (Phenylketonuria) Diet Using Glycomacropeptide was done with the cooperation of the UW-Waisman Center and their PKU patients and families. Glycomacropeptide became a domestic whey ingredient in 2002, making it available for applications development at the CDR. Glycomacropeptide is currently the only food protein that is free of phenylalanine, so it is the only suitable food protein that can be used in the PKU diet. Work will continue on this project in 2003. General whey processing, functionality, applications, and nutrition information were presented 32 times over the course of the year, a 45% increase over last year.

Processing support has involved completion of the whey processing pilot plant. Full utilization of the equipment started with internal use for short courses and instruction. Industry projects began in the second half of the year, with 11 separate trials conducted in September through December. Many of the needs of the whey processors and end-users have been informational needs. Typical requests are for standard methods for chemical and functional analysis, specifications, whey ingredient sources, literature searches, formulations for specific applications, and processing trouble-shooting questions. Membrane processing support is also provided to the CDR cheese group on all projects using ultrafiltered milk, buttermilk, and whey-based fluids.

Presentations

Karen Smith, Ph.D.
Top 10 Tales from the Front-DMI Dried Dairy Ingredients Forum, January 8

Recovering High Value Whey Components from Whey, Alto Dairy, March 12.

Membrane Processing, Evaporation and Drying Lab, Chemistry and Technology of Dairy products Course, UW-Food Science Mar 8, 22, April 5.

Challenges in the Workplace, Food Science 601, April 2.

Overview of Whey Processing, for Dennis Buegge-UW Meat And Animal Science, April 10.

Fractionating the Components of Whey to Maximize Value, International Cheese Technology Expo, April 23-25.

Spray Drying Dairy Products, Food Engineering, April 30.

Fractionating Whey Into Value Added Components, DFA Presentation, June 6.

Processing Whey into Value-Added Ingredients, USDEC Mission Group, June 12.

Milk Proteins and the Future of Wisconsin's Dairy Industry, Wisconsin Dairy Products Association Annual Meeting, August 13.

Evaporation and Drying of Whey Products, 12. Processing Whey into Value-Added Products, 13. Processing Parameters Impacting Functionality, Wisconsin Whey Utilization Short Course, May 8.

Principles of Membrane Separation, 15. Membrane Processing of Dairy Products, 16. Minor Whey Protein Fractionation, 17. RO/UF/MF in the Dairy Plant, Membrane Processing Short Course, October 29,30.

Processing Whey Into Value-Added Ingredients, USDEC Mexican Mission Group, November 4.

DMI Project Update, CDR Cheese Industry Team Research Forum, December 3.

K.J. Burrington
Top 10 Tales from the Front-DMI Dried Dairy Ingredients Forum, January 8.

Properties of High Value Whey Ingredients, Alto Dairy, March 12.

Dairy Ingredient Functionality Lab, Chemistry and Technology of Dairy products Course, UW-Food Science Mar 8, 22, April 5.

Whey Functionality and Applications for Dennis Buegge-UW Meat And Animal Science, April 10.

Whey Applications Program, Cheese Industry Team Meeting, April 23.

Nutrition is the Future-Nutritional Improvement through Utilization of Whey Components, International Cheese Technology Expo, April 23-25.

The Success of High Protein Sports Drinks, ADPI Annual Meeting, April 29.

Food Applications, Wisconsin Whey Utilization Short Course, May 8.

Whey Ingredient Functionality and Applications, Nutritional Properties of Whey Ingredients, Dairy Farmers of America Presentation, June 6

Whey Ingredient Functionality and Applications, USDEC Mission group to CDR, June 12.

Whey Applications Program, WMMB Liaison Committee Meeting, June 20.

Processing Impacts on Whey Functionality, UW Membrane Processing Short Course, October 29,30.

Whey Functionality and Applications, Nutritional Properties of Whey Ingredients, USDEC Mexican Mission Group, November 4.

Publications

K.J. Burrington
New Dairy Ingredients “Moove” To Enhance Products, Food Product Design, April 2002

The New Dairy-Outside The Dairy Case, Food Product Design Supplement, June 2002.

The Whey to Nutrition, CDR Dairy Pipeline, June 2002.

More Than Just Milk, Food Product Design, October 2002.

Edited sections of the revised USDEC Reference Manual for Whey and Lactose Products.

Karen Smith
A Primer On Milk Proteins, CDR Dairy Pipeline, September 2002.

Edited sections of the revised USDEC Reference Manual for Whey and Lactose Products.

Safety/Quality Applications Program

Personnel
Marianne Smukowski

Funding
Wisconsin Milk Marketing Board

Dates
January 2002 to December 2002

Objectives
1. Provide technical assistance to Wisconsin companies in the areas of safety/quality audits, preparation for regulatory audits, sanitation program reviews and overall GMP reviews.

2. Assist in development of HACCP plans and programs.

3. Provide technical support for safety/quality problem solving

4. Assist in Executing the Wisconsin Cheese Food Safety Initiative Program

Summary
The Safety/Quality Applications Program assists Wisconsin cheese manufacturers in the following areas: safety/quality audits, third party audits, recall issues, Good Manufacturing Practice (GMP) reviews, and developing HACCP plans. In addition, I assist the Wisconsin Master Cheesemaker program and provide technical support in regulatory matters.

I continue to be a member of the NCIMS laboratory committee, which addresses the use of drug residue kits, and laboratory practices.

Numerous plant visits were made to assist plants in third party audits and HACCP implementation. I also assisted a small food company with GMP training of their employees.

Some highlights of the Safety/Quality Applications Program are listed as follows.

The American Butter Institute (ABI) requested assistance in determining growth and survival of mold on butter surfaces. Documentation was provided to ABI. USDA-Dairy is assessing their current grading practices to eliminate downgrades for the appearance of rough surfaces on butter.

I met with USDA-Dairy to review their HACCP certification program. USDA-Dairy requested my assistance with desk audits of their HACCP review. I have “volunteers” to participate in the pilot study.

A group met with DATCP to review possible revisions to ATCP 80.40. This rule pertains to pasteurization of dairy products. I collected information from trade associations and submitted to DATCP language changes to the current ATCP 80.40. Waiting for FDA's interpretation of the pasteurization requirements for a product form an intermediate step.

A group met with cheesemakers and buttermakers to review and discuss kosher cream. Several trials were run with the non-kosher whey cream. We were able to provide a use for whey cream butter in another non-standardized product.

Publications and presentations

WI cheese grading short course, Italian cheese evaluation (twice a year)

Collegiate Dairy Products Evaluation Contest (Lead Butter Judge)

WI CIP Workshop, Plant Sanitation Audits

WI Dairy Products Assoc. Cheese and Butter Evaluation Clinic, Overview of butter grading

Dairy HACCP Workshop, Program coordinator

WI Process Cheese Seminar, HACCP for Process Cheese

WI Cheese Technology Short Course, Cheese Handling-Plant to Retail (Twice a year)

A Fresh Look at Fresh Cheeses Artisan Seminar, Safety and Fresh Cheeses

Wisconsin Dairy Technology Society Meeting, Troublesome Parts of HACCP

Butter Grading Workshop, Foremost Farms—Reedsburg

Contributing author for the International Encyclopedia of Cheese, Sanitation in Cheesemaking

Cheese Industry and Applications Program

Personnel

John Jaeggi,, coordinator, Amy Bostley, research specialist, Carol Chen, researcher, Rani Govindasamy-Lucey, PhD, associate scientist, Lorraine Heins, assistant coordinator, Bill Hoesly, research cheese maker, Kristen Houck, research specialist, Mark Johnson, senior scientist, Nathan Leopold, research cheese maker, Cindy Martinelli, research specialist, Alice Ping, sensory coordinator, Juan Romero, analytical coordinator, William Tricomi, assistant researcher, Matt Zimbric, research specialist

Funding

Wisconsin Milk Marketing Board UWA9901-2

Dates

January 2002 to December 2002

Objectives

1. Provide direct technical support for the use of commodity and specialty cheese, processed cheese, cold pack/club cheese and cream cheese in food application systems through consultations, pilot plant trials, application lab evaluations and plant visits.

2. Conduct industry directed cheese applications research - modifying manufacturing processes or ingredients during cheese making to produce a cheese with specific functional characteristics.

3. Direct contact with industry, DMI, WMMB, IFT, ADSA or other cheese industry related outlets to meet informational needs from manufacturers through end users.

4. Provide technical support on internal cheese trials and projects, funded by WMMB, DMI, CDR, CDR Cheese Industry Team, and/or other UW departments through consultations, pilot plant trials, and application lab evaluations.

5. Provide technical support to other CDR Application Program areas and to University of Wisconsin Food Science Department through consultations/lectures, pilot plant trials/ lab sessions, and application lab evaluations/demonstrations.

6. Participate in international efforts that affect standards of uniformity of import/export cheese opportunities.

7. Work with WMMB and DMI to develop and execute the state and national cheese research plan. Also continue the transfer of technology generated from past farmer-funded research.

Summary

This report lists Wisconsin cheese industry activities, national cheese industry activities, international cheese industry activities, and internal CDR and various UW interdepartmental cheese activities.

This report does not account for the multiple contacts we have from different individuals from the same state, national, and international companies on a wide range of topics. The increasing number of interactions continues from milk production through end users and all facets in-between. This demonstrates the continued commitment of the Wisconsin Center for Dairy Research, and specifically the Cheese Industry and Applications Program, to the cheese industry.

We support the industry via phone and e-mail consultations, short courses, CDR or on-site meetings, research trials, on-site scale up or troubleshooting, and working in conjunction with other CDR program areas including Wisconsin Master Cheesemaker, Safety/Quality, Analytical, Economics, Whey and Whey Applications, and Communications.

Industry contacts include (but are not limited to) topics such as cheese defects, cheese end use, regulatory, cheese functionality, cheese texture, sensory, cheese flavor development, manufacturing protocols for natural/processed (sauces/foods/spreads)/cold pack/cream cheese, cheese or milk microbiology, cheese milk standardization, cheese yield, labeling, analytical protocol, data interpretation, project updates, and general cheese technology.

One of the functions of the Cheese Industry and Application Program is the manufacture of cheese on a contract basis for ingredient/flavor suppliers, cheese manufacturers, equipment manufacturers, end users/distributors, consultants, and milk producers.

The Cheese Industry and Applications research work on behalf of ingredient /flavor suppliers in 2002 included the addition of ingredients to extend shelf life of fresh cultured and un-cultured cheese, evaluating coagulant effect on yield/ripening/flavor, evaluation of starter cultures/adjuncts and their effect on cheese flavor/texture/functionality, addition of ingredients to increase cheese yield, addition of various enzymes and studying effect on flavor, and addition of various stabilizers and/or emulsifying salts to processed cheeses and studying effect on physical characteristics.

The program also worked on behalf of numerous cheese manufacturers. Some of this work included developing standardization methodologies using different streams such as ultrafiltered (UF) milk (whole and skim), non-fat dry milk (NDM), and concentrated buttermilk to manufacture commodity, specialty, and non-standard cheeses. The impact on cheese manufacture, yield, composition, functionality, texture, microbiology, ripening, and sensory was studied as part of these multiple projects.

The Cheese Industry and Applications Program continued to work with cheese manufacturers developing altered manufacturing protocols for altering physical or functional characteristics of cheese. The program also continued its work in specialty cheese development by setting up manufacturing methods, carrying out successful trials, submitting all results, and working on-site scaling up at the plant.

The program also assisted manufacturing plants in the area of improved efficiencies. This was accomplished by working with plants on adding whey protein concentrate (WPC) as secondary starter and studying the effect on the end product. We continued to work with manufacturers on increasing plant throughput by increasing milk solids levels through standardization.

As in the past three years, we have continued working with farmstead producers who work with existing cheese manufacturers to make a specialty cheese. This year saw the first producer in Wisconsin build an on-site facility and begin manufacture of specialty Italian cheese varieties.

Work has increased drastically with end users. We continue to work directly with cheese manufacturers and large state and national end users to tailor manufacture ofCheddar, mozzarella, and other varieties of chees for food product, appetizer, and pizza applications. Other examples include working on manufacturing protocols for processed specialty cheeses to target specific functional attributes, working with a very large snack food distributor on breaded mozzarella sticks, working with a very large national company on cheese for snack crackers.

We continue to work on cheese related projects funded by various outside or internal sources, many reported in detail elsewhere in this report. The CDR Cheese Industry Team (CIT) currently funds one on-going project. This project, "Understanding and Controlling the Calcium Equilibrium in Cheese" involves the study of re-creation of calcium lactate crystal formation in Cheddar and Colby cheese, evaluating the type of crystals formed and altering milk standardization and manufacturing protocols to minimize or eliminate this defect.

One CIT project we are wrapping up at the end of 2002 involves the use of ultra-filtered (UF) milks to manufacture different cheese varieties. We evaluated the effects milks manufacturing, whey composition, cheese properties (chemical, physical, and sensory), and cheese yield.

The Cheese Industry and Applications Program also continues to work with other University of Wisconsin Departments or CDR personnel on various cheese projects. Two such projects includes "Development and Application of a Cheese Shred / Texture Map Delineated by Cheese Rheological, Sensory and Chemical Analysis" funded jointly by WMMB and DMI and "Relationship Between Cheese Melt Profiles and Chemical / Textural / Sensory Properties" funded by DMI in which multiple vats of different varieties were manufactured and analyzed at multiple time points. These projects are detailed elsewhere in this annual report.

Another project that the CDR Cheese Industry and Applications Program worked on was "Evaluation of Sweet Cream Buttermilk for Use as Cheese Ingredient". In this phase of the project we are looking at the addition of condensed buttermilk in the manufacture of mozzarella cheese.

"Relating Rheological Properties to Cheese Functional Performance" is a project the Cheese Industry and Applications Program assisted with that began near the end of 2002. This is a joint project between the CDR, UW Food Science, and North Carolina State University. This project started with the manufacture of mozzarella with different fat in dry matter (FDM) targets.

The Cheese Industry and Applications Program also assisted with a joint project "Development of Predictive Formula for Estimation of Cheese Yield From Sheep Milk", between the CDR, Animal Science Department, and the Food Science Department that involved the manufacture of Manchego cheese using ovine milk sourced from different lactational periods over the course of a lactation cycle.

Finally the Cheese Industry and Applications has begun to work in the area of cream cheese. Work has begun by manufacturing cream cheese for a UW Food Science Project titled "Impact of processing conditions on the texture of cream cheese".

The Cheese Industry and Applications Program also continues to assist the Specialty Cheese/Master Cheesemaker Program area by coordinating grading and sampling of Master Cheesemaker and Master Mark candidates' cheeses, grading final exams, and attending all Master Cheesemaker member and board meetings. This past year, program personnel also assisted the Specialty Cheese/Master Cheesemaker Program and/or the Food Science Extension Program by providing assistance with lecturing and setting up lab sessions for the two Wisconsin Cheese Technology short courses, one Wisconsin Processed Cheese short courses, the fresh cheese short course, the Membrane Processing Technology short course, to name a few.

Dairy Marketing and Economics Program

Personnel

Brian W. Gould, Ph.D., Hector J. Villarreal, graduate student, John Hackney, graduate student, Jorge Aguero, graduate student

Funding

Wisconsin Milk Marketing Board

Dates

January 2002 to December 2002

Objectives

1. Economic analysis of cheese yield

2. Economic analysis of changing dairy policy on dairy farm operators and processors

3. Use of dairy futures markets by the dairy industry for risk management

4. Economic analysis of alternative multiple component pricing systems

5. Analysis of consumer demand for dairy products

6. Structure and performance of the dairy processing industry

Summary

Economic analysis of cheese yield

The objective of this area of research is to understand the factors that influence cheese yield and to quantify the economic impacts for both the cheese manufacturer and the dairy farm operator. We assisted a number of cheese plants across the U.S. to understand the factors determining cheese yield as well as the economic implications of changes in milk quality or characteristics of their final cheese. Research in this area involved the use of the CDR software program, ***E****conomic* ***A****nalysis of* ***C****heese* ***Y****ield* (**EACY**™) which is supported by the Dairy Economics and Marketing program. This software is available electronically by contacting the author, Dr. Brian W. Gould at the email address, gould@cdr.wisc.edu . A brochure describing the software package can be obtained by accessing the following PDF file: **www.cdr.wisc.edu/pdf/eacy_brochure.pdf**. The front page of this software package is shown in Figure 1.

Economic analysis of changing dairy policy on dairy farm operators and processors

During 2002 the dairy industry has experienced (i) dramatic reductions in farm milk price, (ii) the passage of a new national Farm Bill, (iii) enactment of the Milk Income Loss Contract (MILC) Program, (iv) changes in the butter/powder "tilt" and modifications to the Classified Pricing of fluid milk within the Federal Order system. The Dairy Marketing and Economics program maintains the University of

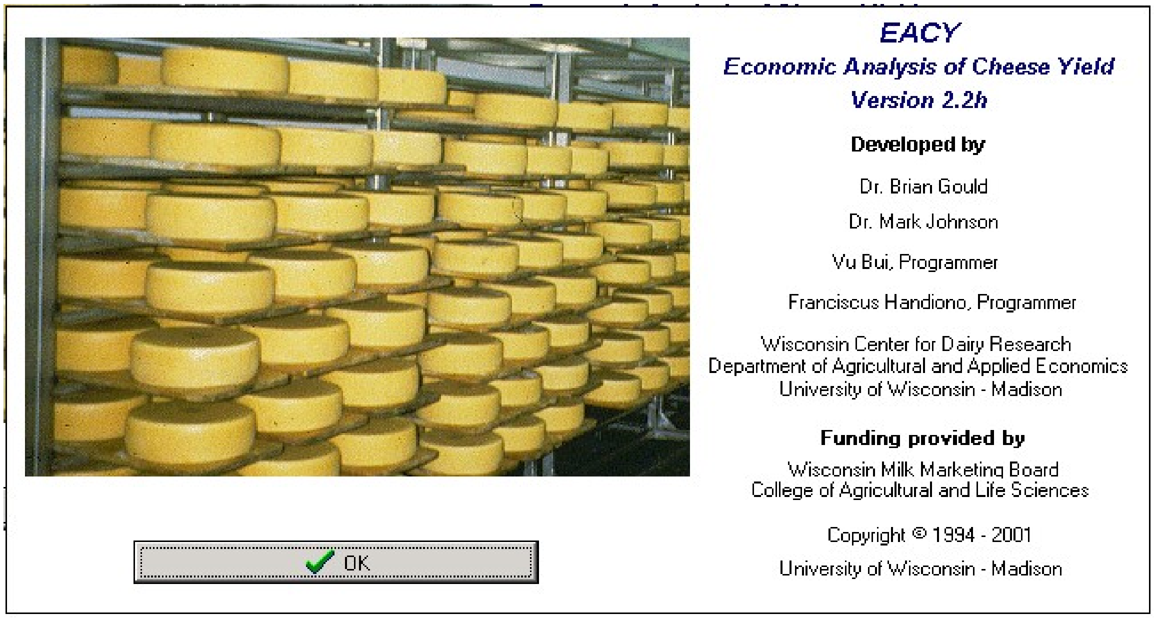


Figure 1. Start-Up Page of ***E**conomic **A**nalysis of **C**heese **Y**ield* (EACY™)

Wisconsin Dairy Marketing Web Site (www.aae.wisc.edu/future). This website requires daily maintenance given the amount of dairy price, production, and consumption data that is published concerning the Wisconsin and national dairy industry. We collect this information and make it readily available in a user-friendly environment for dairy industry participants.

Within this web site we provide materials analyzing factors influencing the Wisconsin and U.S. dairy industries. For example, we developed material that describes the Milk Income Loss Contract Program (http://www.aae.wisc.edu/future/milc.htm).This page is shown in Figure 2.

Figure 2. Milk Income Loss Contract (MILC) Program Page from University of Wisconsin Dairy Marketing Website (www.aae.wisc.edu/future/milc.htm)

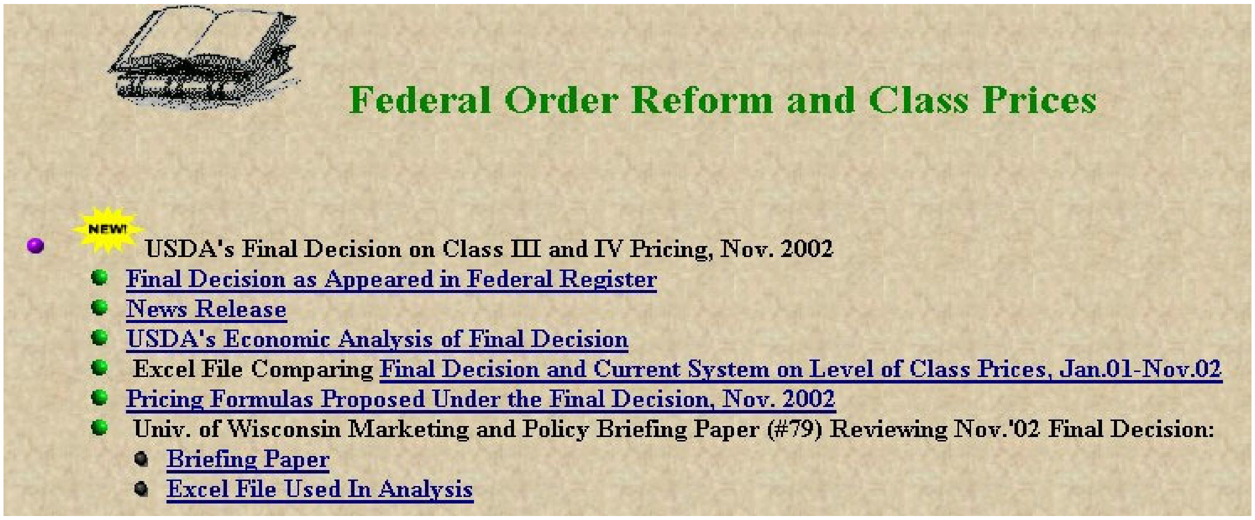


Figure 3. Federal Order Reform Page from the University of Wisconsin Dairy Marketing Website (www.aae.wisc.edu/future/front_class_price_changes.htm).

Another example of our research can be found in the section of the website devoted to the analysis of proposed changes to the Federal Order Classified Pricing system announced on November 2002 (www.aae.wisc.edu/future/front_class_price_changes.htm). We developed a Marketing and Policy Briefing paper (www.aae.wisc.edu/future/publications/m_p_79REV_11_14_02.pdf) and a series of spreadsheet files that explain the impacts of the proposed price system changes. Figure 3 shows the web page devoted to this analysis.

These pages are just a sampling of the wealth of material on the University of Wisconsin Dairy Marketing web site. There are approximately 6,000 files contained within this site, occupying approximately 500 MB of data, charts, publications, software, etc. The University of Wisconsin Dairy Marketing web site is accessed by approximately 4,000 unique users per month (i.e., unique IP addresses) and the number is continually increasing.

Use of dairy futures markets by the dairy industry for risk management

Since depressed farm milk prices have characterized the industry for much of 2002, we've seen growing interest in the use of alternative dairy futures/options risk management strategies to control input and output price risk. The University of Wisconsin Dairy Market Web Site (www.aae.wisc.edu/future) is now a major dissemination point for the University of Wisconsin Extension Dairy Risk Management teams initiative to improve the Wisconsin dairy industry's price risk awareness. As part of this effort a number of alternative risk management curriculum have been developed and are available for download (www.aae.wisc.edu/future/front_tutorials.htm). The UW-Extension risk management curriculum can be accessed via the following web site address: www.aae.wisc.edu/future/risk_team/risk_team_1.htm. Also, contained in the publications section of the University of Wisconsin Dairy Marketing Web Site (www.aae.wisc.edu/future/front_publications.htm) are materials that will be useful for understanding various risk management tools available to both dairy farm operators and processors.

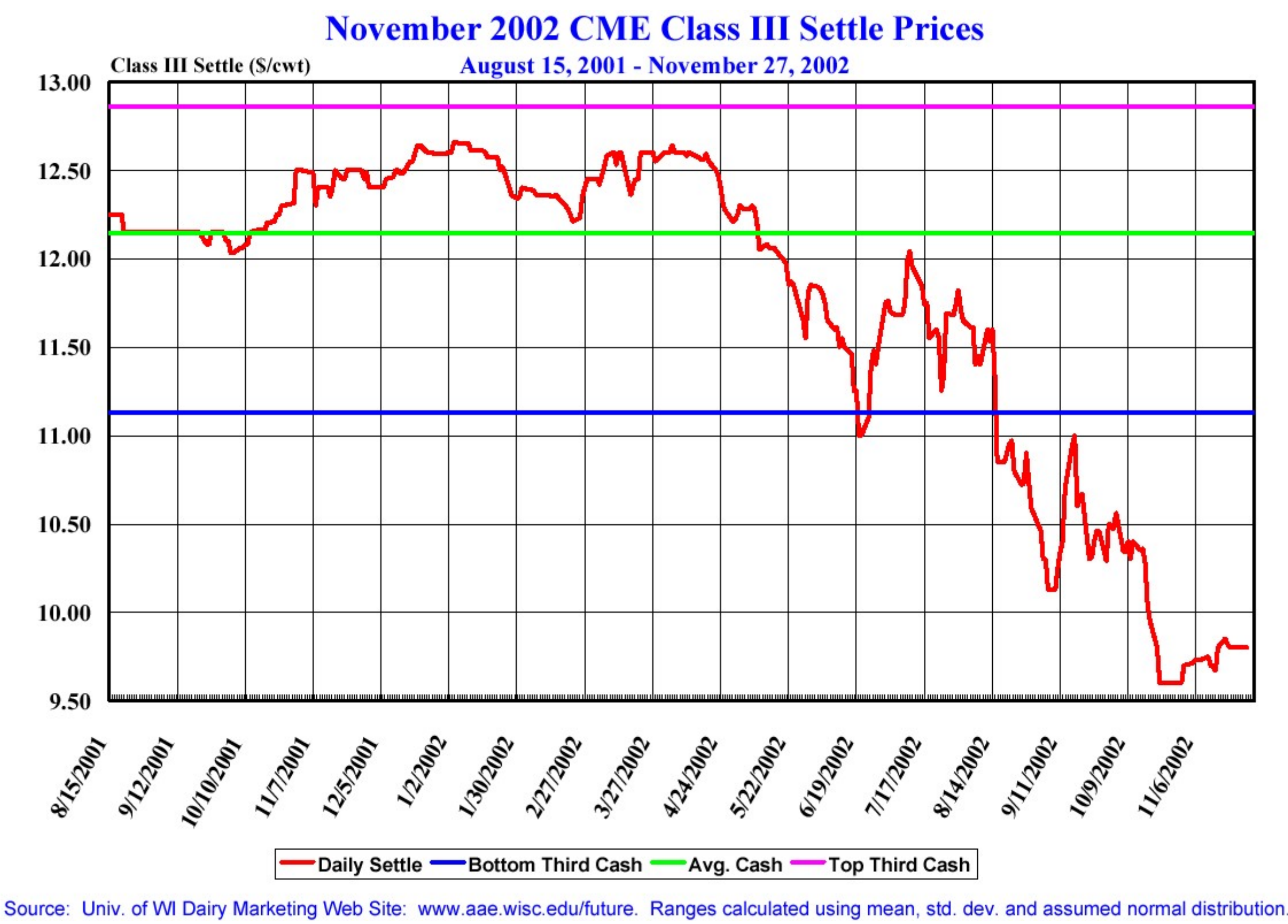


Figure 4. Time Series of November, 2002 Daily CME Class III Settle Prices (www.aae.wisc.edu/future/trends/iiiNov02chart.pdf)

In addition to developing and disseminating educational material related to the use of dairy futures and options, we generate daily analyses of current futures and options prices for the dairy-based contracts (Class III, Class IV, and Butter) that are traded. An example of the type of graphical analyses that we make available to the industry is shown in Figure 4. This graph shows the time-path of the dairy settle prices for the November Class III milk contract as it was traded over its lifetime from August 15, 2001 until November 27, 2002 (the trading day before the November 2002 announced price was released by USDA). The non-linear path shows the daily settle prices. The top horizontal line shows the top third Class III prices derived from the observed November Class III prices over the 1988-2001 and assuming a normal distribution of prices. The middle horizontal line shows the average Class III price over the above 14-year period. The bottom horizontal line shows the Class III prices that define the bottom third of Class III prices, again assuming a normal distribution. The trend displayed by dramatic reduction in daily settle prices for November 2002 milk after the middle of May, 2002 shows that early in the history of this contract there may have been some opportunities to set a "reasonable" minimum November Class III price (e.g., at or above the average historical cash price of $12.10 for November milk).

Another example of the software systems developed for assist in making decisions regarding the type of risk management strategy to follow is shown in Figure 5. This figure displays a spreadsheet page from a file evaluating a number of price risk management strategies from the producer's perspective. (www.aae.wisc.edu/future/risk_team/resources/milk_marketing_calculator.xls).

	A	B	C	D	E	F	G	H	I
1	**Buying a put option**			**Cost of Production**		**$ 13.00**			***Contract Month***
2									January
3	**Data Input**	**(all costs are reported on a hundredweight basis)**							
4	**Increment for**	**Strike Price**	**Estimated**	**Put**	**Broker**	**Expected**		**High basis**	**$ 3.00**
5	**Class III**	**of put**	**Basis**	**option**	**Fee**	**Floor Price**		**Avg. basis**	**$ 2.45**
6	**Sensetivity**	**option**		**premium**				**Low basis**	**$ 2.06**
7	**Analysis**								
8	$0.10	$12.00	$1.00	$0.21	$0.10	**$12.69**		Print Chart and Graph	
9									
10	**Results from strategy under Alternative Class III Announced Prices**								
11	Announced	Estimated	Estimated	Put option	Put option	Put option	Broker	Net mailbox	Net mailbox
12	Class III	Basis	Mailbox	gain	exercised	premium	Fee	price with	price without
13	Price		Price					Put Option	Put Option
14	$11.00	$1.00	$12.00	$1.00	**Yes**	$0.21	$0.10	$12.69	$12.00
15	$11.10	$1.00	$12.10	$0.90	**Yes**	$0.21	$0.10	$12.69	$12.10
16	$11.20	$1.00	$12.20	$0.80	**Yes**	$0.21	$0.10	$12.69	$12.20
17	$11.30	$1.00	$12.30	$0.70	**Yes**	$0.21	$0.10	$12.69	$12.30
18	$11.40	$1.00	$12.40	$0.60	**Yes**	$0.21	$0.10	$12.69	$12.40
19	$11.50	$1.00	$12.50	$0.50	**Yes**	$0.21	$0.10	$12.69	$12.50
20	$11.60	$1.00	$12.60	$0.40	**Yes**	$0.21	$0.10	$12.69	$12.60
21	$11.70	$1.00	$12.70	$0.30	**Yes**	$0.21	$0.10	$12.69	$12.70
22	$11.80	$1.00	$12.80	$0.20	**Yes**	$0.21	$0.10	$12.69	$12.80
23	$11.90	$1.00	$12.90	$0.10	**Yes**	$0.21	$0.10	$12.69	$12.90
24	$12.00	$1.00	$13.00	$0.00	**No**	$0.21	$0.10	$12.69	$13.00
25	$12.10	$1.00	$13.10	$0.00	**No**	$0.21	$0.10	$12.79	$13.10
26	$12.20	$1.00	$13.20	$0.00	**No**	$0.21	$0.10	$12.89	$13.20
27	$12.30	$1.00	$13.30	$0.00	**No**	$0.21	$0.10	$12.99	$13.30
28	$12.40	$1.00	$13.40	$0.00	**No**	$0.21	$0.10	$13.09	$13.40
29	$12.50	$1.00	$13.50	$0.00	**No**	$0.21	$0.10	$13.19	$13.50
30	$12.60	$1.00	$13.60	$0.00	**No**	$0.21	$0.10	$13.29	$13.60
31	$12.70	$1.00	$13.70	$0.00	**No**	$0.21	$0.10	$13.39	$13.70
32	$12.80	$1.00	$13.80	$0.00	**No**	$0.21	$0.10	$13.49	$13.80
33	$12.90	$1.00	$13.90	$0.00	**No**	$0.21	$0.10	$13.59	$13.90

Figure 5. Example Page Showing Impacts of Using a Put Option Under Alternative Class III Prices (www.aae.wisc.edu/future/risk_team/resources/milk_marketing_calculator.xls)

In this example, we show the impacts of using a Class III put option under alternative Class III prices. In addition to this example, the file examines both simple and advanced risk management strategies including: hedging using a Class III futures, using a cash forward contract, selling a call option, combine a cash forward contract and buying a call option, using a "short fence", buying a put option and rolling up to a futures, rolling down futures and risk reversal.

Economic analysis of alternative multiple component pricing systems

Under this sub-project we assisted a number of cheese plants to investigate the economic impact of implementing farm operator pay plans based on alternative systems for valuing milk components. Most of this work was undertaken on a confidential basis so we can not provide details here concerning specific systems. Our contribution included developing spreadsheet models accounting for the total mass balance of farm milk from transformation of raw milk to finished cheese product and the use of whey to manufacture whey-based products. The overall philosophy of these systems is to provide appropriate information to the plant's patrons to maximize returns both to the plant and to the farmer patrons. The "optimal" composition of farm milk will vary, depending on the products produced by the plant.

Analysis of consumer demand for dairy products

During 2002 we continued to develop a number of alternative econometric methodologies applicable to the analysis of household food (dairy product) expenditures. The first area of research focused on analyzing food (dairy product) expenditure patterns in U.S. Mexico, Brazil and China (Aguero and Gould, 2002(a); Aguero and Gould 2002(b); Gould, Dong and Lee, 2002; Dong, Gould and Kaiser,2002). Within these models we incorporate a number of alternative methods for characterizing the age/gender impacts of household composition on food (dairy product) expenditures. We can use these models to compare expenditure patterns of households of differing sizes and composition.

A second area of our research continues in the area of developing methodologies for estimating food demand parameters. We estimate a number of systems which account for the presence of significant numbers of households that do not purchase a particular type of food (dairy product). By using a censored demand system, we can eliminate biased conclusions.

A third area of research undertaken over the previous year involves examining the impact of generic promotion efforts on the household demand for dairy products in the U.S. In this analysis we follow the biweekly purchases of this panel of consumers over the 1997-99 period resulting in a total of 78 bi-weekly purchase periods and 84,864 total observations. Our approach is unique because we account for the panel nature of the data, the potential for serial correlation of equation error terms and the censoring of dairy product purchases. Our model is unique allows us to use simulated probability techniques to solve high-order integrals, and also partitions the data into smaller components allowing analysis of longer time periods, increased accuracy, and reduced computing time. The empirical results of this study are useful in providing additional insight regarding the impact of generic cheese advertising on households cheese purchases and how this in turn influences returns to producers.

Structure and performance of the dairy processing industry

A new area of research involved market level analyses of the performance of the dairy processing/retailing sector. Funding for this research was primarily provided by the Food System Research Group via a special U.S. Department of Agriculture grant to the University of Wisconsin-Madison. Under this research program we focused on examining price variability in the retail pricing of fluid milk in major U.S. markets (Dhar, Stiegert and Gould, 2002). We also undertook two methodological research efforts where we examined brand level pricing behavior using the soft drink industry as an example (Dhar, et al, 2002; Dhar, Chavas and Gould, 2002). We intend to extend these models to the fluid milk and butter markets in the upcoming year.

Evaluating the performance of the U.S. dairy processing sector is another project we are starting, using the Census of Manufacturing data of the industry. Though early in the investigation, our analysis will examine changes in the structure of U.S. dairy processing over the 1962-1997 period. We are undertaking both a descriptive as well as an econometric analysis of structural change in the dairy processing industry. The econometric analysis uses a neoclassical cost function approach to estimate the presence of scale and scope economies in the industry, factor substitution and the role of technological change. This econometric modeling approach will require that we use micro-level data from the Center for Economic Studies. This Center, which is a part of the Bureau of Census, has established a network of Census Research Data Centers (RDCs) providing access to researchers, federal agencies and other institutions.

Our analysis of the structure of U.S. dairy processing accounts for some unique characteristics of the dairy industry. For example, the role of cooperatives in processing dairy products needs to be recognized. Another factor we need to consider is the joint nature of the production of dairy products. For example, in the manufacture of cheese, if cream is skimmed to reduce the fat content of raw milk to manufacture mozzarella, the cream is often made into butter. In addition many plants that have the capability of producing multiple products. For example, cheese manufacturers often have the technology to transform the whey stream into value-added dry products such as whey protein concentrates, dried whey, etc.

The Longitudinal Research Database (LRD) contains data that identify individual establishments, detailed manufacturing inputs and manufactured products. Input data include total employment, number of production workers, hours worked, labor costs, materials costs, materials consumed, services and energy used, inventory levels, depreciable assets, and capital expenditures. Product data include receipts (value of shipments, value added, value of resales), production details and exports. The LRD is updated annually with data from the latest manufacturing census or annual survey of manufacturers. To gain access to the LRD, researchers must undertake their analyses at one of the RDCs, thus we are doing our research at the Chicago Research Data Center. This project was started in July 2002 and results will be available next year.

Publications

T. Schmit, Brian W. Gould, D. Dong, H. Kaiser and C. Chung, 2002. The Impact of Generic Advertising on Household Cheese Purchases: A Censored Autocorrelated Regression Approach, Canadian Journal of Agricultural Economics.

T.P. Dhar, J.P. Chavas and Brian W. Gould, 2002, An Empirical Assessment of Endogeneity Issues in Demand Analysis for Differentiated Products, American Journal of Agricultural Economics

Deller, S., B.W. Gould and B. Jones., 2002. Agriculture and U.S. Rural Economic Growth,Journal of Agricultural and Applied Economics, Dec., 2003

T. Schmit, C. Chung, D. Dong, H. Kaiser and Brian W. Gould, 2002. Identifying the Effects of Generic Advertising on the Household Demand for Fluid Milk and Cheese: A Two-Step Panel Data Approach, Journal of Agricultural and Resource Economics.27(2):165-186, July

Aguero, J. and B.W. Gould, 2002. Household Composition and Brazilian Food Purchases: An Expenditure System Approach, Canadian Journal of Agricultural Economics, 2nd revision, Dec. 2002.

T.P. Dhar, J.P. Chavas, R. W. Cotterill and B.W. Gould, 2002, An Econometric Analysis of Brand Level Strategic Pricing Between Coca Cola and Pepsi Inc., Journal of Economics, Management and Strategy, July 2002.

B.W. Gould, Y. Lee and D. Dong, 2002, Household Size and Composition Impacts on Meat Demand in Mexico: A Censored Demand System Approach, Journal of Agricultural and Resource Economics 2nd Revision.

D. Dong, B.W. Gould and H. Kaiser, 2002. The Structure of Food Demand in Mexico: An Application of the Amemiya-Tobin Approach to the Estimation of a Censored System, American Journal of Agricultural Economics, Dec. 2002.

T. Dhar, K. Stiegert and B.W. Gould, 2002, The Presence of Price Dispersion in the Retail Market for Fluid Milk in the U.S., Review of Industrial Organization, Dec, 2002

Aguero, J. and B.W. Gould, 2002. A Household Level Analysis of Food Expenditure Patterns in Urban China: 1995-2000, *Babcock Institute Discussion Paper*, December

E. Jesse, B.W. Gould and R. Cropp, 2002. Federal Milk Marketing Order Reform: Nov. 2002 Final Decision on Class III/IV Formulas , *Marketing and Policy Briefing Paper # 79*, Department of Agricultural and Applied Economics, University of Wisconsin-Madison, Nov.

If you would like more information concerning these activities contact program coordinator, Dr. Brian W. Gould at the email address: gould@cdr.wisc.edu .

CDR Communications Program

Personnel

Mary Thompson,coordinator; Joanne Gauthier, communications specialist; Tim Hogensen, graphic designer; and Karen Paulus, editor

Funding

Wisconsin Milk Marketing Board

Dates

January 2002 to December 2002

Objectives

1. Design conferences, workshops, and seminars to deliver technical information and training

2. Coordinate industry short courses, training programs and events3. Develop publications and other communication vehicles to deliver technical information

4. Maintain and update the CDR Web site Summary

CDR Communications (CDRC) team supports the Center's research and associated applications programs to sustain the viability and enhance the economic position of the Wisconsin dairy industry. CDRC provides Wisconsin's dairy industry the information necessary to maintain or enhance their competitive advantage.

Design conferences, workshops & seminars

(*CDR sponsored)
International Cheese Technology Exposition*
Cheese Industry Team Research Forum*
Quality Milk Conference*
Research seminar by Dr. Paul McSweeney, University of Cork, Cork, Ireland*
Research seminar by Dr. David Horne, Charis Research Center, Ayr, Scotland*

Coordinate and/or support short courses, training programs, and events

(*CDR sponsored)
Process Cheese short course*(offered 2 times a year)
Cheese Technology short course (offered 2 times a year)
Dairy HACCP short course*
Cheese Grading short course (offered 2 times a year)
Whey and Whey Processing short course
Fresh Cheeses artisan cheesemaking short course*
Membrane Processing short course*
Wisconsin Milk Marketing Board Producer Value Showcases
CDR Cheese Industry Team meeting*
WI Master Cheesemaker recognition ceremony*
International Dairy Federation Legislation Week*
WI Dairy Technology Society annual meeting∑
ADSA Discover Conference
Historic Cheesemaking Day, Wisconsin Master Cheesemakers*

USDEC Mexico trade mission
Babcock Institute Emerging Markets, Chinese Delegation
USDEC Chinese Delegation
Farm Progress Days
26th IDF World Dairy Congress, Congrilait 2002

Develop publications and other communication vehicles to deliver technical information

Dairy Pipeline Newsletter, published quarterly
Cheese Wedge newsletter, for Master Cheesemakers, published 2 times a year
2001 Annual Report
Juustoleipa media briefing and press releases
Articles:
University contributions include improving flock genetics, helping the dairy sheep cooperative strategize and creating new blended cheeses
New method of adding salt to mozzarella cheese
Whey points the way to more effectively using milk as a raw material
Fine tuning the role of culture in today's cheesemaking

Maintain and update the CDR Web site

CDR web page includes pilot plant equipment fact sheets, a calendar of CDR and industry events. Short course and informational brochures are placed on the website and can be downloaded for viewer use. CDR news is posted to the web site on a regular basis.

CDR specialty cheese applications program

Personnel

Jim Path, outreach specialist

Funding

Wisconsin Milk Marketing Board

Dates

January 2002 to December 2002

Objectives

1. Continue developing the artisan workshops, a module of the Wisconsin Master Cheesemaker® program.

2. Provide technical support to cheesemakers, including workshops, consulting, and on site manufacturing trials.

3. Manage the Wisconsin Master Cheesemaker® program.

Summary

The development of Juustoleipä cheese played a major role in the specialty cheese program in 2002. The cheese is unique because it is possibly the only cheese in the world that is baked before it is distributed to the consumer. The baking process caramelizes the outside giving it a sweet taste. In January, Jim Path traveled to Hancock, Michigan, to observe and visit with producers of “squeaky cheese,” an American version of Juustoleipä. This cheese is produced by descendants of Finnish immigrants on farmsteads in northern Michigan, Wisconsin and Minnesota. At the time of the visit, Jim met with the last known legal producers of this cheese in Michigan, a husband and wife in their 70’s. Cookbooks of the region included manufacturing procedures, but the process was a long and difficult, with extensive draining of the whey. After the trip, CDR started to explore types of ovens available to shorten the baking process.

A small trial run of Juustoleipä cheese was conducted at Babcock Hall. The cheese was tested for safety and evaluated by a focus group from the Finnish American Society of Madison. Some members of the group were from Finland and others had experience baking the product with their mothers or grandmothers. They became a valuable source to appraise the cheese.

In April I traveled to Finland to visit commercial cheese factories and distributors of Juustoleipä cheese. Parts of the trip took me around and above the Arctic Circle, where the cheese was traditionally produced. I visited Riitan Herkku Cheese, Milka Coop, Niemitalon Leipäjuustoa Cheese, and Luonto Foods. Also visited MTT Agrifood Research School in Jokioninen. In Finland, Juustoleipä represents about 1 to 1.5 percent of total cheese production and it is growing. That percent in terms of Wisconsin production would equal 22 million pounds of cheese.

Samples were also collected in Helsinki to evaluate packaging and content. A great deal of information regarding this type of cheese was collected and it was very useful as we developed it in the USA.

A commercial trial run was conducted on June 19th with Bass Lake Cheese of Juustoleipä type cheese at Babcock Hall. A Lincoln Equipment Impinger type oven was used to bake the cheese. Different baking times and temperatures were evaluated to extend shelf life.

In July additional trial runs of Juustleipä type cheese were performed in Babcock Hall to determine specs and requirements for ovens. Lincoln equipment also brought in a portable oven to determine capacities and types of ovens available for this cheese.

In September, Juustoleipä was included in the “A Fresh Look at Fresh and other Unique Cheeses” seminar held September 24 and 25, 2002. Several factories have indicated an interest to produce this cheese. Babcock Hall at the University of Wisconsin has also started a limited production of this cheese. The sales of this cheese at Babcock Dairy Store have been very good.

A great number of press inquiries and articles have been written about the cheese (NBC TV, Madison Capital Times, Milwaukee State Journal, Eau Claire Leader, a Green Bay paper and many local papers). This has generated a number of inquiries about purchasing the cheese.

Interest has also been generated in the manufacture of Polish type cheeses. CDR has consulted with a Wisconsin cheese factory regarding the manufacture, labeling and shapes of Polish style cheese.

The Wisconsin Process Cheese Seminar was presented on February 26 and 27 2002. Class was filled with 35 students. The class continues to be a popular course with both international and domestic students.

In March 2002, Jim Path traveled to the Czech Republic to attend SELMA International Food Show. He also visit Madeta Coop Cheese factory, Czech Cheese Technical School and various cheese markets. Much information (mainly textbooks) was gathered and is being sorted and translated.

Three sections – 1. Cheese Yields and Economics – 2. Mechanization of Cheesemaking and 3. Specialty Cheese, were taught at each Wisconsin Cheese Tech Short Course held in March and September.

The Wisconsin Dept. of Agriculture held a meeting on April 24, 2002. At the meeting Jim Path became part of advisory group on Farmstead Cheese Manufacture and Regulation.

Master Cheese Maker Recognition Ceremony held on April 25, 2002 held. Six new Master Cheese Makers were recognized, with three existing Master Cheese Makers returning for additional cheeses.

Several sections on cheese making were written for the International Encyclopedia of Cheese to be published by Oxford Press in 2003.

In September — Conducted "A Fresh Look at Fresh and other Unique Cheeses" seminar held September 24 and 25, 2002. 28 persons attended the seminar, including 11 Master Cheesemakers and one person from the U.K. This is the largest class attendance we have ever had for an Artisan seminar. Cheeses discussed in the seminar included Juustoleipä, Cottage Cheese, Queso Blanco-type, Paneer, Panela and Käsegemüse.

Work continued on the World Cheese Exchange database. The database is found on the CDR web site and contains information on over 1,400 cheese names. We receive many worldwide emails with helpful comments and information regarding existing and new cheeses.

A Master Board meeting was held at WMMB on December 6th 2002. Five new Wisconsin Master Cheese Makers and two Wisconsin Master Cheese Makers with additional cheeses were confirmed. The program continues to be popular with cheese makers.