

Wisconsin

Center for

Dairy Research



Annual Report 2003 

Wisconsin
Center for Dairy Research
annual report 2003

University of Wisconsin—Madison
1605 Linden Dr.
Madison, WI 53706-1565

608/262-5970
fax 608/262-1578
<http://www.cdr.wisc.edu>



CDR Annual Report

Published March 1, 2004, 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 2003. 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.

Please seek the author's written consent before reprinting, referencing, or publicizing any reports contained in this document.

For more information call Karen Paulus at (608) 262-8015.
(E-mail: paulus@cdr.wisc.edu)

CDR staff

J. Russell Bishop, director

Administration

Tom Szalkucki, administrative coordinator
 Curtis Blevins
 Carmen Huston
 Seth Keel
 Matt Malloy
 Marge Schobert
 Susie Strang

Applications Staff

K.J. Burrington, whey applications coordinator
 Brian Gould, marketing and econ. coordinator
 John Jaeggi, cheese applications coordinator
 Jim Path, specialty cheese coordinator
 Juan Romero, analytical coordinator
 Marianne Smukowski, safety & qual. coordinator

Communications Staff

Mary Thompson, coordinator
 Joanne Gauthier
 Tim Hogensen
 Karen Paulus

CDR's Cheese Industry Team

Alto Dairy
 Bel/Kaukauna
 Chrs. Hansen Labs
 Danisco USA Inc.
 Foremost Farms
 DSM Food Specialties Inc.
 Grande Cheese
 Hormel Foods Corporations
 International Flavors and Fragrances (IFF)
 Kraft Foods Technology Center
 Land O' Lakes Inc
 DFA/Plymouth Cheese
 Rhodia Inc.
 Saputo Cheese
 Schreiber Foods Inc.
 Sorrento Lactalis
 Degussa Bioactives LLC

Research Staff

Gene Barmore
 Amy Bostley
 Carol Chen
 Rani Govindasamy-Lucey
 Cathy Landers
 Brian Leitzke
 Kate Lim
 Lorraine Heins
 Bill Hoesly
 Kristen Houck
 Mark Johnson
 Cindy Martinelli
 Wenhua (Pam) Payne
 Karen Smith
 Dean Sommer
 William Tricomi

CDR Directory

Barmore, Gene	(608) 265-5919	barmore@cdr.wisc.edu
Bishop, Rusty	(608) 265-3696	jrbishop@cdr.wisc.edu
Bostley, Amy	(608) 265-2271	ald@cdr.wisc.edu
Burrington, KJ	(608) 265-9297	burrington@cdr.wisc.edu
Chen, Carol	(608) 262-3268	cchen@cdr.wisc.edu
Gauthier, Joanne	(608) 263-1874	gauthier@cdr.wisc.edu
Gould, Brian	(608) 263-3212	gould@cdr.wisc.edu
Govindasamy-Lucey, Rani	(608) 265-5447	rani@cdr.wisc.edu
Heins, Lorraine	(608) 263-4078	heins@cdr.wisc.edu
Hoesly, Bill	(608) 262-2264	hoesly@cdr.wisc.edu
Hogensen, Tim	(608) 265-2133	hogensen@cdr.wisc.edu
Houck, Kristen	(608) 265-6346	houck@cdr.wisc.edu
Huston, Carmen	(608) 262-3416	huston@cdr.wisc.edu
Jaeggi, John	(608) 262-2264	jaeggi@cdr.wisc.edu
Johnson, Mark	(608) 262-0275	jumbo@cdr.wisc.edu
Landers, Catherine	(608) 262-5798	clanders@cdr.wisc.edu
Leitze, Brian	(608) 263-4179	bleitzke@cdr.wisc.edu
Lim, Kate	(608) 262-9554	klim@cdr.wisc.edu
Keel, Seth	(608) 265-6194	keel@cdr.wisc.edu
Martinelli, Cindy	(608) 262-3990	martinelli@cdr.wisc.edu
Nelson, Kathy	(608) 265-3570	knelson@cdr.wisc.edu
Path, Jim	(608) 262-2253	jpath@cdr.wisc.edu
Paulus, Karen	(608) 262-8015	paulus@cdr.wisc.edu
Payne, Pam	(608) 265-2271	payne@cdr.wisc.edu
Romero, Juan	(608) 265-9242	romero@cdr.wisc.edu
Schobert, Marge	(608) 265-2117	mschobert@cdr.wisc.edu
Sommer, Dean	(608) 265-6469	dsommer@cdr.wisc.edu
Smith, Karen	(608) 265-9605	smith@cdr.wisc.edu
Smukowski, Marianne	(608) 265-6346	msmuk@cdr.wisc.edu
Strang, Susie	(608) 265-9113	strang@cdr.wisc.edu
Szalkucki, Tom	(608) 262-9020	tszal@cdr.wisc.edu
Thompson, Mary	(608) 262-2217	thompson@cdr.wisc.edu
Tricomi, Bill	(608) 262-1534	btricomi@cdr.wisc.edu

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

Chapter One, Interim Reports

Mechanisms for intensifying and modulating cheese flavor: A global approach	3
Cheese structure/function manipulations to improve shreddability	3
Identification of physical/chemical changes in shredded cheese over time	4
Relationship between cheese melt profiles and chemical/textural/sensory properties	4
Technical and economic development of a milk refinery	5
Understanding and controlling the calcium equilibrium in cheese	5
Relating rheological properties to cheese functional performances	6
Production of intensely flavored cheddar-type cheeses by adjunct cultures	6
Developing pH-sensitive biodegradable smart hydrogels using whey protein concentrate	7
Control of annatto cheese colors in whey products	7
Improving lactose refining technology by controlling crystallization	8
New starter systems for accelerated ripened Cheddar cheese	8
Development of parmesan cheese flavor using selected bacteria	9
Crystallization kinetics of calcium lactate	9
Development of information manuals on controlling whey flavor	10
Mother liquor for production of lactose and a calcium-based product	10
Effects of cheese solids on <i>Clostridium botulinum</i> in process cheese products	11
Feasibility study for development of shelf-stable cheeses	11
Identifying genes involved in cheese flavor development	12
Nutraceutical protein recovery from acid whey	12
Phase/state transitions that affect drying of whey products	13

Enhanced nutraceutical value of fermented milk beverages using flaxseed lignans	13
Understanding structure/function relationship in cream cheese responsible for its performance	14
Identification and control of off-flavors in commercially produced GMP products	14
Review and comparison of nutritional and functional properties of dairy proteins relative to other market protein sources	15
Characterization of pigments and conditions responsible for browning in whey powders	15
Develop innovative solutions for the “Cold Melt” of cheese when partnered with another food ingredient (i.e. meat)	16
Manufacture of a no-sugar frozen desert	16
Production of sialyllactose from lactose using a bioreactor	17
Improving WPI functionality for beverage applications	17
A chemistry-based approach to understanding process cheese functionality	18
Develop a process for adhering meat products (pepperoni) to cheese for one-step pizza topping application	18
Manufacture of flavored fun cheeses for kids	19
Develop nonfat mozzarella for use in the school lunch program	19
Evaluation of sweet cream buttermilk for use as cheese ingredient	20
Chapter Two, Final reports	
Biochemistry of full and reduced fat cheddar shred ripening	23
Development and application of a cheese shred / texture map delineated by cheese rheological, sensory and chemical analysis	25
Use of whey proteins in pasteurized processed cheese products	36
Model development for manipulation of rheological properties of cheese	38
Analysis of the economic impact of cheese defects	46
Determination of the minimum levels of galactose and lactic acid that lead to stickiness during drying of whey	54

Alpha-lactalbumin production for clear bottled drinks and nutraceutical beverages	57
---	----

Chapter Three, Applications

Whey applications research program	63
Cheese industry and applications program	66
Safety/quality applications program	73
Dairy marketing and economics program	75
Specialty cheese applications program	81
Communications program	83

Chapter One

Interim reports

annual report 2003

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.

Cheese structure/function manipulations to improve shreddability

Personnel

Chen, Carol; Jaeggi, John

Funding

Dairy Management, Inc.

Dates

1/1/2004 to 12/31/2005

Objectives

1. Understanding chemistry, structure/function, acid development for enhancement and/or control of cheese performance
2. Develop new and novel functionality characteristics

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.

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.

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).

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.

Relating rheological properties to cheese functional performances

Personnel

Lucey, John; Foegeding, Allen; Gunasekaran, S.; 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 functional 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.

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.

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.

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.

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.

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*.

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.

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 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.

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.

Effects of cheese solids on *Clostridium botulinum* in process cheese products

Personnel

Norback, John; Johnson, Eric

Funding

Dairy Management, Inc.

Dates

9/1/2001 to 8/31/2005

Objectives

1. To determine the effect of substituting cheese solids with other dairy ingredients (whey, whey protein concentrate, nonfat dry milk) on botulinal toxin production in pasteurized process cheese products. Hypothesis: The percentage of cheese solids (provided fat levels are standardized) used will not affect the safety of process cheese products.
2. To determine if “percentage of cheese solids” can be used as a parameter in an improved predictive model to cover formulation-safe, non-standard of identity process cheese products/sauce.
3. To compare the effect of condiment types on botulinal toxin production in process cheese products. Hypothesis: Acidified or brined condiments will not negatively affect the safety of formulation-safe process cheese products.
4. To develop a computer program to adjust formulations of nonstandard-of-identity process cheese products with <50% cheese.

Feasibility study for development of shelf-stable cheeses

Personnel

Sommer, Dean

Funding

Dairy Management, Inc.

Dates

1/1/2004 to 12/31/2004

Objective

Develop high quality cheeses for availability in unrefrigerated snack packs.

Identifying genes involved in cheese flavor development

Personnel

Steele, Jim

Funding

Dairy Management, Inc.

Dates

7/1/2002 to 12/31/2004

Objectives

1. Develop microarrays that contain *Lb. helveticus* CNRZ32 genes encoding enzymes thought to be responsible for flavor development in bacterial-ripened cheeses.
2. Determine the effect of cheese ripening conditions on expression of these genes.
3. Construct isogenic mutants of *Lb. helveticus* CNRZ32 that differ in metabolic activities found to be expressed under cheese ripening conditions and believed to impact cheese flavor development.
4. Establish the role of these metabolic activities in cheese flavor development by analysis of isogenic pairs in a system that models ripening cheese environments.

Nutraceutical protein recovery from acid whey

Personnel

Etzel, Mark

Funding

Dairy Management, Inc.

Dates

1/1/2003 to 12/31/2004

Objectives

1. Develop and evaluate new process chemistries to capture and fractionate proteins from acid whey using process chromatography.
2. Measure the throughput, yield, and recovery as a function of the feed stream properties and target protein fractions.
3. Scale up and manufacture each protein fraction in amounts sufficient for functional and preliminary nutritional evaluation.
4. Estimate the costs of installation and operation of a commercial-scale process.

Phase/state transitions that affect drying of whey products

Personnel

R.W. Hartel

Funding

Dairy Management, Inc.

Dates

1/1/2003 to 12/31/2004

Objectives

1. Investigate the effects of various components (minerals, galactose, lactic acid, etc.) in whey products on the glass transition behavior of lactose, the primary component that leads to glass formation.
2. Assess the effects of holding conditions on drying of whey products, since it may be during holding of the whey products that negative effects are induced.
3. Investigate potential additives (i.e., maltodextrins, proteins) that might aid in drying.

Enhanced nutraceutical value of fermented milk beverages using flaxseed lignans

Personnel

Plhak, Leslie

Funding

Dairy Management, Inc.

Dates

3/1/2002 to 12/31/2002

Objectives

Demonstrate the feasibility of using fermentation bacteria in dairy beverages to deliver elevated levels of health beneficial nutraceuticals in the diet.

1. Identify starter culture species and/or bifidobacteria that optimally metabolize plant lignans in defined media systems containing secoisolariciresinol diglycoside (flaxseed lignan) or ground flaxseed.
2. Confirm that starter cultures and/or probiotic bacteria (identified in Objective 1) are capable of increasing the biological value of lignans in fermented milk systems.

Understanding structure/function relationship in cream cheese responsible for its performance

Personnel

Govindasamy-Lucey, Rani

Funding

Dairy Management, Inc.

Dates

7/1/2003 to 12/31/2003

Objectives

1. To identify how manufacturing conditions influence the functionality/textural properties of cream cheese products. Hypothesis: The initial gel formation and processing conditions used during the manufacture of cream cheese greatly affect the texture and other physical properties of the cream cheese.
2. To investigate the utilization of the cream cheese as an ingredient or its incorporation into other food ingredients. Hypothesis: Modification of cream cheese texture by the use of different processing conditions will result in alterations in its end-use functionality (e.g. in baking, and reworking/mixing with other food materials). Understanding the relationship between cream cheese manufacturing conditions and its end use functional properties will allow manipulation of the functional characteristics for a particular end-use.

Identification and control of off-flavors in commercially produced GMP products

Personnel

Rankin, Scott

Funding

Dairy Management, Inc.

Dates

4/1/2003 to 12/31/2003

Objective

Using modern mass spectral capabilities, identify the compounds responsible for the off-flavor present in commercially produced glycomacropeptide (GMP) product.

Review and comparison of nutritional and functional properties of dairy proteins relative to other market protein sources

Personnel

Rankin, Scott

Funding

Dairy Management, Inc.

Dates

4/1/2003 to 12/31/2003

Objective

Utilizing available abstracting resources, an extensive literature review will be conducted as the basis for a review paper to be published in an appropriate journal.

Characterization of pigments and conditions responsible for browning in whey powders

Personnel

Rankin, Scott

Funding

Dairy Management, Inc.

Dates

4/1/2003 to 12/31/2003

Objective

Using compositional data and LC technologies, the nature of these browning pigments will be determined and the chemistry of their formation will be determined.

Develop innovative solutions for the “Cold Melt” of cheese when partnered with another food ingredient (i.e. meat)

Personnel

Wendorff, Bill

Funding

Dairy Management, Inc.

Dates

7/1/2003 to 12/31/2003

Objectives

1. To determine parameters influencing the migration of moisture to cheese pieces in process meat products.
2. To develop processing aids or manufacturing procedures for production of natural cheese products that eliminate or retard the migrations of moisture to the cheese pieces.

Manufacture of a no-sugar frozen desert

Personnel

Bradley, Robert

Funding

Dairy Management, Inc.

Dates

4/1/2003 to 12/31/2003

Objective

To produce a finished frozen dessert with excellent flavor and no carbohydrates to meet the demands of lactose mal-digesters and Atkins diet followers.

Production of sialyllactose from lactose using a bioreactor

Personnel

Romero, Juan

Funding

Dairy Management, Inc.

Dates

4/1/2003 to 12/31/2003

Objective

Feasibility study to evaluate the use of a bioreactor to produce sialyllactose from lactose as a value added ingredient for infant formula manufacturers and as a probiotic.

Improving WPI functionality for beverage applications

Personnel

Etzel, Mark

Funding

Dairy Management, Inc.

Dates

1/1/2004 to 12/31/2005

Objectives

1. Understand the causes of sediment formation and increased turbidity in current WPI products made using membrane processes and ion exchange.
2. Determine the operating parameters and equipment requirements needed to avoid damage to the enhanced WPI during downstream processing by membrane concentration and spray drying.
3. Develop and test prototype 'high protein' beverage formulations of different pH for lack of sediment formation and turbidity after low heat and high heat treatments.
4. Identify the individual proteins in the enhanced WPI that contribute most to sediment formation and turbidity and in prototype high-protein beverage formulations.
5. Adapt the processing conditions and explore food-grade additives to decrease sediment and turbidity and in prototype high-protein beverage formulations.

A chemistry-based approach to understanding process cheese functionality

Personnel

Lucey, John

Funding

Dairy Management, Inc.

Dates

1/1/2004 to 12/31/2006

Objectives

1. To measure efficiency of the chelating properties of emulsification salts (ES) and the potential to promote cross-linking between ingredients
2. To control the performance of process cheese used in specific applications by understanding the interactions between raw materials (cheese), emulsification salts, and processing steps (temperature, time, shear).

Develop a process for adhering meat products (pepperoni) to cheese for one-step pizza topping application

Personnel

Johnson, Mark

Funding

Dairy Management, Inc.

Dates

1/1/2004 to 12/31/2004

Objective

Manufacturers of meat products for use as toppings on pizza have approached us to test the feasibility of developing a process by which their products could be directly applied to cheese prior to the manufacture of the pizza. In this manner the cheese and pizza topping would be applied in a prefabricated form directly to the pizza.

Manufacture of flavored fun cheeses for kids

Personnel

Jaeggi, John

Funding

Dairy Management, Inc.

Dates

1/1/2004 to 12/31/2004

Objectives

1. To develop a manufacturing protocol and identify ingredients and colorants to make flavored cheeses that would be especially appealing to children.
2. Scale-up production to work with plants that currently have equipment available and would be willing to work with us on this endeavor.

Develop nonfat mozzarella for use in the school lunch program

Personnel

Johnson, Mark

Funding

Dairy Management, Inc.

Dates

1/1/2004 to 12/31/2004

Objectives

Research completed at the Wisconsin Center for Dairy has shown that the judicious use of condensed buttermilk (buttermilk condensed via evaporation of membrane processing) for the manufacture of pizza cheese does not compromise cheese quality or functional characteristics. Our proposal is to use buttermilk in the manufacture of nonfat mozzarella for use in the School Lunch Program with the intent that it will produce a nutritious, totally dairy based cheese with desirable sensory attributes.

Evaluation of sweet cream buttermilk for use as cheese ingredient

Personnel

Johnson, Mark;
Govindasamy-Lucey, Rani; Lucey, John

Funding

Dairy Management, Inc.

Dates

7/1/2002 to 12/31/03

Objectives

1. To characterize the composition of cream and sweet cream buttermilk from at least 3 different processing plants over one season to determine the effects of using these buttermilks on cheese functionality. Hypothesis: It is likely that there is considerable variation in the composition of sweet cream buttermilk although little documented evidence is available. We believe that variation in the composition of sweet cream buttermilk may limit its use as a cheese ingredient and this study will help develop detailed specifications regarding the composition of sweet cream buttermilk that could be used in cheeses.
2. To evaluate whether the variations in sweet cream buttermilk is due to the specific buttermaking processing conditions rather than compositional differences between creams. Hypothesis: The functional properties of sweet cream buttermilk are variable and it can be related to actual processing steps such as pasteurization of the cream and buttermilk.
3. To develop procedures to incorporate a commercially available source of sweet cream buttermilk fraction, rich in phospholipids in the manufacture of cheese. If a source is not available commercially, a phospholipid-rich fraction derived from sweet cream buttermilk will be produced. The effects of sweet cream buttermilk fraction on the functionality and sensory characteristics of the cheese will be evaluated. Hypothesis: Phospholipids act as emulsifiers and as surface active agents. Thus they may reduce blister formation. In turn this will reduce burning and excessive drying or skin formation.

Chapter Two

Final reports

annual report 2003

Biochemistry of full and reduced fat cheddar shred ripening

Personnel

Rankin, Scott A.

Funding

Dairy Management Inc.

Dates

4/15/2001 to 12/31/2002

Objectives

1. Characterize the effects of gas composition (CO_2 , N_2 , CO_2/N_2 blends, fat content, shred size and light exposure on the biochemical, (glycolysis, proteolysis, lipolysis, volatile) and microbial (starter, NSLAB) ripening indices of MAP packaged cheddar cheese shreds. An understanding of the degree to which MAP storage effectors influence cheese ripening will enable processors to select conditions conducive to optimal ripening and storage quality.
2. Characterize the effects of the packaging variables described above on the descriptive sensory profiles and consumer responses of MAP cheddar cheese shreds. Characterizing the sensory impact of MAP conditions will provide a valuable index of shred quality as it relates to human consumption.

Summary

Three replicates (i.e. this had been repeated on three separate occasions with three separate cheddar blocks) of cheddar cheese have been subjected to shredding, antimycotic and anti-caking agent application, proximate analysis, and randomly assigned to one of six treatments: 100% CO_2 , 70/30 blends, 100% N_2 . Control cheese treatments included vacuum packages shreds and a vacuum packed block. Several indexes of aging were assessed over a 180 day period, including residual lactose, D- and L- lactate, proteolysis, lipolysis, starter and nonstarter bacteria, and yeast and mold counts. Sensory analysis of the cheeses was conducted only at the 90 day interval. Some preliminary results were presented at the Institute of Food Technologists annual meeting in June, 2001. While some additional work is still in progress, the project is however complete relative to the original objectives.

Publications/Presentations

Colchin, L.M., S.L. Owens, G. Lyubachevskaya, and Russek-Cohen, E., and S.A. Rankin. 2001. Modified Atmosphere Packaged Aged Cheddar Cheese Shreds: Influence of Fluorescent Light Exposure and Gas Type on the Color and Production of Volatile Compounds. *J. Agric. Food Chem.* 49:2277.

B. C. Fermin-Ramos, S. L. Owens, V. Galindo-Cuspinera, and S. A. Rankin. 2002. Biochemical, Microbial and Sensory Changes in Cheddar Shreds Held Under Modified Atmosphere Packaging. *J. Food Protection*. In preparation.

Colchin, L.M. and Rankin, S.A. Effects of modified atmosphere packaging conditions on color stability and volatile profiles of shredded cheddar cheese. Presented at American Dairy Science Association annual meeting, Memphis, TN, July, 1999.

Colchin, L.M., S.L. Owens, G. Lyubachevskaya, and Russek-Cohen, E., and S.A. Rankin. 2002. Modified Atmosphere Packaged Aged Cheddar Cheese Shreds: How light and gas type influence color and volatile compounds. Dairy Pipeline. Dec 2001, 13(4): 1;4.

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

Personnel

Chen, Carol

Funding

Dairy Management Inc.

Dates

July 1, 1999 to December 31, 2001

Objectives

1. To develop a shred/texture map of cheeses based on rheological, sensory and chemical measurements.
2. To define manufacturing protocols of cheddar and mozzarella tailored for shredding.

Summary

The most important textural factor in the conversion of block cheese to shreds is the firmness. A trained panelist can measure this by compressing a cube of cheese between the thumb and forefinger (shred grades correlation to sensory firmness $R^2 = 0.68$). This relationship is true regardless of cheese type, manufacturing style, composition or age. Cheese fracturability and adhesiveness are of secondary importance. Fracturability is more important for American type cheeses (cheddar and colby types) while adhesiveness is important in LMPS mozzarella cheeses (pasta filata and non-pasta filata). Using sensory firmness, fracturability, and adhesiveness scores we are able to accurately predict shred grade (an index of shredding quality), with R^2 values ranging from 0.56 to 0.85. Manufacturing a cheese with good shred attributes requires controlling the cheese firmness (through composition and pH) and limiting proteolysis, which minimizes the impact of cheese fracturability and adhesiveness.

Cheeses evaluated for the Shred Map Project varied in type, manufacturing style and included a wide range of compositions and ages. Table 1 summarizes the 248 lots of cheese that were shredded using an Urshel CC-D shredder (Head size #22897 Oval Shred, 0.125" thick x .0250" wide.) Some cheeses shredded well, others did not. Shredded cheese was then analyzed for size distribution, dimensions, character and preference. Shred size distribution was determined by separating shredded cheese on different screen sizes (US mesh #4, US mesh #6, pan) using a Ro-Tap Sieve Shaker. This measurement describes the distribution of cheese particulates (shreds and fines) according to size after converting cheese blocks into shreds. Shred sizes were long (shreds greater than 3/4" long), short (shreds less than 3/4" long), fines (cheese particulate collected in the pan) and clumps (multiple shreds stuck together after shaking or single shreds balled up). To determine shred dimensions, an electronic caliper was used to measure the width, thickness and length of 20 to 25 randomly

Table 1. Summary of CDR and commercially manufactured cheeses shredded and analyzed for texture in the Shred Map Project. Total number of analysis points equals 248.

Type of Cheese	Description	% Moisture	% FDM	Cheese Age, wk	Lots Analyzed
American – Type					
Brick	Mesophilic cultures, washed curd	Range: 41.1 - 42.1 Mean: 41.6	Range: 54.4 - 53.8 Mean: 54.1	1 to 10	Lots: 2 Total: 8
Cheddar	Milled curd, no curd washing	Range: 36.8 – 40.7 Mean: 38.3	Range: 52.0 – 53.8 Mean: 52.7	1 to 26	Lots: 6 Total: 32
Cheddar	Stirred Curd, no curd washing	Range: 36.1 - 37.5 Mean: 36.7	Range: 51.8 - 53.7 Mean: 52.9	1 to 26	Lots: 4 Total: 22
Colby and Monterey jack	Mesophilic cultures, washed curd	Range: 37.6 – 45.7 Mean: 41.2	Range: 52.2 - 54.1 Mean: 53.3	1 to 21	Lots: 9 Total: 42
Muenster	Thermophilic cultures, no curd washing	Range: 45.4 – 49.0 Mean: 46.8	Range: 44.3 - 54.1 Mean: 49.1	1 to 13	Lots: 4 Total: 14
LMPS Mozzarella					
Pasta filata	Typical make, Higher than normal milk pasteurization temperatures, WPC addition)	Range: 43.0 - 51.0 Mean: 46.7	Range: 32.7 – 46.5 Mean: 42.0	1 to 15	Lots: 21 Total: 78
Stirred Curd Non Pasta filata	Typical make (CDR stirred curd Mozzarella, direct salted), higher than normal milk pasteurization temperatures, WPC added)	Range: 44.6 - 48.0 Mean: 46.1	Range: 41.1 – 48.5 Mean: 44.0	1 to 15	Lots: 11 Total: 52

selected long shreds. Shred character scores were visual observations on the following attributes: clumping, wetness, shine, straightness, roughness, elasticity and shape. Each attribute was given a score according to a general 15-point category scale. Fifteen to twenty panelists evaluated cheese preference using a 7-point category hedonic scale.

Table 2 summarizes analysis completed on cheeses for the Shred Map Project. Cheese chemical and textural analysis was conducted in conjunction with shred evaluations. Cheese chemical analysis included moisture, protein, fat, salt, pH and 12% TCA soluble nitrogen (a measure of proteolysis). Cheese texture was determined by sensory analysis and two rheological methods. All cheese texture evaluations were completed at 40°F, the shredding temperature. Most literature cheese texture evaluations are conducted between 45 - 55°F, or the temperatures at which cheese is commonly graded. However, in this experiment, we felt it more important to evaluate the cheese at the shredding temperature.

Figure 1. General reference scale used in quantitative descriptive sensory analysis.

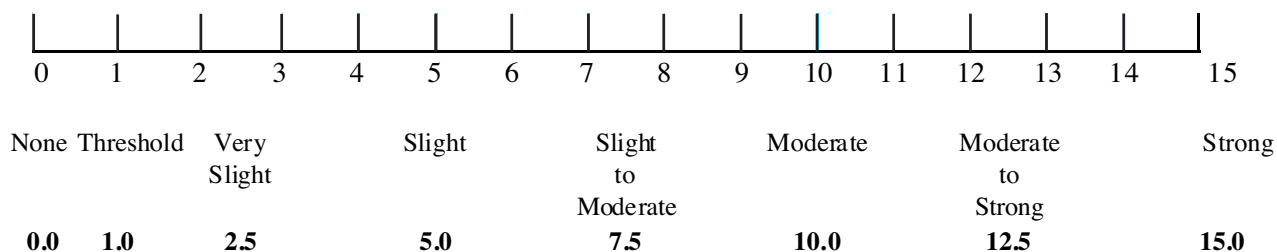


Table 2. Type of Analysis completed on cheeses for Shred Map Project

Analysis	Brief Description
Shred Size Distribution	Using a Ro-Tap Sieve Shaker (W.S. Tyler Company, Cleveland OH) and U.S. Standard Testing Sieves sizes No. 4, No. 6 and a pan, cheese shred were separated into long shreds (> $\frac{1}{2}$ inch), short shreds (< $\frac{1}{2}$ inch) and fines.
Shred Character	Using a 15-point category scale the following attributes were assessed: clumping, shed wetness, shred shine, amount of powdery fines, shred roughness, straightness, elasticity, fine shape.
Shred Size Measurements	Dimensions of 20 to 25 randomly selected shreds measured to the nearest 0.01 mm using an electronic digital caliper.
Shred Preference	15 to 20 untrained panelists scored visual shred preference of 80g of cheese in a round dark-colored 10-inch cake pan using a 7-point hedonic scale (extremely dislike to extremely like).
Chemical Analysis	Proximate analysis: moisture by vacuum oven, fat by Mojonnier method, protein by Kjeldahl titration, salt by silver chloride titration, pH by quinhydrone method, proteolysis by 12% TCA soluble nitrogen.
Sensory Texture Analysis	Following IFT Quantitative Descriptive panel guidelines, the following attributes were evaluated in duplicate by a trained panel using a 15-point category scale: firmness, deformability, hardness, fracturability, adhesiveness and cohesiveness.
Torsion Rheometry	Stress, Strain and G' measured by twisting a plugs of cheese. Experiment required 12 replicates. Torsion stress is a measure of hardness, torsion strain is a measure of deformability and Torsion G'.
Texture Profile Analysis	Using standard TPA protocol – Double Bite, 80% compression: hardness, springiness, cohesiveness, resilience, gumminess, and chewiness.
Texture Analyzer	Using the Texture analyzer, we measured the force to fracture (80% compression) and the force to cut cheese with a wire (60% of cheese width).

Sensory analysis followed IFT guidelines for Quantitative Descriptive analysis. Cheese texture attributes were defined and reference foods were chosen and associated with specific points on the 15-point category scale. Panelists were 'calibrated' using the reference foods for each attribute. The attributes evaluated were as follows: firmness (hand test), deformability and hardness (1st bite), fracturability (1st chew) and adhesiveness and cohesiveness of mass (chewdown characteristics). Figure 1 shows a general 15-point reference scale used for each attribute.

We chose two different rheological test methods. Texture Profile Analysis (TPA) and Texture Analyzer (TA) 'force to fracture' methods were chosen because of their wide use. These methods use one sample size with a set speed and percentage of compression. If any of those input variables are changed, the values are not comparable. Torsion rheometry offers a more fundamental type of measurement. Torsion rheometry measures strain, stress and G' as it twists a cheese cylinder (dumbbell shape). This is an advantage because the cheese does not change shape during twisting (no assumptions need to be made in the output formulas) and if no clear fracture points are made, the researcher can change the dimension of the cheese cylinder and output values are still comparable. This makes torsion rheometry a good choice for testing cheese that will have a wide range of textures.

For data analysis we utilized Stepwise Regression Analysis, a multiple regression model that simultaneously assesses all explanatory variables. The model searches for the one variable, which gives the best explanation of the dependent variable (highest R² of all possible simple regressions). Next the model searches for a second explanatory variable and chooses

the one that gives the maximum increase in R2 to the value of R2 from the first step. This search continues until remaining variables have insignificant contributions to the dependent variable.

Shred Grade

To determine which shredded cheese attributes had the greatest impact on shredded cheese preference, stepwise regression analysis was run using shredded cheese preference as the dependent variable and shred size distribution, size measurements and character as the independent or explanatory variables. The top three explanatory variables for shred preference were percentage of long shreds (from size distribution), shred thickness (from shred dimension measurements) and shred straightness (from shred character observations). Panelists preferred cheese shreds that were long, thick and straight. Percentage of long shred had the greatest impact on preference, with shred thickness and straightness being of secondary importance. For example, when a cheese is moderately firm in texture, the percentage of long shreds is not necessary any less, but the cheese shreds are thinner. A thinner cheese shred will result in a lower shred grade. In another scenario, when the cheese texture is soft, the cheese is extruded through the blades instead of cut. The resulting shreds are short and thick. Even though the cheese shreds are thick (in this case undesirable), there is a lower percentage of long shred and the overall grade will be lower. It is important to include all three attributes in the shred grade. For this experiment, we defined shred grade as a ratio of percentage of long shreds (60%), shred thickness (20%) and shred straightness (20%); having a R2 value of 0.77.

Figure 2. Linear relationship between shred grade and shredded cheese preference.

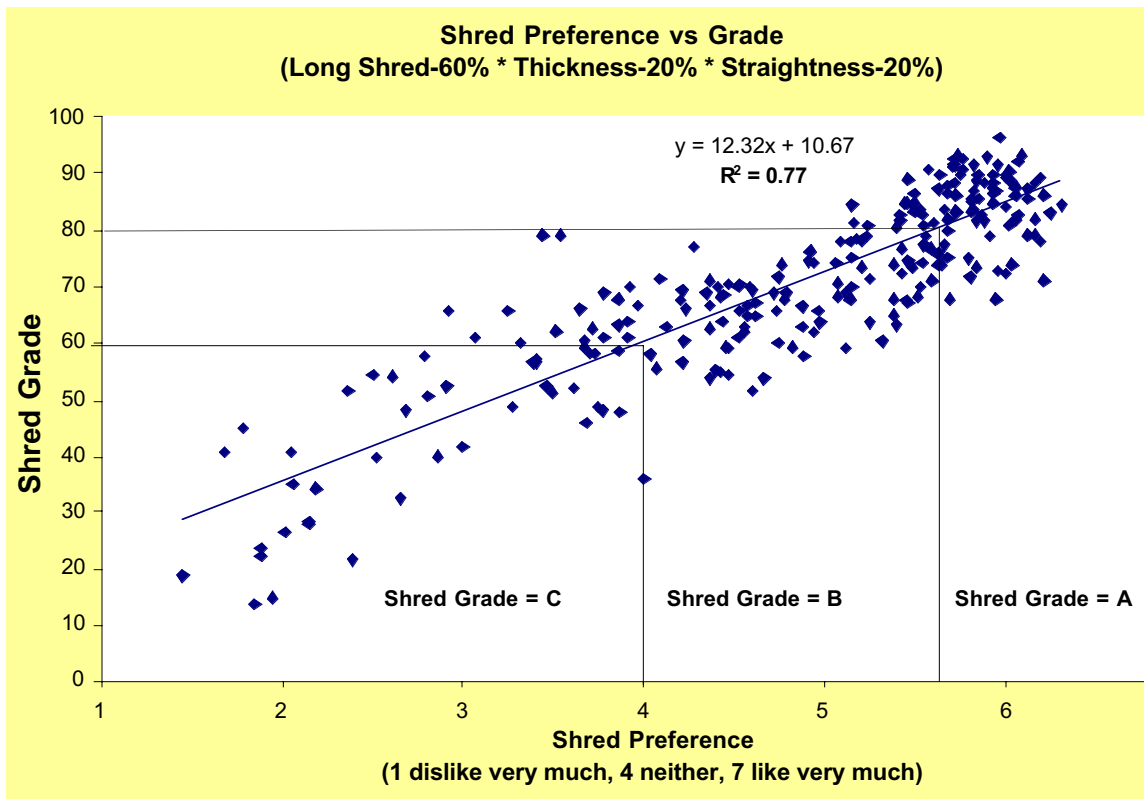
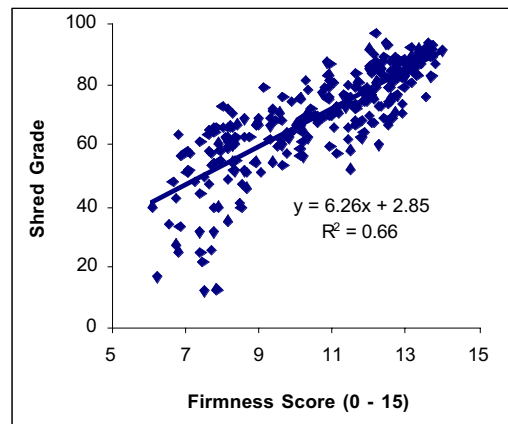
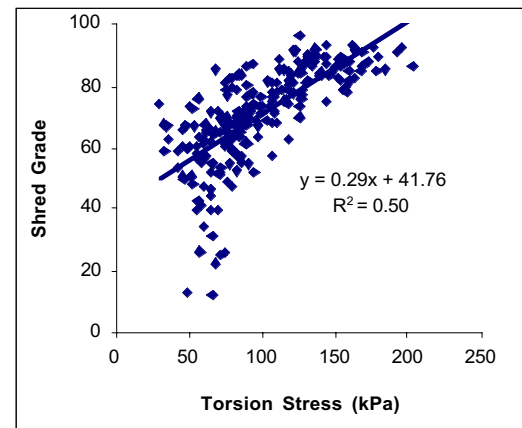


Figure 3. Relationship between Shred Grade and Sensory Firmness and Torsion Stress.

3A. Sensory Firmness



3B. Torsion Stress



In this report, shred grade will be used as the index for quality when converting block cheese into shreds, Figure 2. We define an ‘A’ as having a shred grade between 80 – 100 and a preference above 5.5. These shreds are long, very straight and thick. The shred grade ‘B’ has a score between 60 – 80, which is also acceptable. These shreds tend to be thinner and less straight. Shred with a score below 60 were called ‘C’. These shreds were unacceptable, had preference scores below 4 and tended to be thinner, have more bent shreds and a lower percentage of long shreds.

Primary textural attribute required for shredding

To determine the most important textural attributes in the conversion of block cheese to shreds, shred grade was chosen as the dependent variable and cheese texture measurements (TPA, TA, torsion rheometry and sensory analysis) were the independent or explanatory variables. This stepwise regression used all cheese types and ages (248 lots). There were only two attributes that highly correlated to cheese shreddability and both related to the rigidity of the block cheese. The top attributes were sensory firmness and torsion stress (a measure of hardness). The individual linear relationships are plotted in Figures 3A and 3B. The sensory firmness is defined as the force required to compress cheese between the thumb and forefinger. Panelists were instructed to compress the cheese, but not fracture it. The sensory firmness measurements correlated higher to shred grade than torsion stress and it is simpler and faster to conduct. Regardless of the cheese type, manufacturing style, composition or age, a trained judge can measure the force to compress a cube of cheese at 40°F and estimate how the cheese will shred.

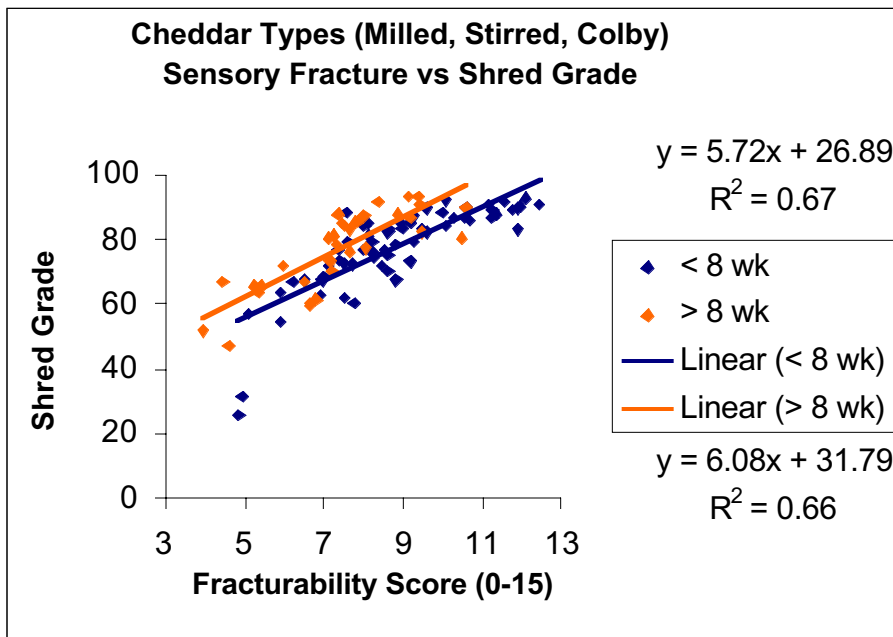
The relationship between shred grade and sensory firmness did change slightly with the age and type of cheese. As a general rule, for a cheese to have a shred grade of ‘A’, the firmness needs to be above a 12.5 (texture moderate to very firm). For a shred grade of ‘B’, the firmness needs be between 9 and 12.5. Firmness levels below 9 (slight to moderately firm) generally result cheese with a shred grade of ‘C’.

Secondary textural attributes required for shredding

Cheese type and age significantly affected the ability to shred cheeses. Cheese data was split into cheddar or mozzarella type cheeses in order to determine secondary textural attributes required for shredding. The cheddar type cheeses included milled and stirred curd cheddar, colby and monterey jack. The mozzarella cheeses included pasta filata and stirred curd (non pasta filata) manufacturing styles. In addition to splitting the cheese by type, it was necessary to divide the cheeses into two different ages (cheddar-types < 8 weeks, > 8 weeks; mozzarella-types < 6 weeks, > 6 weeks).

For cheddar type cheese less than 8 weeks of age, sensory firmness was the primary explanatory variable with TA 'force to fracture' and sensory fracturability having a significant affect on shred grade. For cheddar-type cheeses greater than 8 weeks of age, torsion stress was the primary explanatory variable with sensory fracturability and TPA resilience having a significant contribution to shred grade. With both age groups, as the force to fracture (as measured by texture analyzer or sensory analysis) decreased, the shred grades decreased. The more brittle the cheddar-type cheese, the lower the shred grade. During shredding, if a cheese fractures readily it is more likely to break apart into shorter shreds. This is especially true with a firm cheese such as cheddar (~37% moisture, 52% FDM). Sensory fracturability and TA 'force to fracture' were the best methods for accessing the force required to fracture cheese. In this experiment, sensory fracturability had higher correlations to shred grade than TA 'force to fracture'. In addition, with sensory fracturability we were able to measure the force to fracture over a wider range of cheese textures. The TA 'force to fracture' failed to have a clear fracture point in older, high moisture cheeses such as colby or monterey jack. Sensory fracturability is defined as force with which the sample breaks. Panelists were in-

Figure 4. Correlations between Shred Grade and Sensory Fracturability for cheddar type cheeses less than 8 weeks and greater than 8 weeks of age.

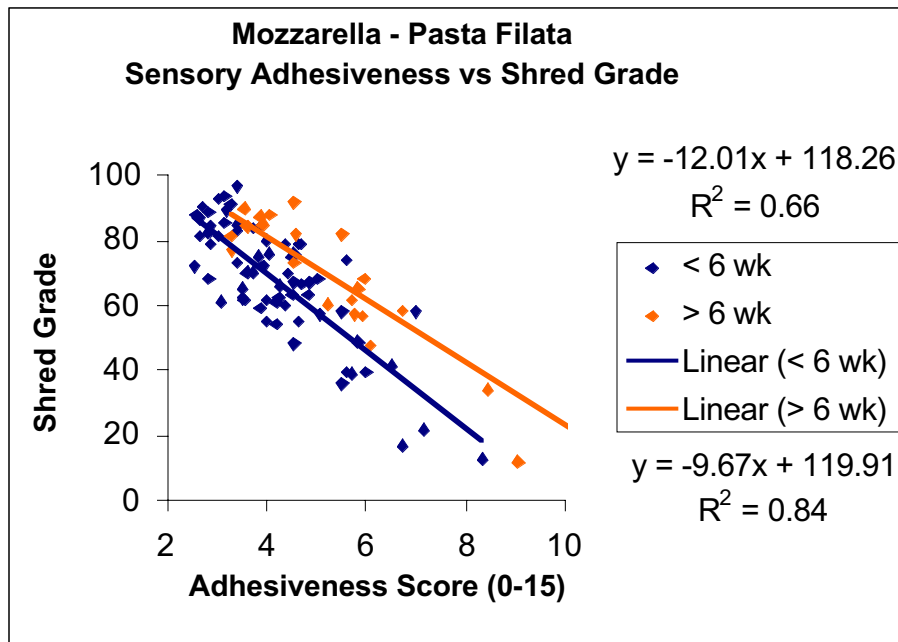


structed to bite through the cheese with molars and measure the force required to fracture the sample. Figure 4 plots the correlations between shred grade and sensory fracturability.

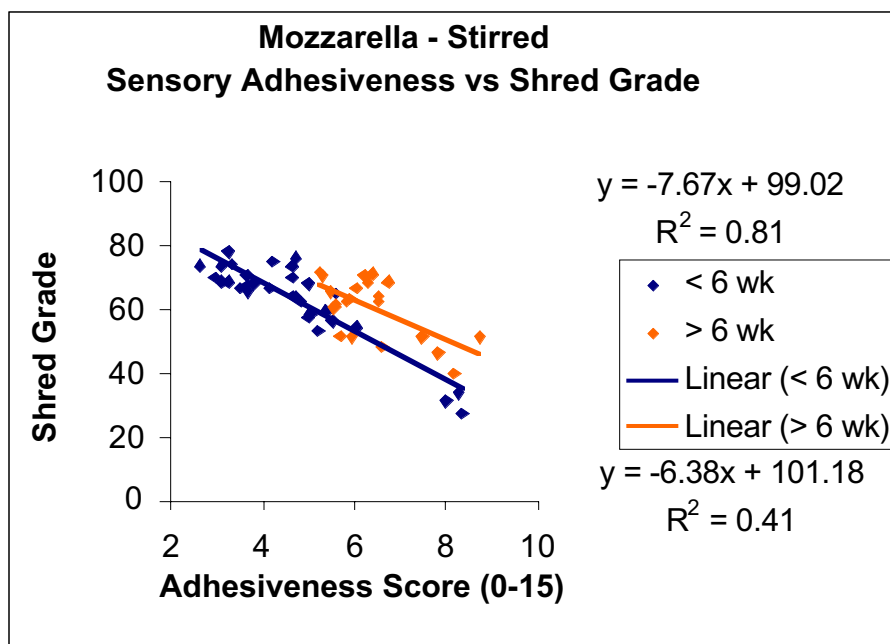
For mozzarella-type cheese less than 6 weeks of age, torsion stress was the primary explanatory variable with sensory adhesiveness also having a significant effect on shred grade. For mozzarella-type cheeses greater than

Figure 5. Correlations between shred grade and sensory adhesiveness for mozzarella pasta filata and stirred curd style cheeses.

5A.



5B.



8 weeks of age, sensory adhesiveness was the top explanatory variable. As cheese adhesiveness increased, shred grade decreased. During shredding, a more adhesive cheese will stick to blades, causing the cheese to slow as it is being pushed through the blades. At slow speeds, the cheese no longer has a clean cut and a shred is more apt to be bent. Sensory analysis was the best method for measuring cheese adhesiveness in these experiments. Sensory adhesiveness of mass is defined as the degree to which the cheese mass sticks to the roof of mouth or teeth. Panelists were instructed to chew the sample between molars fifteen times and then evaluate cheese adhesive properties. See Figures 5A and 5B for plot of shred grade and sensory adhesiveness correlations.

Shredding of cheddar, colby/monterey jack and mozzarella cheeses

Table 3 summarizes shred grades and characteristics of cheddar, colby/monterey jack and LMPS mozzarella cheeses shredded between 1 week and 5 months. Cheddar cheese had the highest shred grades at all ages. The shred attributes, percentage of long shreds, shred straightness and shred thickness did not change over time. The shred grade for colby/jack only decreases slightly over 3 months. The overall shreddability of mozzarella cheeses, pasta filata and stirred curd style, was lower than the American-style cheeses. The decrease in mozzarella - pasta filata shred grade was mainly due to a decrease in the percentage of long shreds (more short shreds and fines). Decreases in shred grades for mozzarella – stirred curd were attributed to a decrease in the percentage of long shred and a decrease in shred straightness and thickness. Mozzarella cheeses had the greatest

Table 3. Summary of shred grades and shred characteristics for cheddar, colby / monterey jack and mozzarella cheeses.

	cheddar - milled & stirred curd	colby and monterey jack	LMPS mozzarella – Pasta Filata	LMPS mozzarella – Stirred Curd
Cheese Composition	37% moisture 52.5 % FDM	41.5% moisture 53.5 % FDM	46% moisture 43% FDM	46% moisture 43% FDM
Shred Grade A = 80 to 100 B = 60 to 80 C = 0 to 60	88 @ 2 wk 87 @ 3 mo 83 @ 5 mo	72 @ 2 wk 69 @ 3 mo	75 @ 1 wk 65 @ 3 mo	71 @ 1 wk 59 @ 3 mo
% Long Shreds, 60% of shred grade	89 % @ 2 wk 88 % @ 3 mo 82 % @ 5 mo	78 % @ 2 wk 79 % @ 3 mo	87 % @ 1 wk 73 % @ 3 mo	77 % @ 1 wk 71 % @ 3 mo
Shred Straightness (0 – none straight, 15 very straight), 20% of shred grade	13 @ 2 wk 13 @ 3 mo 12 @ 5 mo	10 @ 2 wk 9 @ 3 mo	11 @ 1 wk 8 @ 3 mo	12 @ 1 wk 8 @ 3 mo
Shred Thickness (mm), 20% of shred grade	3.1 mm @ 2 wk 3.2 mm @ 3 mo 3.2 mm @ 5 mo	2.8 mm @ 2 wk 2.7 mm @ 3 mo	2.5 mm @ 1 wk 2.7 mm @ 3 mo	2.6 mm @ 1 wk 2.4 mm @ 3 mo

decrease in shred grade over time. By 3 months, block mozzarella often could not be acceptably converted into shreds. What differences and changes in cheese texture occur to create these differences between cheddar and colby/jack/mozzarella? To answer this question, examination of differences in cheese texture attributes that are most important to the shred grade are necessary.

Cheese texture over time

Cheddar cheese had the highest shred grades, highest firmness and fracturability scores. For cheddar or colby/jack cheese under 3 months old, if firmness is in the moderate to very hard range (score = 13) and fracturability in the moderate range (score above 9.0), the cheese is likely to shred well. Due to the higher moisture content of colby/jack it is less likely to be in this firmness range, so there were fewer Shred Grade 'A' colby/jack lots. At all time points, colby/jack, mozzarella – pasta filata, and mozzarella – stirred curd are less firm than cheddar. This is to be expected, as cheddar cheese is significantly lower in moisture. Mozzarella cheeses ranged in adhesiveness from very slight (score = 3) to slight to moderate (score = 7). The adhesiveness of cheddar and colby/jack at the same age was greater than that of mozzarella. Mozzarella shred grades are highly correlated to adhesiveness and firmness scores. Even though mozzarella cheeses are less adhesive than American-type cheeses, adhesiveness plays a larger role in converting block cheese to shreds. We speculate that a softer cheese moves through the Urshel cutting blades more slowly, so cheese adhesiveness or stickiness plays a more significant role in shred quality.

Analysis of the data from this project provides us with a map that outlines cheese texture attributes required for shredding. Cheese hardness, force to fracture and adhesive properties offer us information needed to predict if a cheese will have acceptable shredding. Table 4 (cheddar) and Table 5 (mozzarella) provide the texture coefficients and y-intercept for the linear relationship that can be used to predict shred grade from sensory firmness, fracturability and adhesiveness scores. These tables also provide general texture attribute requirements for the three grades of shredded cheese.

Table 4. Summary of the Cheddar texture coefficients and y-intercept for the linear relationship used for predicting shred grade from sensory firmness and fracturability scores. General texture requirements for three grades of shredded cheese.

Age of Cheddar	Linear Regression Information				Cheese Texture Scores		
	R ² value	Firmness Coefficient	Fracturability Coefficient	y- intercept	Shred Grade A	Shred Grade B	Shred Grade C
< 8 wk	0.82	5.99	1.61	-9.28	Firmness > 12.5	Firmness 10-12.5	Firmness < 10
					Fracture > 9	Fracture 6-12.5	Fracture < 6
> 8 wk	0.71	3.50	2.71	15.93	Firmness > 12.0	Firmness 9-12	Firmness < 9
					Fracture > 8	Fracture 5-8	Fracture < 5

Follows the formula: $y = m_1 x_1 + m_2 x_2 + b$

Shred grade = Firmness score x Firmness coefficient + Fracturability Score x Fracturability coefficient + y-intercept

Tailor manufacturing cheese for shredding

Cheddar cheeses shredded well over time. If the firmness of cheddar cheese is maintained at sensory firmness score of 12.5, no problems should arise during shredding. In our experiments, the only cheddar cheeses lots with firmness scores below 12.5 were quite high in moisture (above 40%). Through moisture control, a cheesemaker should be able to control the texture of cheddar cheese that is to be converted to shreds.

Mozzarella cheeses to be shredded must be firm in texture and not adhesive. The firmness of a pasta filata mozzarella cheese is dependent on cheese composition and does not change much over time (typical decrease is about 1 unit through 3 months of aging). To make a shreddable pasta filata mozzarella cheese the cheesemaker must control the cheese adhesiveness over time. As the degree of proteolysis increases, cheese adhesiveness increases. In a follow-up experiment, Center for Dairy Research cheesemakers manufactured 4 vats of LMPS mozzarella-pasta filata style cheeses. The treatments were as follows: Treatment 1: 47% moisture, 135°F curd temperature upon exit from mixer, Treatment 2: 47% moisture, 150°F curd temperature upon exit from mixer, Treatment 3: 50% moisture, 135°F curd temperature upon exit from mixer, Treatment 4: 50% moisture, 150°F curd temperature upon exit from mixer. The higher mixer temperature was chosen as a means to decrease proteolysis by inactivating higher levels of residual rennet and decreasing overall microbial populations. We noted no difference in the shreddability, texture and proteolysis between Treatments 1 & 2. Both cheeses had acceptable shredding. However, at the higher moisture treatments, the higher mixer temperatures significantly affect the shreddability of the cheeses. Treatment 3 was unshreddable after 10 days (sensory firmness score below 8, adhesiveness score above 9), while Treatment 4 remained shreddable at 2 months. These cheeses maintained a firmness score of 9 and an adhesive score below 5. No differences were noted in TCA soluble nitrogen levels.

Controlling the texture of a mozzarella – stirred curd (non pasta filata style) proved to be more difficult. Mozzarella – stirred curd starts out firm, but the texture softens more rapidly than other cheeses over time. In the follow-up experiment, we attempted to control the firmness of the cheese through pH control, as we did not want to lower the overall moisture content of the cheese. Our goal was to retain a greater mineral content or increase the buffer capacity of the cheese, so the cheese would be more rigid. CDR cheesemakers completed critical cheesemaking steps (renneting, draining, salting, hooping) at higher pH values. The resulting cheeses (control and experimental) had similar composition and final pH values, however, there was no differences between treatments with respect to shreddability and cheese firmness and adhesiveness. We believe that the theory behind the rationale is correct, but the final pH of the cheese needs to be higher and we need to increase the mineral retention even more.

Table 5. Summary of the Mozzarella texture coefficients and y-intercept for the linear relationship used for predicting shred grade from sensory firmness and fracturability scores. General texture requirements for the three grades of shredded cheese.

Age of Mozzarella	Linear Regression Information			y- intercept	Cheese Texture Scores		
	R ² value	Firmness Coefficient	Adhesiveness Coefficient		Shred Grade A	Shred Grade B	Shred Grade C
Pasta < 6 wk	0.81	4.38	-7.79	56.6	Firmness > 12 Adhesiveness < 3	Firmness 9 - 12 Adhesiveness 3 - 5	Firmness < 9 Adhesiveness > 5
Pasta > 6 wk	0.85	2.69	-7.56	81.6	Firmness > 11.5 Adhesiveness < 4	Firmness 9 – 11.5 Adhesiveness 4 - 6	Firmness < 9 Adhesiveness > 6
Stirred < 6 wk	0.81	2.09	-5.46	66.0	Firmness > 13.5 Adhesiveness < 2.5	Firmness 10 – 13.5 Adhesiveness 2.5 – 5	Firmness < 10 Adhesiveness > 5
Stirred > 6 wk	0.56	3.65	-3.64	51.5	Firmness > 12.5 Adhesiveness < 3.5	Firmness 8.5 – 12.5 Adhesiveness 3.5 – 6.5	Firmness < 8.5 Adhesiveness > 6.5

Follows the formula: $y = m_1 x_1 + m_2 x_2 + b$

Shred grade = Firmness score x Firmness coefficient + Adhesiveness Score x Adhesiveness coefficient + y-intercept

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 of whey proteins 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 proteins when they are subsequently incorporated into processed cheese products.

Summary

A range of commercial samples of whey powders including WPC, WPI, and reduced lactose whey (RLW) were analyzed for the size and molecular weights of each of the main proteins and aggregates that were present. This technique was size-exclusion chromatography coupled with light scattering. Differences were observed between these samples due to processing (heat treatment, concentration/separation technique, e.g., MF, UF, or ion exchange, and mineral contents). These differences in the protein aggregation state could influence the functional properties of the final product that they are used in, e.g., processed cheese. A method was developed to also quantify the amount of glycomacropeptide (GMP) and its molecular weight in WPI samples.

Three commercial samples of RLW, that had high, intermediate and low viscosities, were investigated further. RLW is commonly used in processed cheese especially cold-pack products. A high viscosity in the RLW powder is considered critical for the functionality of the cheese. However, the causes of the high viscosity in this whey product are not well known, even for manufacturers of this whey product. We demonstrated that the differences in the viscosities of these three different RLW samples did not appear to be due to differences in the levels of whey protein denaturation. The addition of Ca and phosphate salts to the low viscosity protein dispersion greatly increased viscosity. Adjustment of the pH of the high viscosity protein dispersion to 5.0 greatly reduced the viscosity. At approx. pH 5.0 all insoluble Ca phosphate salts are dissolved. The addition of EDTA (to chelate Ca) greatly reduced viscosity. The Ca and phosphate concentrations were higher in the high viscosity sample. These results suggested that the differences in the viscosities of commercial RLW powders could be due to the concentration and type of mineral in these powders. The causes of differences in the mineral contents could be due to type of

cheese whey, ingredients added during manufacture and the other processing steps.

The impact of the three different reduced lactose whey powders in processed cheese was investigated for both heated and cold-pack types. We used two types of cookers (Stephan and a twin-screw auger) that have two different heating systems (i.e., water-jacket and direct stream injection). The heat treatment applied in the manufacturing process had a major impact on which of the three types of reduced lactose whey samples yielded the firmest cheese. Using a Stephan and heating to 80°C resulting in the high viscosity RLW producing the hardest cheese but a more complex situation occurred with longer/other heat processing steps. The other RLW samples did yield harder cheese under other processing conditions. This emphasizes that the whey protein and the processing conditions must be taken into account to achieve the appropriate final texture in the process cheese. Variability in the viscosity of commercial RLW powders is a major concern for users of this product in the manufacture of processed cheese.

Publications/Presentations

Mleko, S., Janas, P., Wang, T. and J. A. Lucey. 2003. Rheological properties of reduced lactose whey dispersions. *International Journal of Dairy Technology* 56:157-161

Wang, T. and J. A. Lucey. 2003. Characterization of commercial whey protein isolates and whey protein concentrates using multi-angle laser light scattering and size-exclusion chromatography *Journal of Dairy Science* (in press)

Wang, T. and J. A. Lucey. 2003. Characterization of commercial whey protein isolates and whey protein concentrates using size-exclusion chromatography with multiangle laser light scattering (SEC-MALLS) *IFT Annual Meeting Technical Program*. Chicago, poster #14A-20.

Model development for manipulation of rheological properties of cheese

Personnel

Gunasekaran, S.; Lucey, J.; Foegeding, E.A.; and McMahon, D.

Funding

Dairy Management Inc.

Dates

3/16/2000 to 6/30/2002

Objectives

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

Summary

Cheddar, hi-melt process cheese, process cheese, Velveeta, monterey jack, and mozzarella cheeses were tested at different ages for their melt qualities by different tests.

SAOS Test

The small strain oscillatory shear (SAOS) tests were performed using 1-mm thick samples sliced and stored in a refrigerator until testing. The tests were performed in a dynamic rheometer (Bohlin CVO) using 20-mm parallel plates. The target strain level of 0.05% was used to ensure that the tests were within the linear viscoelastic limit of the samples. Frequency sweep test was conducted in the frequency range of 0.01 to 10 Hz at temperatures of 25, 50, 80°C. For the temperature, sweep tests were performed at frequency of 1 Hz and heating rate of 1 °C/min over two cycles of heating (25 to 80°C) and cooling (80 to 25 °C). From the G' and G'' traces, the $G'-G''$ crossover temperatures were determined and the averages were plotted for monterey jack and mozzarella cheese as a function of age (Figure 1A and B) and for different cheeses (Figure 1C). The crossover temperature can be considered to represent the melting temperature of the cheese. There was no significant difference in the crossover temperature due to temperature cycling. However, as expected, the crossover temperature decreased with age.

Stress relaxation and creep tests

Stress relaxation and creep compliance tests were conducted using cylindrical cheese specimen (30 mm diameter x 20 mm height). The stress relaxation tests were performed (MTS Synergie200) at room temperature in compression at crosshead speed of 16 mm/s and the

Figure 1. The G' - G'' crossover temperatures obtained during temperature sweep (up: heating from 25 to 85 °C; down: cooling from 85 to 25 °C at 1 °C/min).
A: Monterey Jack; B: Mozzarella cheese.
C: for different cheeses.

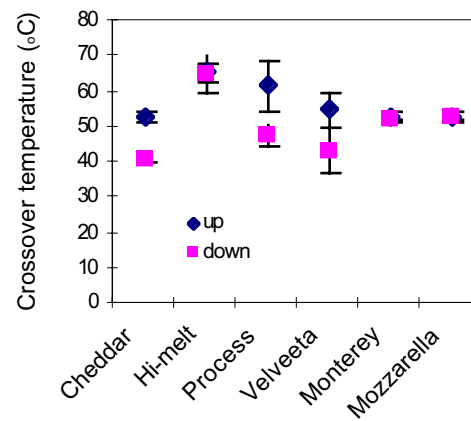
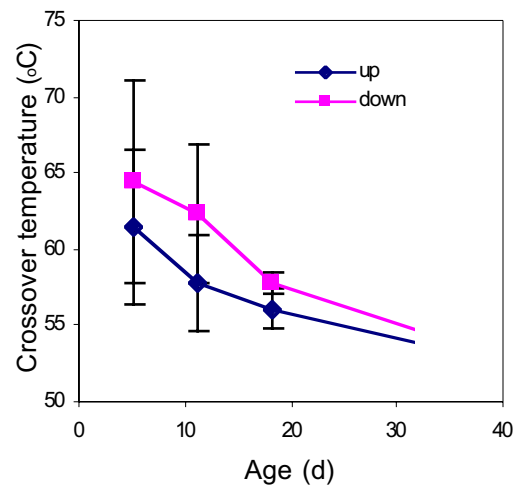
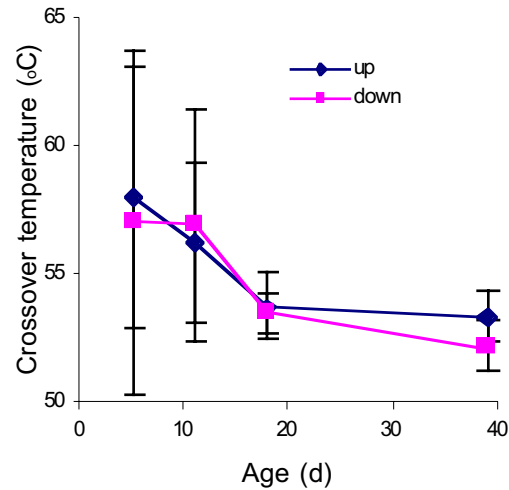
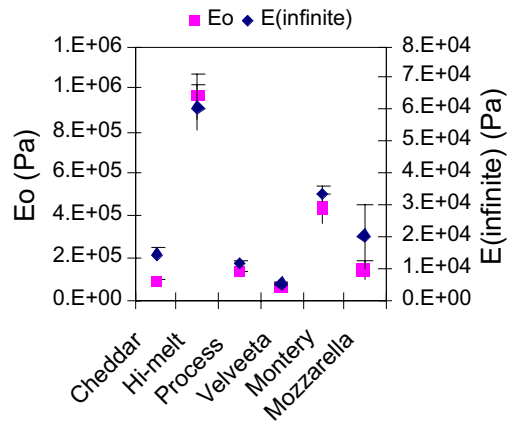
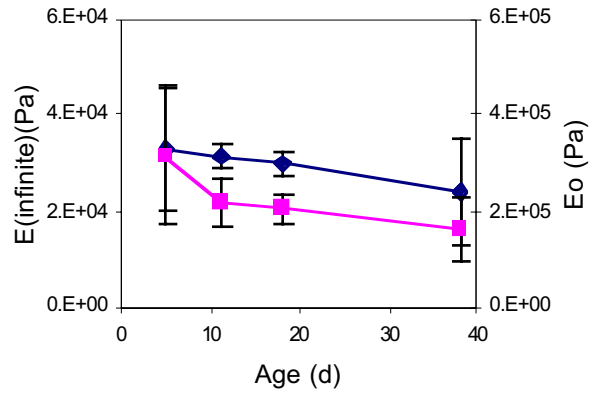
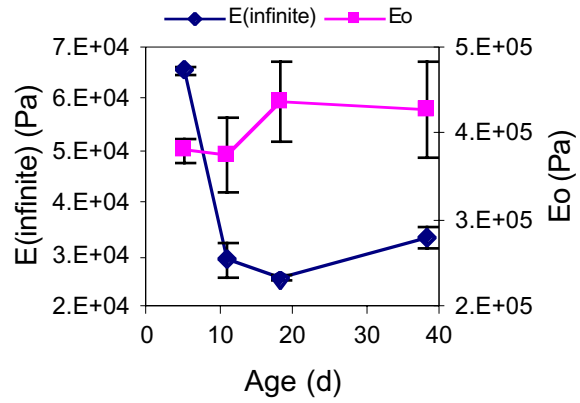


Figure 2. Stress relaxation data at room temperature for Monterey Jack (A) and Mozzarella (B) cheeses. Comparison for differen



initial strain was 30 %. The stress vs. time data were collected for five minutes. The creep tests were performed at 40 °C using the UW Meltmeter device. A constant weight of 0.5 N was applied and data were collected for two minutes.

The effect of cheese aging on mozzarella cheese is as expected – lower E_0 , the initial modulus and E_∞ , the equilibrium modulus (Fig. 2A). However, the trends with respect to monterey jack indicates slight stiffening of the cheese, though this change is not statistically significant (Fig. 2B). The E_∞ decreased drastically during initial aging (from day 4 to 7) but remained about the same subsequently. Comparing different cheeses (Fig. 2C) the high-melt process cheese was by far the stiffest, which is hard to explain.

The creep compliance and viscoelasticity index (VI) data for monterey jack (Fig. 3A) and mozzarella (Fig. 3B) cheeses show slightly different trends. The compliance and VI increased steadily with aging for mozzarella but for monterey jack this increase was only observed until 21 d of aging. Beyond that these values actually decreased. These values for different cheeses (Fig. 3C) indicate that Velveeta would probably having the melt qualities among the cheeses tested.

UW Meltmeter and UW MeltProfiler tests

Cylindrical cheese disks (30 mm diameter x 7 mm height) were cut and equilibrated in a refrigerator. For the UW Meltmeter test the temperature was 60°C and the cheese flow vs, time data were collected for two minutes. For the UW MeltProfiler test, the test temperature was 70°C and the cheese flow data were collected for 30 min.

The cheese flow (i.e., deformation of sample height) in the Meltmeter test indicates a slight increase in cheese flow with aging especially during the first two weeks post manufacture for both monterey jack and mozzarella cheeses (Fig. 4A and B). This trend is more obvious during the early flow times (0 s and 5 s after start of the test compared to 1000 s). However, more differentiation among the different cheeses was possible when comparing the data for 1000 s (Fig. 4C).

The UW MeltProfiler data provided both softening point temperature and average flow rate (AFR). The AFR can be considered an indicator of cheese meltability. As expected for both monterey jack and mozzarella cheeses, the softening point temperature decreased and AFR increased with aging (Fig. 5A and B). These changes were more pronounced for mozzarella cheese than for monterey jack. These values may be used to compare the relative meltability of different cheeses (Fig. 5C).

Schreiber Test and Tube Test

For the Schreiber test cheese discs (30 mm diameter x 7 mm height) were heated on a stainless steel plate in an oven at 120 °C for 5 min. The melt spread area was determined using a computer image analyzer. For the tube test, 30 diameter x 20 mm height samples were used. They were placed in vented test tubes and heated in hot water bath at 90°C. The travel distance of the leading edge was measured after 4, 8, 12, and 16 min.

The Schreiber and tube test results of cheese meltability measurement indicated a close to an expected trend for monterey jack and mozzarella

Figure 3. Creep data at room temperature for Monterey Jack (A) and Mozzarella (B) cheeses. Comparison for different cheeses is shown in C.

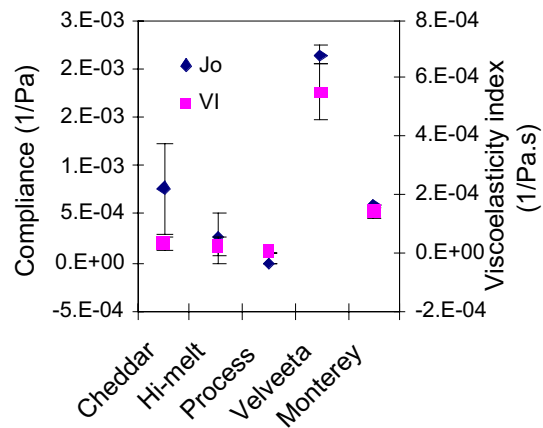
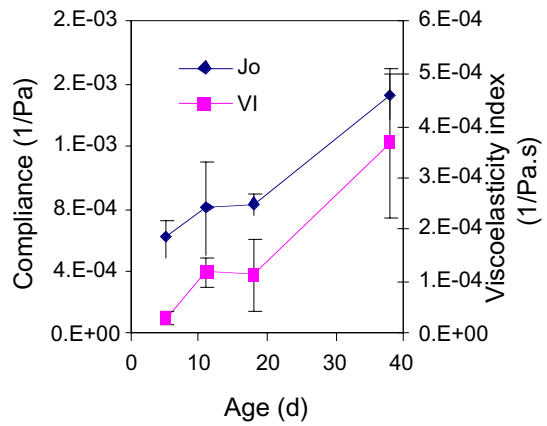
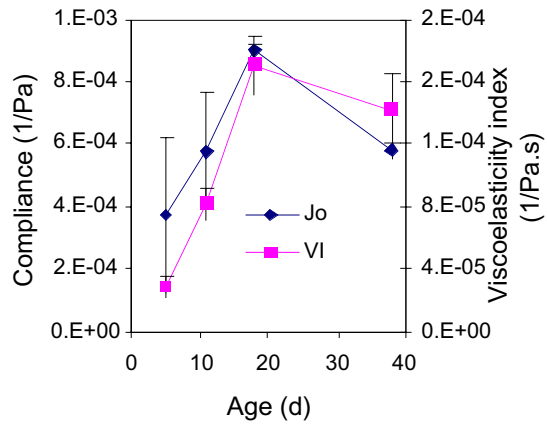
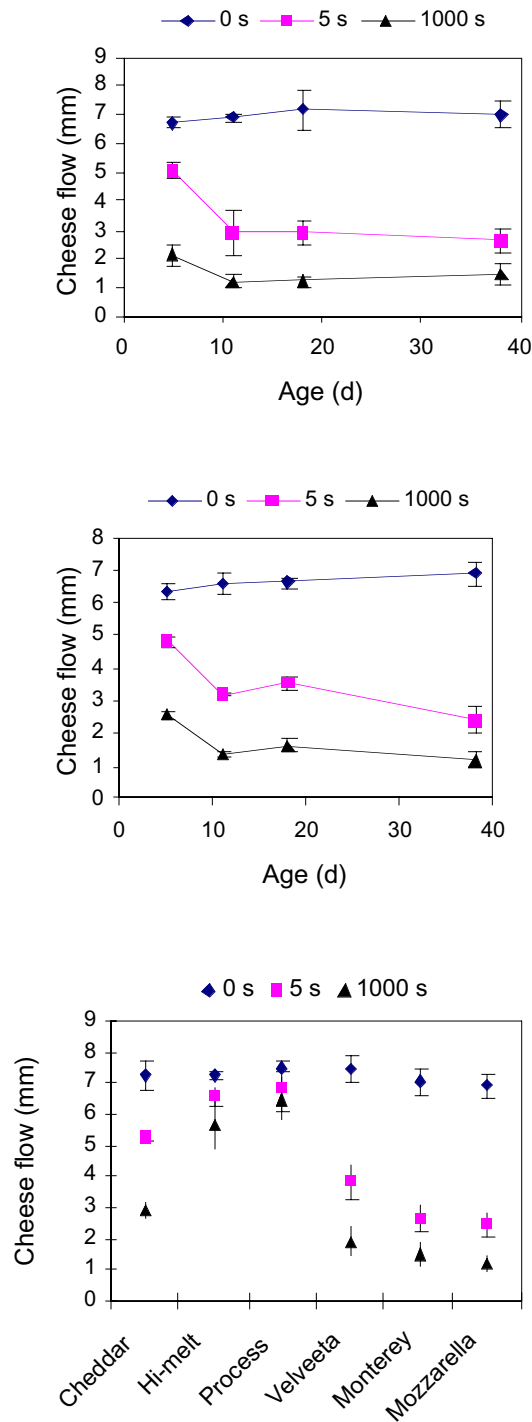


Figure 4. UW Meltmeter flow curves for Monterey Jack (A) and Mozzarella (B) cheeses as a function of aging and comparison for different cheese (C).



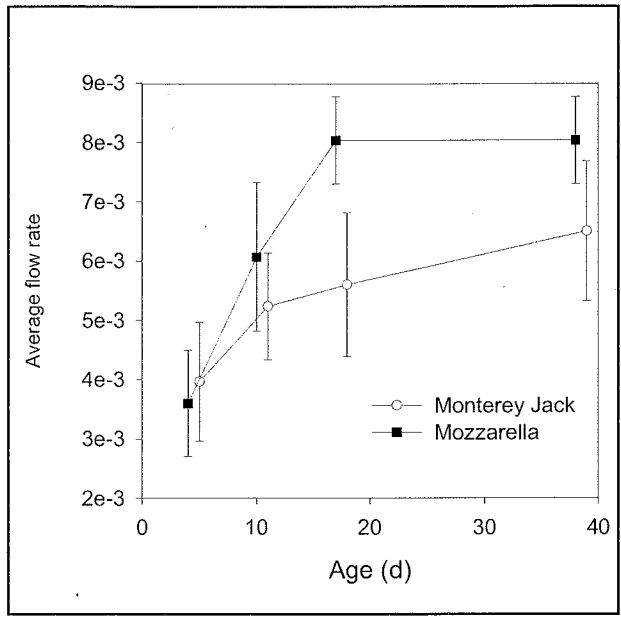


Figure 5A

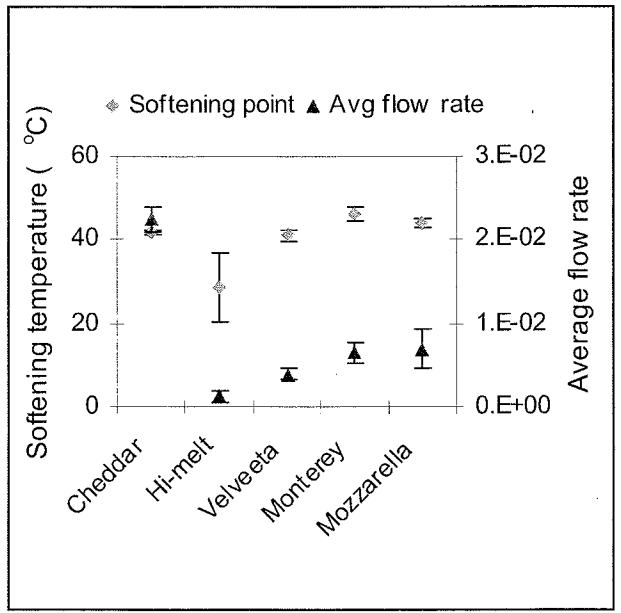


Figure 5B

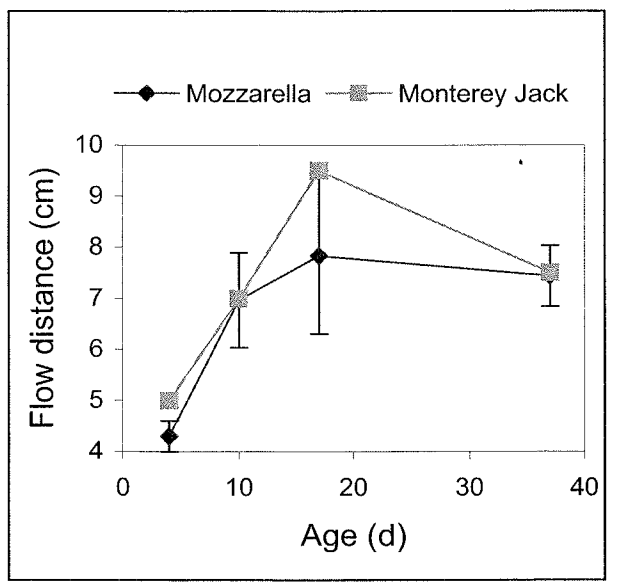


Figure 5C

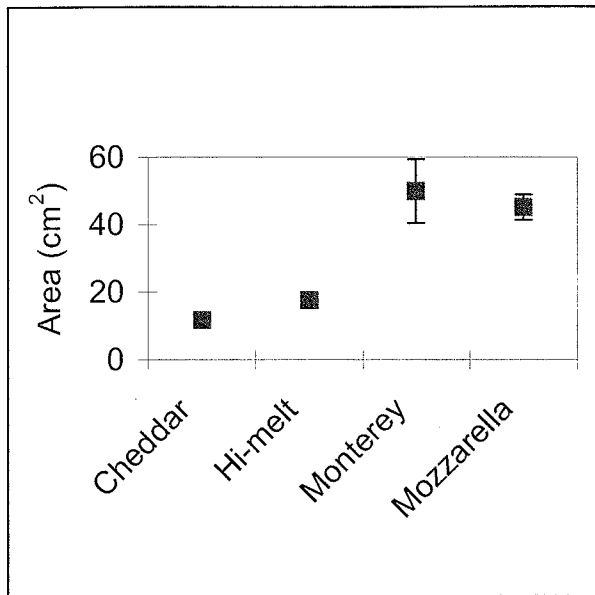


Figure 6A

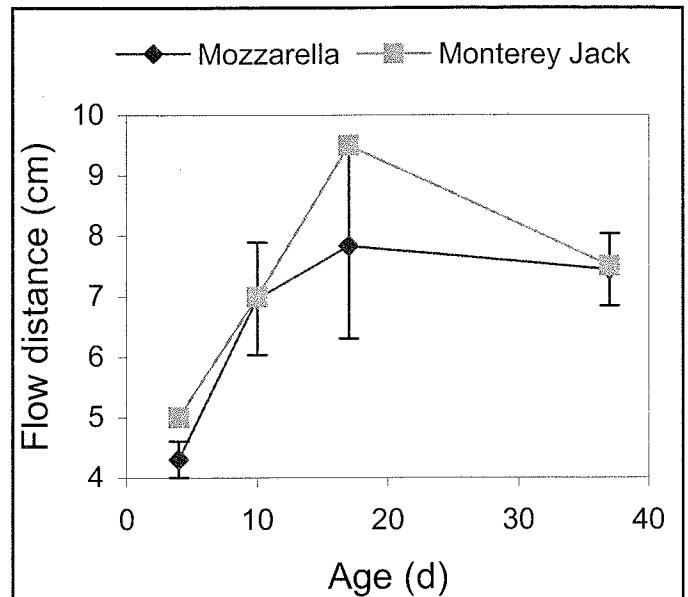


Figure 6B

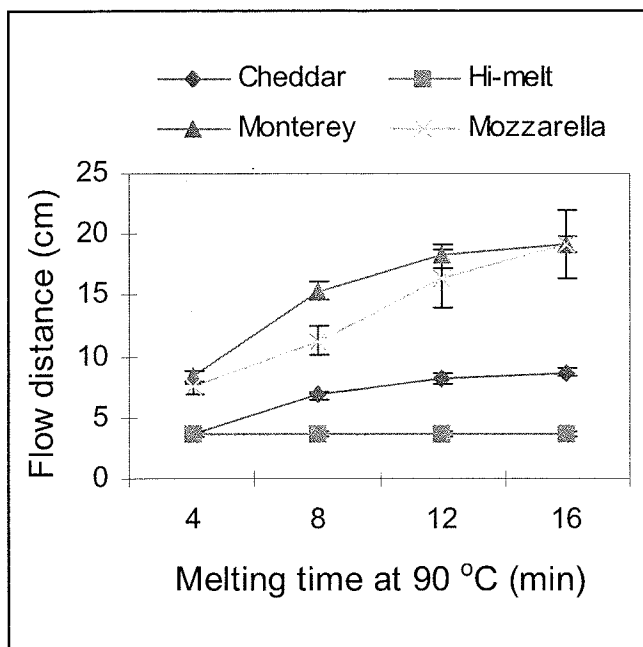


Figure 6C

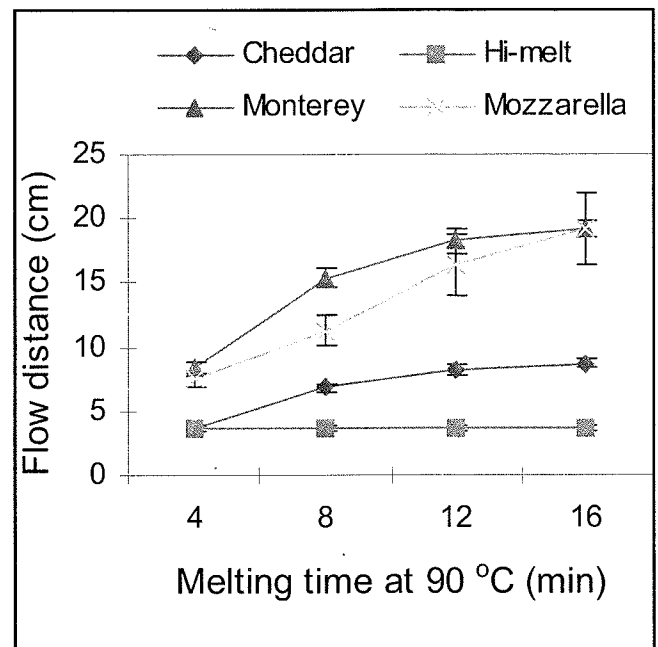


Figure 6D

cheese concurring with the UW MeltProfiler data (Fig. 6 A and B). Again in these tests, the Hi-Melt process cheese indicated the poorest tendency for melt and flow (Fig. 6C and D) concurring with results from many of the above tests.

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

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

Summary

The flavor and textural qualities of cheese will impact the value of cheese in the marketplace. United States Department of Agriculture (USDA) and licensed cheese graders routinely assess the quality of cheese and establish grades for cheddar, colby, jack and swiss, based on USDA or Wisconsin grade standards (USDA, 2001; WDATCP, 2002). When specific defects are present in a cheese, a lower grade is placed on the cheese and the value of the cheese is reduced due to the downgrade.

Industry survey

Grading records for cheddar, colby, monterey jack, bulk American and swiss cheese were obtained from ten national cheese manufacturers or processors over a six-month period in 2001. Records included volume of cheese manufactured or purchased, defects identified and grades established for each lot, and decrease in price due to downgrade of each defective lot. Grades were established based on the USDA grade standards for mild cheddar, bulk American, colby, monterey jack, and swiss cheese (USDA, 2001). Bulk American cheese is cheddar, washed curd, stirred curd or colby cheese for manufacturing that is packaged in bulk form. Information from each of the respondents was pooled by age of cheese at grading to provide confidentiality for each of the companies.

Retail Cheddar cheese survey

Two hundred samples of mild cheddar cheese were randomly purchased from 10 supermarkets in Dane county (Wisconsin) over a 3-month period. At the point of purchase, cheeses were selected that had at least 6 weeks or more remaining before the pull date listed. Cheeses were held at 5°C until evaluated by a trained sensory panel. Fourteen panelists were trained to identify defects in mild cheddar cheese against the USDA grade standards (USDA, 2001). The poten-

tial defects include aroma and flavor attributes: acid, bitter, feed, fermented, flat, fruity, lipase, metallic, old milk, high salt, low salt, sulfide, utensil, whey-taint and yeasty, and body and texture attributes: corky, crumbly, curdy, gassy, mealy, open, grainy, pasty, pin holes, short, sweet holes and weak. Within 5 days of purchase, cheeses were removed from cold storage and tempered to 10°C prior to sensory evaluation

Panelists evaluated ten cheese samples per tasting session. Cheeses were cut into 10x2x2 cm rectangular pieces for presentation. The cheeses were coded with 3-digit numbers and presented to panelists in random orders. Panelists were provided with unsalted crackers, water and expectoration cups to cleanse the palate between samples. Napkins were provided for panelists to clean the hands between samples. Testing was conducted twice a week for ten weeks. Tasting ballots were collected and tabulated after each tasting session. Defects were recorded if at least five of the panel members identified a defect as definite in intensity.

Industry survey

Table 1 lists the quantities of cheese graded by the ten national natural cheese manufacturers and processors during the six-month survey period. USDA grade standards (USDA, 2001) specify that cheddar, colby and monterey jack cheese be 10 days of age before grading and swiss must be over 60 days of age. Some cheese plants, with limited aging facilities, will grade cheddar, colby and monterey jack cheese at 4 days of age when cheese is shipped out to aging warehouses. For official grade certification, those cheeses would need to be graded again after completing the proper aging requirements. The cheeses graded at 30 to 60 days were generally graded at processing facilities that were cutting and wrapping cheese for retail distribution or further processing. Those plants were the facilities providing information on decreases in cheese value due to downgrades in cheese quality.

At 4 days of age, cheddar cheese exhibited very few defects as over 99% of the cheese graded out as A Grade (Table 2). At 4 days of age, 5.7% of the colby cheese had both acid flavor and weak body defects. Colby cheese was probably more susceptible to faster development of excess acid and rapid body breakdown with the higher moisture content in the final cheese. At 10 days of age, only 94.8% of the cheddar cheeses were graded as A Grade and 85.68% of bulk American was A Grade. Body and flavor defects identified in 4-day old cheddar cheese were similar to colby

Table 1. Quantity of cheeses graded during the six-month survey period.

Variety	1000 Kg of cheese graded		
	4 days ¹	10 days ¹	30-60 days ¹
Cheddar	11,535	2,676	18,985
Colby	67	---	2404
Monterey Jack	---	---	2673
Swiss	---	---	506
Bulk American	---	1,471	---

¹ Age of cheese when graded.

Table 2. Percentage of various grades of cheddar and colby cheeses when graded at 4 and 10 days of age.

Grade ¹	Cheddar at 4 days	Colby at 4 days	Cheddar at 10 days	Bulk American at 10 days
A	99.36	94.30	94.80	85.68
B	0.33	0	3.70	1.42
C	0	0	0.68	0.72
Below grade	0.31	5.70	0.82	12.16

¹ Based on USDA grade standards for mild cheddar, colby and bulk American cheeses.

Table 3. Frequency of various body and flavor defects in cheddar cheese graded at 4 and 10 days of age.

Defect	4 days of age % of cheese	10 days of age % of cheeses
Any defect	0.64	16.83
Acid	0.35	13.35
Unnatural	---	1.24
Mottled	0.01	1.22
Bitter	---	1.01
Rough surface	---	0.37
Open	---	0.26
Short	0.23	---
Weak	---	0.16
Feed	---	0.16
Grainy	0.13	---
Flat	0.05	0.10
Corky	0.10	---
Seamy	---	0.05
Mealy	---	0.05
Sour	0.03	---

with acid flavor and short body being the primary defects (Table 3). At 10 days of age, graders identified defects in 16.83% of the cheddar cheeses (Table 3). However, some cheeses with very slight acid flavor were still acceptable as A Grade cheese. Therefore, only 5.25 % of the cheeses had defects resulting in a downgrade. Some defects, e.g., seamy and bitter, were not observed in 4 day-old Cheddar cheese but were starting to show at 10 days of age. Some defects reported for bulk American cheese, e.g., rough surface, moldy and leakers were more typical for that type of cheese (Table 4). They are generally the result of poor curd handling and packaging as versus chemical interactions contributing to body and flavor defects.

When cheddar, colby, and monterey jack cheeses were graded and evaluated at cheese processors at 30-60 days of age, there was not only the greater propensity to downgrade a cheese based on the USDA grade standards, but there was also the potential for decrease in cheese value due to non-compliance with purchase specifications. Table 5 lists the frequency of downgrades in cheddar, colby and monterey jack cheeses based on both USDA grade standards and standard purchase specifications. At 30-60 days of age, over 7.26 % of the cheddar cheese was downgraded compared to 0.64% at 4 days and 5.2% at 10 days of age. Over 9.5% of the monterey jack cheese was downgraded compared to only 4.0% for colby. Acid and curdy were the primary defects identified in cheddar cheese at 30 to 60 days of age (Table 6). Whey taint in cheddar cheese was first noted as a defect at this age. Defects in colby and monterey jack were limited to weak body and acid and whey flavors.

The size and distribution of eyes are extremely critical toward the overall quality of swiss cheese (USDA, 2001). In our survey, 16.8% of the swiss cheese was downgraded (Table 7). The majority of defective cheeses were lacking the proper number of eyes (underset) for good quality swiss cheese. Splits and cracks, overset and nutshell eyes were also common defects involving eye formation in swiss cheeses. The most common flavor defect in swiss cheese was utensil.

Economic impact of defects

To estimate the economic impact of cheese defects on the cheese industry, we assumed that the percentage of downgraded cheese in our survey was representative of cheese quality throughout the United States. The average price reduction for downgraded cheese (Table 8) was based on the price reductions reported by the respondents in the industry survey. Ranges of price reductions were not reported in order to protect the proprietary information from individual companies. Using 2001 U.S. production figures for the graded cheeses, we estimated that the cheese industry annually loses over 29 million dollars in value on cheddar cheese, 10 million dollars on other American cheeses (colby and monterey jack) and 24 million dollars on swiss cheese. This estimated loss in revenues is due to the downgraded status of the cheese as a result of identified defects that were present in the cheese. What percentage of this loss could be reduced or eliminated with improved cheesemaking practices and

Table 4. Frequency of defects in bulk American cheese at 10 days of age.

Defect	% of cheeses
Any defect	22.97
Acid	12.24
Rough surface	3.79
Curdy	2.35
Moldy	1.98
Leakers	1.81
Bitter	1.44
Whey taint	0.90
Flat	0.36
Short	0.18

Table 5. Frequency of downgrades in American type cheeses when evaluated at 30-60 days of age.

General defect	% of cheeses		
	Cheddar	Colby	Monterey Jack
Any defect	7.26	4.00	9.66
Body/texture ¹	6.54	2.96	7.78
Microbiological ²	1.60	0.09	1.22
Flavor ¹	0.66	2.32	2.45
High moisture ^{1, 2}	0.25	0.89	0
pH ²	0.11	0	0.08
Size and shape ¹	0.10	0.39	0.67
Foreign matter ²	0.07	0.07	0.12

¹ Defects based on USDA grade standards.

² Defects based on purchase specifications of cheese processors.

Table 6. Frequency of body and flavor defects in cheddar cheeses graded at 30 to 60 days of age.

Defect ¹	% of cheeses
Any defect	15.50
Acid	4.31
Curdy	4.23
Open	3.09
Weak	2.65
Whey taint	2.07
Bitter	0.77
Mottled	0.70
Fruity	0.47
Flat	0.10

¹ Based on USDA grade standards for mild cheddar cheese.

Table 7. Frequency of defects in swiss cheese when graded at 30-60 days of age.

Defect ¹	% of cheeses
Any defect	16.80
Underset	8.06
Splits and cracks	4.80
Utensil	4.06
Overset	3.07
Shape and appearance	1.72
Nutshell	1.65
Weak/pasty	1.50
Nesty	0.88
Flat	0.45

¹ Based on USDA grade standards for swiss cheese.

Table 8. Estimated annual economic losses to the U.S. cheese industry due to downgrades for cheese defects.

Cheese	Annual US production ¹ (1000 Kg)	Downgraded cheese ² (%)	Ave price for downgrade (\$/Kg)	Annual loss to industry (US \$)
Cheddar	1,248,182	7.26	.3203	29,026,949
Other American	351,364	6.98	.4246	10,413,402
Swiss	111,591	16.80	1.3004	24,378,973

¹ Source: USDA, National Agricultural Statistics Service, 2001 production.

² Downgraded cheese at 30 to 60 days of age.

Table 9. Frequency of flavor defects in retail samples of mild cheddar cheese purchased in Dane county (Wisconsin) in 2002.

Defect ¹	% of cheeses
Any flavor defect	93
Acid	57
Flat	33
Whey-taint	32
Bitter	24
Utensil	21
Metallic	13
Sulfide	7
Fermented	2
Fruity	2
Old milk	2
Oxidized	1
Lipase	1
High salt	1

¹ Based on USDA grade standards for mild cheddar cheese.

Table 10. Frequency of body and texture defects in retail samples of mild cheddar cheese purchased in Dane county (Wisconsin) in 2002.

Defect ¹	% of cheeses
Any body/textural defect	79
Short	39
Pasty	33
Open	19
Weak	17
Curdy	13
Crumbly	13
Mealy	4
Corky	4
Grainy	1

¹ Based on USDA grade standards for mild cheddar cheese.

proper handling of cheeses is not currently known. Cheesemakers must routinely evaluate cheese quality to determine which defects could be reduced or eliminated to reduce losses in revenue for their plants.

Retail Cheddar cheese survey

The quality of mild cheddar cheese at the retail market was significantly reduced from that observed at 30 to 60 days of age as 91% of the retail cheeses would have been downgraded to B grade or lower due to flavor or body defects. The flavor defects identified in retail cheeses are shown in Table 9. Acid, flat, whey taint and bitter were the major flavor defects identified in the mild cheddar cheeses. Results were similar to those reported by Hansen and Keziah (2000) for cheddar cheese in the North Carolina retail market. They reported flavor defects of acid, bitter, whey taint, and sulfide at 75, 45, 40, and 35%, respectively, of the cheeses sampled. The increased occurrence of sulfide flavor in the North Carolina market may have been due to a larger portion of cheddar cheese that was produced in New England which typically has a higher prevalence of sulfur flavor in cheddar cheese (Wendorff, et al., 1998). Barnard (1992) had reported 53% of retail cheddar cheeses had fruity, fermented, unclean, rancid or moldy flavor defects. Of the potential body defects, short, pasty and open were the primary defects identified in the mild cheddar cheeses (Table 10). Hansen and Keziah (2000) had reported body defects of short, open and crumbly at 52, 35 and 22 %, respectively. Unlike the results reported by Hansen and Keziah (2000), we did not observe any notable differences in the quality of national brands of cheese versus store brands. Some retail outlets appeared to have better inventory control in their dairy cases than others. However, we did not observe any notable differences in the overall quality of cheeses obtained from any outlet.

The occurrence of defects in natural cheeses can significantly impact the overall quality and value of those cheeses. Some defects may be a result of poor milk quality or inadequate cheesemaking practices but they do not develop until the aging of cheeses or during the distribution or marketing of the cheese. Therefore, cheesemakers must continuously evaluate cheeses throughout the aging process and marketing of cheeses to effectively assess their cheesemaking procedures and practices. Only then will they be able to identify potential quality concerns that need to be addressed to reduce or eliminate defects that result in lost revenues.

References

- Barnard, S. E. 1992. Butter, cheese and ice cream don't taste good. *Hoard's Dairyman* 137: 78.
- Baryshev, D. A. 1975. All-Union grading of cheese. *Molochnaya-Promyshlennost'*, No. 2, 6-8.
- Bodyfeldt, F. W., J. Tobias, and G. M. Trout. 1988. *The Sensory Evaluation of Dairy Products*. Van Nostrand Reinhold, New York, NY.
- Hansen, A., and M. Keziah. 2000. Quality attributes of cheddar cheese in the North Carolina marketplace. *J. Dairy Sci.* 84 (Suppl. 1): 145.

Mcbride, R. L., and C. Hall. 1979. Cheese grading versus consumer acceptability: an inevitable discrepancy. *Austr. J. Dairy Technol.* 34: 66-68.

Richards, E. 1984. Cheese quality – today's requirements. *Dairy Industries Intl.* 49(5): 13-16.

Sabados, D., and B. Rajsic. 1980. Trappist cheese. II. Organoleptic quality. *Mljekarstvo* 30 (11): 323-330.

Scott, R., R. K. Robinson, and R. A. Wilbey. 1998. *Cheesemaking Practice*. Aspen Publishers Inc., Gaithersburg, MD.

USDA Agricultural Marketing Service. 2001. Grading and inspection, general specifications for approved plants and standards for grades of dairy products. Title 7 of the Code of Federal Regulations, Part 58. U.S. Government Printing Office, Washington, DC.

WDATCP. 2002. Cheese grading, packaging and labeling. Chapter ATCP 81. Register, June 2002, No. 558, Wis. Agriculture, Trade and Consumer Protection, Madison, WI.

Wendorff, B., M. Johnson, and N. Olson. 1998. The great cheddar debate. *UW Dairy pipeline* 10(4): 1-3, Center for Dairy Research, Univ. of Wisconsin-Madison, Madison

Determination of the minimum levels of galactose and lactic acid that lead to stickiness during drying of whey

Personnel

Hartel, Richard W.; Smith, Karen

Funding

Dairy Management Inc.

Dates

6/1/2003 to 12/31/2003

Objective

To determine the minimum levels of galactose and lactic acid that lead to stickiness during drying of whey permeate.

Summary

The effects of galactose on the glass transition temperature (T_g) of lactose were evaluated by using a Differential Scanning Calorimeter (DSC). A plot of T_g for different levels of galactose and lactic acid was generated to help understand the effects of lactose hydrolysis on stickiness during drying.

Stickiness of whey powders during drying and storage is a problem for the dairy industry. Stickiness is related to numerous factors, the most important being composition, water content and temperature. In whey, lactose is the main ingredient that solidifies during drying, whether in crystalline or glassy state. However, even a precrystallized lactose powder contains some amount of amorphous lactose and is prone to stickiness. Stickiness occurs when the surface of the whey particle becomes fluid-like, which can happen either when the temperature is too high or the surface contains sufficient moisture.

Lactose itself is very easy to dry due to its high glass transition temperature (T_g), about 101°C. As long as temperature remains below 101°C, anhydrous lactose remains in the glassy state and is not sticky. If the lactose glass contains water, T_g is reduced considerably since water acts like a plasticizer in this case. When the combination of water content and temperature produces whey powder that has a temperature above its T_g , the powder becomes fluid-like and stickiness occurs. As long as temperature remains below T_g , regardless of the water content, the powder is not sticky. However, composition of the powder plays a role in stickiness as well since some components of whey have significantly lower T_g than lactose. Specifically, the by-products of lactic acid bacteria digestion, galactose and lactic acid, have much lower T_g than lactose and when present at sufficiently high levels can cause the mixture to experience stickiness. Galactose has a T_g of about 18°C, whereas lactic acid acts much like water since its T_g is about -60°C. It doesn't take much of either component to reduce the T_g of the mixture below the temperature of the powder, especially in the spray drier where temperatures are already high.

During drying, fluid whey is sprayed into small droplets to promote drying. As the droplet floats through the air in the dryer, it loses moisture to the air and the surface becomes amorphous (T_g increases due to moisture loss, with T_g at the surface increasing fastest). At some point, the surface dries beyond the sticky point (just slightly above T_g) and the droplet is stable. At this point, the droplet can contact walls and other powder particles without sticking. If the droplet comes into contact with the wall or other droplets before it has dried sufficiently (before the water content has been decreased so the droplet temperature is about the same as T_g), the surface is fluid-like and the droplet is prone to sticking. The combination of drying rate (moisture content), temperature and flow pattern in the drier control whether sticking occurs or not.

If the galactose and lactic acid content of whey increase beyond some point, the surface of the droplets remain fluid-like and stickiness occurs. The question is, at what level of galactose and lactic acid does whey drying become a problem? To answer this question, we need a better understanding of the effects of galactose and lactic acid on the T_g of mixtures with lactose.

Samples were made with different levels of lactose and galactose to cover the range from pure lactose to pure galactose. These samples were melted (very low water content) in the DSC, cooled quickly to quench them into the glassy state and scanned upwards in temperature to measure the glass transition temperature (T_g). The inflection point in the baseline shift associated with the glass transition was taken as T_g .

Although water content can significantly affect T_g , water content of these samples was not controlled (or measured). Since it was lactose monohydrate added to the sample pans, a small amount of water was present in each sample, and the water content varied slightly according to the ratio of lactose to galactose. Despite this experimental problem, results for T_g came out close to that expected for a dry system, with T_g of pure lactose nearly 100°C. Since the literature value for dry lactose is 101°C, this suggests that water was evaporated during heating so that all samples were essentially dry.

Figure 1 documents the decrease in T_g caused by addition of either galactose or lactic acid. T_g of pure galactose is about 18°C, whereas that of pure lactic acid is -60°C. Since the T_g of the mixture is directly proportional to the percentage of either galactose or lactic acid added, the T_g of any blend can be predicted. If there is some residual water content, as would be the case with dried whey, the T_g lines would be at slightly lower temperatures, as estimated by the dashed and dotted lines in the figure.

What remains to be seen is how much galactose and lactic acid can be added before stickiness occurs. In a recent study, Rao (MS thesis, 2003) found that as low as 3% of either galactose or lactic acid caused a significant increase in stickiness of a lactose glass. Stickiness of lactose glass with 3% added lactic acid was significantly higher than that for the lactose glass with 3% added galactose, as would be expected from Figure 1 and based on their T_g values. From these results, it seems that even very low levels of galactose and/or lactic acid will cause stickiness.

In a spray drier, temperatures are significantly higher than in the Rao study (she used room temperature to measure stickiness). Thus, products

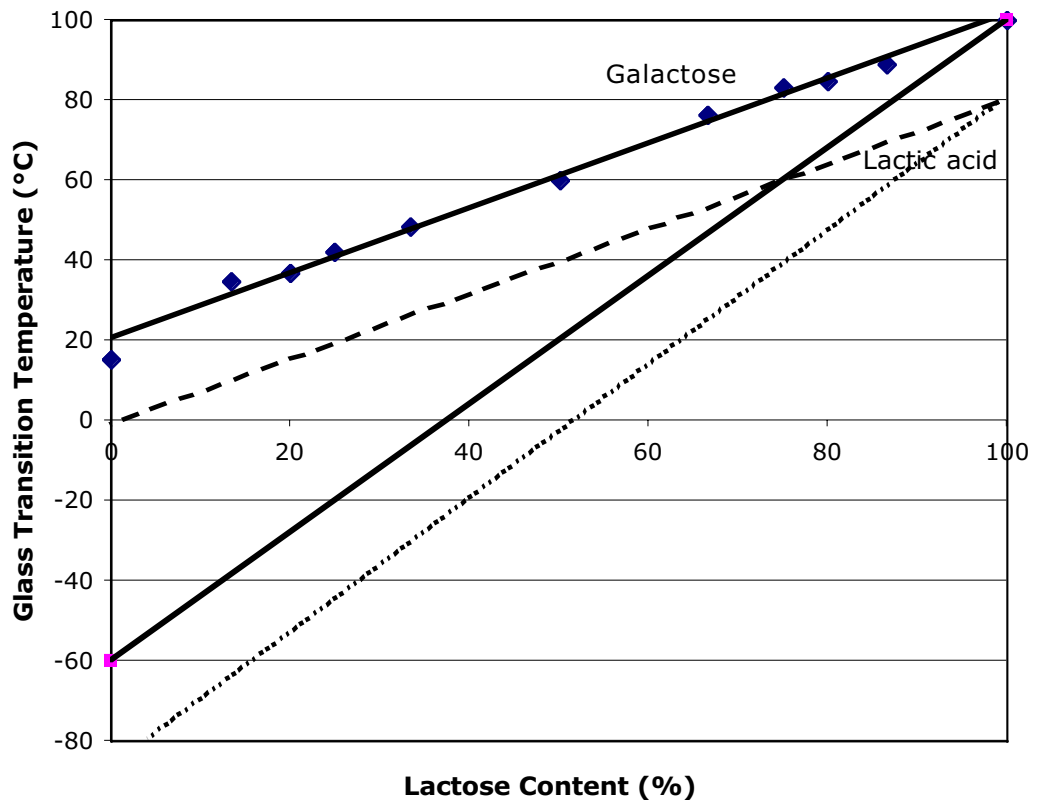


Figure 1. Effects of galactose and lactic acid on glass transition temperature (T_g) of dry lactose. The dashed and dotted lines represent estimated T_g of lactose with about 1 % water.

are more likely to be sticky because of the elevated temperatures. However, no measure of surface temperature of a droplet during spray drying is available and we can only make estimations. Based on the experimental measurement that 3% galactose and lactic acid cause stickiness of whey powders at room temperature, we can use Figure 1 to estimate that the surface temperature of a droplet during the early stages of spray drying, when droplets are most prone to sticking, must be between 60 and 70°C.

Stickiness during drying of whey powders is due to a combination of temperature, moisture content and composition that lead to the surface remaining above T_g at the point when the droplet comes in contact with the wall of the drier. Under normal conditions, the lactose in whey gives a sufficiently high T_g that stickiness does not usually occur. However, when the galactose and lactic acid content of the whey increases above some minimum level, perhaps about 3%, T_g of the whey mixture is decreased to the point where the surface remains above T_g (and is therefore sticky) when the droplets contact the walls of the drier.

Potential solutions to the problem of stickiness in certain whey products can be developed based on this understanding. First, maintaining galactose and lactic acid levels below the sensitive point will allow proper drying of whey. Alternatively, drying conditions might be modified to accommodate a slightly reduced T_g to prevent stickiness. Further work quantifying surface properties of whey powders during drying will be needed to ascertain if this approach has any commercial merit.

Alpha-lactalbumin production for clear bottled drinks and nutraceutical beverages

Personnel

Mark R. Etzel

Funding

Dairy Management Inc.

Dates

3/16/2000 to 12/31/2002

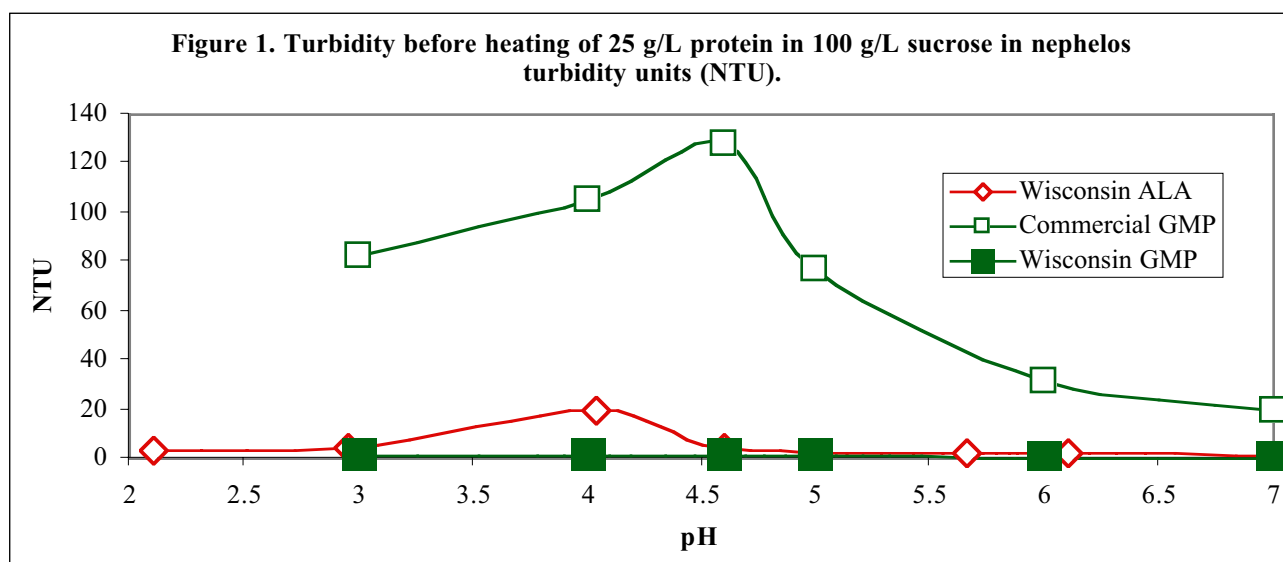
Objectives

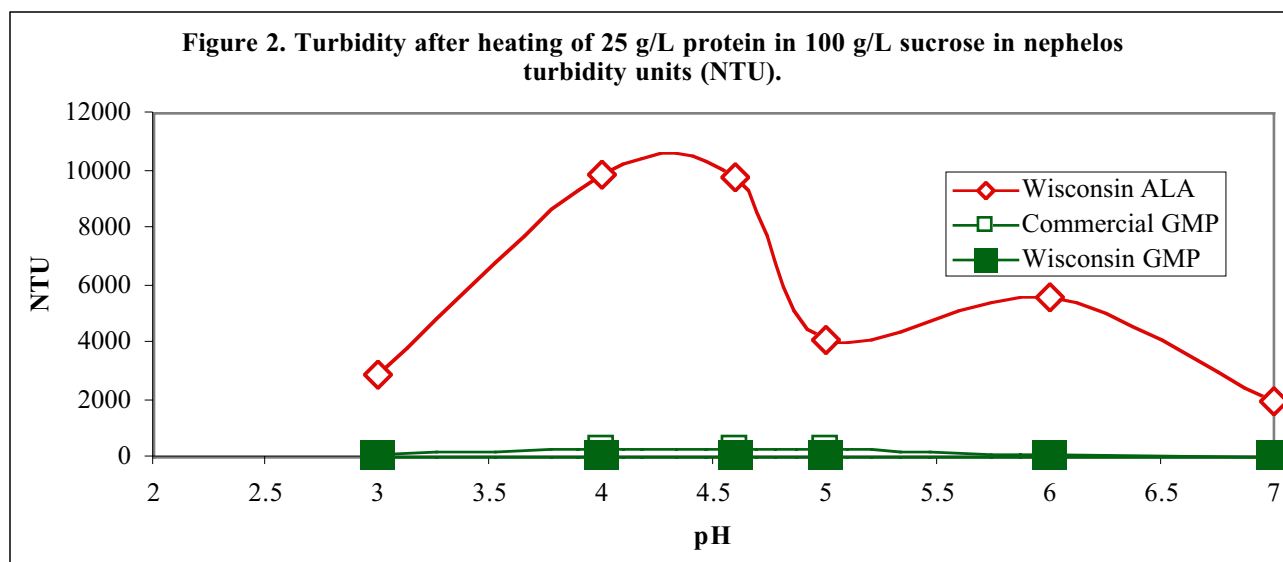
1. Produce alpha-lactalbumin of a purity and absence of denatured protein, suitable for use in development of clear bottled drinks and nutraceutical beverages.

Summary

We developed buffer chemistries and operating conditions and used these developments to successfully fractionate alpha-lactalbumin from whey and from the microfiltration permeate of skim milk. We developed the analytical procedures needed to calculate the purity and mass balance: yield, throughput, and recovery of alpha-lactalbumin using this process. We developed procedures to test for clarity of beverages after addition of alpha-lactalbumin and pasteurization. We have tested a commercially-available sample of alpha-lactalbumin and found it to have unacceptably high turbidity in this application. Our sample of alpha-lactalbumin had much lower turbidity (Figure 1). We also tested a commercial sample of glycomacropeptide and compared this sample to our samples (Figure 1).

Samples were heat-treated to 190 °F for 2 min to simulate hot-fill operations in beverage processing for shelf-stable beverages (Figure 2).





Our glycomacropeptide was suitable for crystal-clear shelf-stable beverages but the commercial GMP and our alpha-lactalbumin were not. The commercial glycomacropeptide had a turbidity of 300 NTU at $\text{pH} \leq 4.6$ and would be suitable for cloudy shelf-stable beverages that may form some sediment on storage.

Our alpha-lactalbumin had a turbidity of 10,000 NTU and was not suitable for use in clear or cloudy shelf-stable beverages. The FDA defines acid foods as $\text{pH} \leq 4.6$. There are no FDA requirements for thermal processing of acid foods except for juices. Therefore, our alpha-lactalbumin would be suitable for refrigerated clear acid beverages that have not been heat-treated. Perhaps sterile-filtered alpha-lactalbumin could be added to these beverages.

Presentations

“Whey Refinery Prototype for Protein Fractionation,” Am. Dairy Products Inst. Annu. Mtg., Rosemont, Illinois, April 23-25, 2001.

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

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

“Commercial-Scale Chromatographic Fractionation of Whey Proteins,” Proc. 3rd Intl. Whey Conf., Munich, Germany, September 12, 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.

“Medical Proteins from Milk,” Grande Cheese Co., Madison, Wisconsin, August 23, 2002.

“Glycomacropeptide for Treatment of Phenylketonuria,” Waisman Center, University of Wisconsin-Madison, Madison, Wisconsin, September 25, 2002.

“Whey and Milk Research,” Cheese Industry Team Research Forum, Wisconsin Center for Dairy Research, December 3, 2002.

“Fractionation and Separation of Proteins from Milk and Whey,” Grande Cheese Co., Lomira, Wisconsin, December 11, 2002.

“Glycomacropeptide (GMP) Update,” *PKU News*, 14: 2 (2002).

“Whey Points The Way To More Effectively Using Milk As A Raw Material,” *Dairy Dimensions*, 2002.

Publications

“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).

“Fractionation of Caseins by Anion-Exchange Chromatography Using Food-Grade Buffers,” (with K.N. Turhan and D.M. Barbano) *J. Food Sci.* (in press).

“Fractionation of Proteins in Whey Using Cation Exchange Chromatography,” (with S. Daultani and K.N. Turhan) *Process Biochem.* (in press).

“Whey Protein Isolate and Glycomacropeptide Recovery from Whey Using Ion Exchange Chromatography,” (with S. Daultani and K.N. Turhan) *J. Food Sci.* (in press).

“Isolation of Whey Proteins Using Ion Exchange Chromatography,” M.S. Thesis, S. Daultani, (2002).

Chapter Three

Applications reports

annual report 2003

Whey Applications Research Program

Personnel

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

Funding

Wisconsin Milk Marketing Board
Dairy Management, Inc.

Dates

January 2003 to December 2003

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 sixth year of the Whey Applications program. In 2003, the Whey Applications program was contacted by 30 Wisconsin-based companies and 100 national companies, consisting of whey processors, ingredient suppliers, end-users, equipment manufacturers, ingredient companies, associations, government organizations, universities, and the press.

Whey applications were developed and presented at the following events, seminars, and companies: International Trade Commission seminar, General Mills seminar, Pepsico seminar, Oscar Meyer, Nestle, WI Whey Utilization Short Course, International Dairy Expo, ADPI visit, Waisman Center, and IFT. Applications development focused on savory energy bars, sports drinks, meal replacement drinks, and fortified fruit leathers. 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. GMP applications developed to date include fruit leather, vanilla pudding, bread, pancakes, and acidified straw-

berry pudding. Work will continue on this project in 2004. General whey processing, functionality, applications, and nutrition information were presented 24 times over the year.

Utilization of the pilot plant included whey processing, milk processing and whey applications projects for a total of 37 trials. 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, whey nutrition information, formulations for specific applications, and processing troubleshooting questions. Membrane processing support is also provided to the CDR cheese group on all projects utilizing ultrafiltered milk, buttermilk, and whey-based fluids.

Presentations

Karen Smith, Ph.D.

By-Product Utilization- Seminar for Kraft, January 13.

Whey Processing-Seminar for Grande Food Ingredients, February 5.

Membrane Processing, Evaporation and Drying Lab, Chemistry and Technology of Dairy products Course, UW-Food Science, February 21, April 4

Whey Processing for ADPI visit to CDR , March 6.

Skills for Working In Industry, for UW-Food Science course-Yvonne Bushland April 8.

USDEC Mission trip to Tunisia, Processing Whey into Value Added Products, May 5.

USDEC Mission trip to Tunisia, Yogurt Applications, May 6.

Grande Engineering Workshop, New Technologies for Whey Processing and Milk Standardization, June 17

Seminar for U.S. International Trade Commission, Processing Parameters Impacting Functionality, 10. Methods of manufacturing Dairy Ingredients-On Farm Concentration, August 20.

Evaporation and Drying of Whey Products, 12. Whey Protein Products 13. Processing Parameters Impacting Functionality, Wisconsin Whey Utilization Short Course, October 21-22.

K.J. Burrington

Whey Applications and Nutrition, Seminar at Grande Food Ingredients February 5.

Dairy Ingredient Functionality Lab, Chemistry and Technology of Dairy Products Course, UW-Food Science March 5.

Whey Applications, ADPI Visit to CDR, March 6.

Whey Applications Program, Cheese Industry Team Meeting, April 14.

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

Whey Applications Program, WMMB Liaison Committee Meeting, June

Dairy Ingredient Processing, Applications, and Nutrition, Seminar at General Mills, September 16.

Dairy Ingredient Processing, Applications, and Nutrition, Seminar for Main Street Ingredients, October, 15.

Food and Nutritional Applications, Wisconsin Whey Utilization Short Course, October 21-22.

Creating Today's Market Basket with High Protein Dairy Ingredients, World Wide Food Expo, IDFA Seminar, October 31.

Dairy-Based Beverages, Seminar at Pepsico, December 4.

Publications

K.J. Burrington

Formulating Cheese Sauces, Food Product Design, April, 2003

Deposit Cookies Here, Baking & Snack, October 2003

Pumped Up Dairy, Food Product Design, October, 2003

Karen Smith

Changes in Galactose and Lactic Acid Content of Whey During Storage, R.D. Rao, W.L. Wendorff, and K.E. Smith, J Food Prot., In press

Cheese Industry and Applications Program

Personnel

Amy Bostley, research specialist, Carol Chen, researcher, Rani Govindasamy-Lucey, associate scientist, Lorraine Heins, assistant program coordinator, Bill Hoesly, research cheesemaker, Kristen Houck, research specialist, John Jaeggi, program coordinator, Mark Johnson, senior scientist, Catherine Landers, research specialist, Brian Leitzke, research cheesemaker, Kate Lim, sensory coordinator, Cindy Martinelli, research specialist, Pam Payne, lab technician, Juan Romero, analytical coordinator, Dean Sommer, cheese and food technologist, William Tricomi, assistant researcher

Funding

Wisconsin Milk Marketing Board

Dates

January 2003 to December 2003

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, DMI, and the Center for Dairy Research Cheese Industry Team to develop and execute the state, national, and Center cheese research plans. Also continue the transfer of technology generated from past farmer-funded research.

Summary

The 2003 Cheese Industry and Applications Program annual report includes 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 list in detail the multiple contacts we had with individual companies over a wide range of topics. The Center uses a technology triangle model which brings together CDR experts with manufacturers and end users to achieve common goals. To be more effective, the Center, with assistance of DMI, hired a new cheese technologist to work more closely with end users. This demonstrates the continued commitment of cheese research and cheese product development between the Wisconsin Milk Marketing Board, Dairy Management, Inc, Wisconsin Center for Dairy Research, the Cheese Industry and Applications Program, and the cheese industry.

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

Our problem solving contacts with the industry involved 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, ingredient addition, cheese/milk chemistry, plant sanitation, labeling/regulatory issues, cheese equipment, cheese ripening, cheese marketing, 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/marketers, consultants, and individual milk producers. Due to the proprietary nature of our contracted cheese trial work, the information supplied below is general, rather than specific.

The Cheese Industry and Application Program research work on behalf of ingredient /flavor suppliers in 2003 included addition of specific acids to manufacture a fresh cultured cheese, evaluation of starter cultures/adjuvants and effect on cheese flavor/texture/functionality, evaluation of different culture strains and effect on the rate of acid development, evaluation on elimination of calcium lactate crystals in cheese when using specific ingredient additions, addition of ingredient 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. This work included developing standardization methodologies using different milk streams. For example, we worked with ultrafiltered (UF)

(whole and skim) and microfiltered (MF) milk, nonfat dry milk (NDM), whey protein concentrate (WPC), and concentrated buttermilk to manufacture commodity, specialty/ethnic, and nonstandard cheeses. We studied the impact on cheese manufacture, yield, composition, functionality, texture, microbiology, ripening, and sensory.

In 2003 we continued to work with cheese manufacturers to develop and alter manufacturing protocols for commodity type cheeses, aiming for different physical or functional characteristics. The final alterations are then scaled-up for production in the plant. The program also continues its work in specialty and ethnic cheese development by setting up manufacturing methods, carrying out successful trials, submitting all results, and working on-site scaling up at the manufacturing facility; all the while keeping in mind the goals of the product end-use. Many of these new cheeses developed by the Cheese Industry and Applications Program in conjunction with the cheese industry are now sold nationally to specialty and ethnic markets.

The program also assisted manufacturing plants to improve efficiencies. One method used to accomplish this was working with plants on adding whey protein concentrate (WPC) as secondary starter and studying the effects on the end product. We worked with manufacturers to increase plant throughput by increasing milk solids levels by standardizing milk. As in the past four years, we have continued working with individual farmstead producers and milk producer cooperatives that make a specialty cheese.

Contact and follow up work has continued to increase drastically with end users the past couple of years. Adding a cheese technologist allows us to continue to work directly with cheese manufacturers and large state and national end users to tailor manufacture cheddar, mozzarella, and other varieties of cheeses for food product, appetizer, and pizza applications. Other examples working with end users includes working on manufacturing protocols for processed specialty cheeses to target specific functional attributes and working with a very large national company on cheese for snack crackers. The program also helped a large national snack cracker manufacturer to pair their specialty crackers with a variety of cheeses. They followed up by developing a cheese and cracker-pairing guide and then sent it out to their customers.

We continue to work on cheese related projects funded by various outside or internal sources, many reported in detail elsewhere in this Annual Report. One internal CDR-Cheese Industry Team (CIT) project wrapping up at the end of 2003 is "Manufacture of mozzarella cheese from milk standardized to intermediate and high solids ranges using UF milk." This was the final part of the overall CIT-funded UF standardization projects. In the past couple of years we looked at using UF retentates to standardize cheese milk for the manufacture of cheddar, swiss, and parmesan. We then evaluate the effects of using these UF-standardized milks on manufacturing, whey composition, cheese properties (chemical, physical, and sensory), and cheese yield. The results of past work have been presented in recent CDR-CIT meetings and several papers will be submitted for peer review and publishing in 2004.

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.

DMI currently funds “Understanding and Controlling the Calcium Equilibrium in Cheese” a project that will determine if changes in the state of calcium in cheese play a role in the functionality changes that occur during ripening. Early results from this study suggest that cheese functionality (including melt, softening, flow and hardness) is greatly influenced by dairy minerals. In collaboration with this Ca equilibrium project the CDR Cheese Industry team funded additional work to study calcium lactate crystal formation in cheddar and colby cheese, evaluating the type of crystals formed. We are looking at possible causes, including manufacturing protocols and milk standardized by membrane concentration using reverse osmosis (RO), which is a common practice in industry.

Another DMI-funded project that the Cheese Industry and Applications Program was involved in 2003 was “Evaluation of Sweet Cream Buttermilk for Use as a Cheese Ingredient”. In this phase of the project we standardized cheese milk with different levels of condensed buttermilk and then looked at the effects on cheese texture, composition, functionality, chemistry, cheese yield, and flavor. We determined the recovery of the added phospholipids from the buttermilk in cheese and losses in whey. As part of this project we also compared standardizing cheese milk by adding buttermilk concentrated by the following methods; condensing, ultrafiltration (UF), and reverse osmosis (RO).

“Relating Rheological Properties to Cheese Functional Performance” is a 2003 ongoing DMI-funded project the Cheese Industry and Applications Program. This joint project, among the CDR, UW Food Science, and North Carolina State University, started with the manufacture of mozzarella with different fat in dry matter (FDM) targets.

The Cheese Industry and Applications Program began to work with cream cheese in 2003 and collaborated with UW Food Science to manufacture cream cheese for a project titled “Impact of processing conditions on the texture of cream cheese.” Cheese manufacturing methods, as well as sensory and texture tests, were developed for cream cheese. A new DMI-funded project in this area, “Understanding structure/function relationships in cream cheese responsible for its performance” also started in late 2003.

Another DMI-funded project that is ongoing includes “Development of Parmesan cheese flavor using selected bacteria.” The Cheese Industry and Applications Program collaborated with UW Food Science to manufacture process cheese using a new steam generator for our process cheese cooker. A new DMI funded project will start in 2004 entitled “Chemistry based approach to understanding processed cheese functionality.” This is

another collaboration between the Cheese Industry and Applications Program and UW Food Science.

The Cheese Industry and Applications Program also assisted with a joint ADD-grant 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 camembert cheese using ovine milk sourced from different lactation periods over the course of a lactation cycle. Work is finishing on the first phase of this project in which we manufactured manchego cheese.

The Cheese Industry and Application Program is also involved in international issues. Program staff assisted with hosting the IDF Food Standards group that includes export certificates, cheese standards, food additives, labeling, and standards for products other than cheese. Program staff also participated in various IDF standards meetings over the course of the year.

Program personnel also helped to organize the shipping of industry manufactured cheese samples to the National Milk Producers Federation for a congressional hearing in Washington D.C. pertaining to Geographical Indicator (GI) issues. Also, program personnel lectured and manufactured processed cheese for the US International Trade Commission.

The Cheese Industry and Applications Program 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 in providing assistance with lectures and setting up lab sessions for the two Wisconsin Cheese Technology short courses, one Wisconsin Cheese Grading short course, one Wisconsin Processed Cheese short course, and the Italian Cheese artisan seminar.

The Cheese Industry and Applications group generated samples for the Analytical Program to conduct chemical, microbiological, physical property, application, and sensory testing on various cheese samples related to applications research projects. Approximately 80% of the Analytical Program's laboratory work conducted is in conjunction with CDR pilot plant cheese making. This shows the cheese industry is placing an emphasis on understanding how the cheese composition/age affects the sensory and physical properties, and thus the functionality in the end application.

We hosted several industry groups to discuss the CDR Cheese Industry and Application Program and current cheese research topics. We also conducted training seminars at the CDR for companies with specific training needs for their employees. The Cheese Industry and Applications group continued to travel to cheese plants not only in Wisconsin, but also nationally to provide one-on-one consultations

regarding cheese making protocols, milk standardization, identifying problems for potential cheese defects, and other cheese technology issues.

Publications/presentations

The staff plays a key role in the Wisconsin Cheese Technology Short Course (March, October), the Wisconsin Process Cheese Seminar (February), the Italian Cheese Seminar (September), and the Wisconsin Cheese Graders Short Course (November) sponsored by the UW Food Science Department and/or the Specialty Cheese/Master Cheesemaker Program.

Throughout the year, the CDR provided tours for various journalists, councils, academe, government agencies, and industry groups.

“Hard ewe’s milk cheese manufactured from milk of three different groups of somatic cell counts.” by J. J. Jaeggi* S. Govindasamy-Lucey, Y.M. Berger, M.E. Johnson, B. C. McKusick, D.L. Thomas, and W.L. Wendorff, *Journal of Dairy Science*, Vol 86, No 10 (2003), 3082-3089.

“Science behind hitting the targets” by M. E. Johnson, at the WCMA/CDR joint Wisconsin Cheese Technology Conference, April 2003 in La Crosse, WI.

An oral presentation was given at the 2003 American Dairy Science Annual Meeting.

Lin, T., J. A. Lucey, R. Govindasamy-Lucey, M. Johnson and J. Jaeggi. 2003. The influence of sweet cream buttermilk on the compositional and rheological properties of a stirred-curd cheese. *Journal of Dairy Science*, Suppl. 1, 86: 9.

“Development of Parmesan cheese flavor using selected bacteria”, by M.E. Johnson at the Center for Dairy Research-Cheese Industry Team Project Update Meeting, December 2003 in Madison, WI.

“Evaluation of sweet cream buttermilk for use as a cheese ingredient” by M.E. Johnson at the Center for Dairy Research-Cheese Industry Team Project Update Meeting, December 2003 in Madison, WI.

“Application of membrane processing for cheese manufacture” by M.E. Johnson at the Center for Dairy Research-Cheese Industry Team Project Update Meeting, December 2003 in Madison, WI.

“Cheese structure/function manipulations to improve shreddibility” by C.M. Chen at the Center for Dairy Research-Cheese Industry Team Project Update Meeting, December 2003 in Madison, WI.

“Understanding and controlling the calcium equilibrium in cheese” by J. Lucey at the Center for Dairy Research-Cheese Industry Team Project Update Meeting, December 2003 in Madison, WI.

“Chemistry based approach to understanding processed cheese functionality” by J. Lucey at the Center for Dairy Research-Cheese Industry Team

Project Update Meeting, December 2003 in Madison, WI.

“Understanding function and structure relationship in cream cheese responsible for its performance” by J. Lucey at the Center for Dairy Research-Cheese Industry Team Project Update Meeting, December 2003 in Madison, WI.

Oral presentation at the 2003 IFT Annual Meeting Technical Program. Chicago, oral #71-8. Mishra, R. and J. A. Lucey. 2003. Effect of pH, temperature and milk solids non-fat on the rheological properties of rennet gels.

Poster presentation at 2003 IFT Annual Meeting Technical Program, Chicago. poster #92F-3. Udayarajan, C. T. and J. A. Lucey. 2003. The use of Fourier transform mechanical spectroscopy to study the melting behavior of cheese.

Safety/Quality applications program

Personnel

Marianne Smukowski

Funding

Wisconsin Milk Marketing Board

Dates

January 2003 to December 2003

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 WI cheese manufacturers in the following areas: safety/quality audits, third party audits, recall issues, GMP reviews, developing HACCP plans, assist the WI 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. I became a certified NFPA supplier auditor for its Food Excellence Program this year. This is a voluntary independent program for conducting audits of suppliers.

I provide technical support through emails, phone calls, lectures, and plant visits on a regular basis. The company contacts consist of dairy manufacturers, regulatory staff (state and Federal), various universities; funding organizations (WMMB and DMI) and various trade associations (IDFA, WCMA, WDPA).

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

The dairy industry expressed interest to USDA-Dairy for a third party HACCP review. USDA-Dairy requested my assistance with their HACCP certification program. Training was provided to the USDA-Dairy staff. Plant visits were completed in February and March to assist the USDA-Dairy in desk- top audits of a dairy plant's HACCP plan. The USDA-Dairy HACCP certification document is currently being reviewed and updated.

The Committee for the Assurance of Wisconsin Dairy Product Safety was formed to assist Wisconsin dairy facilities with their food safety system and to deal with numerous third party audit requests. The intent of this committee was for the Wisconsin dairy industry to buy-in to a uniform audit program. I served as a technical advisor for this committee. This committee created a Wisconsin Dairy Food Safety Manual, which includes sections on Good Manufacturing Practices, Prerequisite Programs, HACCP Program, Audit Program and references.

I was the head judge for the World Dairy Expo Championship Dairy Product Contest. This was the first year for this contest sponsored by Wisconsin Dairy Products Association. There were over 100 samples submitted for the evaluation of butter and cheese in 14 classes of product. Wisconsin companies won 13 of the 14 classes. Next year the contest will add yogurt and ice cream classes to the contest.

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)

ADSA poster presentation:
Impact of Cheese Defects on U. S. Graded Cheeses

WAFP Food Plant Biosecurity: Developing a Food Security Plan

World Dairy Expo Championship Dairy Product Contest 2003 (Head Judge)

Dairy Marketing and Economics Program

Personnel

Gould, Brian W.; Villarreal, Hector J., post-doctoral research assistant; Hackney, John, research assistant; Chang, Yuhe, graduate research assistant

Funding

Wisconsin Milk Marketing Board

Dates

January 2003 to December 2003

Objectives

1. Support cheese production efficiencies through optimization of domestic dairy ingredients for improved cheese composition and yield.
2. Development and delivery of dairy price risk management education materials
3. Examine implications of changing national and international dairy market conditions on the Wisconsin dairy industry

Summary

One of the objectives of the Dairy Marketing and Economics Program (DMEP) is to help Wisconsin dairy farm operators and cheese manufacturers understand the factors that influence cheese yield. Understanding the role that milk and cheese characteristics have in determining cheese yield may improve receipts from the sale of farm milk and the value of that milk in cheese manufacture. A better understanding will also provide a framework by which component value-based payment systems can be implemented. The primary activity associated with meeting this objective was providing technical support to Wisconsin cheesemakers in their use of the Economic Analysis of Cheese Yield (EACY) software program which is supported by the DMEP.¹ An example of the type of support activities undertaken in meeting this program objective can be found in a 1 day workshop where the topic was “Understanding the valuation of milk in cheese manufacture.” This workshop centered on a review of the modified Van Slyke cheese yield formula and the role played by not only the characteristics of farm milk and cheese produced but also the implications of milk and cheese characteristics on byproduct (e.g., whey-based products) valuation.² A series of examples based on the use of the EACY software program provided the basis of the presentation. A copy of this presentation can be obtained from the following website address: www.aae.wisc.edu/future/publications/premiums.ppt.

Development and delivery of dairy price risk management education materials

The major activity associated with this component of the DMEP was devoted to the maintenance and extension of the University of Wisconsin Dairy Marketing Website (www.aae.wisc.edu/future). This website contains an extensive collection of current and historical state, national

and international dairy market data. Examples of information contained in this website include dairy related prices, production, stocks, imports, exports, simulation models of the federal classified pricing system and decision tools related to participation in the MILC program.

Besides providing a central location for dairy industry participants to obtain current (and historical) dairy market information, it is one of the main communication outlets by which the University of Wisconsin Dairy Price Risk Management Extension Team provides information to the Wisconsin dairy industry. A major section of the web site is devoted to providing access to a variety of dairy price risk management curriculum developed by the above extension team for use by Wisconsin dairy farm operators and dairy processors (www.aae.wisc.edu/future/front_tutorials.htm). These curricula are supported by the web site's data archive and by an extensive collection of Dairy Marketing and Policy Briefing Papers and other publications (www.aae.wisc.edu/future/front_publications.htm).

Since an increasing amount of information pertaining to the dairy industry is released on a daily basis, we have started to automate the collection, management and analysis of this data. An example of the types of data management systems that we have established can be seen with respect to the daily analysis of the futures market for Class III milk, Class IV milk and butter. After the daily trading sessions on the Chicago Mercantile Exchange terminate at approximately 1:50, by 2:30 our automated graphical analysis system has collected, managed, created over 30 graphical trend analyses and copied these analyses to the relevant sections of the University of Wisconsin Dairy Marketing Website.³

Another example of the types of activities undertaken in this component of the DMEP is the continuing education efforts targeted to producer participation in the Milk Income Loss Contract (MILC) program (www.aae.wisc.edu/future/milc.htm). We continue to maintain a number of decision-making tools designed to assist Wisconsin dairy farm operators to optimize the timing of program participation given the 2.4 million lb. eligibility limit on program benefits. For example we published the Marketing and Policy Briefing Paper, Enrollment in the 2003/2004 MILC Program: Does Timing Matter?⁴ This paper provides a framework which Wisconsin dairy farm operators can use. Current information from dairy-related cash and futures markets provides guidance for participating in the MILC program.

Examine implications of changing national and international dairy market conditions on the Wisconsin dairy industry

A number of activities were undertaken to provide the Wisconsin dairy industry information regarding the national and international demand for dairy products and the implications of changes in national and international dairy markets. For example, we initiated a project during 2003, funded partially by the Babcock Institute for International Dairy Development. The title of the project is An Analysis of the International Market for Milk Protein Concentrates.

The overall objective of this project is to quantify the determinants of U.S. and international trade in milk protein concentrates (MPC's). In addition, we provide some indication regarding the impact of these imports on the U.S. dairy sector and on U.S. dairy product consumers. The 3 major sections to this project involve developing economic models of: U.S. import demand for MPC's, export supply of MPC by New Zealand and Australia; and examining the impact of imported MPC on both the U.S. dairy sector and U.S. consumers of dairy products. In terms of modeling U.S. MPC imports, the general model we estimate is:

Quantity of MPC Imports = f(U.S. Wholesale NFDM price, EU NFDM price, household income, season, manufactured dairy product production)
 In the empirical implementation of this model we are experimenting with a number of alternative functional forms and lag structures. The model is being estimated over the 1990-2003 period.

The above model is being appended by an examination of the relationship between FOB prices for MPC and world NFDM prices. That is, if convert MPC imports to a "protein-equivalent" basis we will determine whether there is a relationship between the derived protein prices. The general functional relationship to examine U.S. MPC imports from selected countries can be represented as:

Per Unit Value of MPC Imports = f(U.S. Wholesale NFDM price, EU NFDM price, non-U.S. supply of NFDM)

We are also working with researchers in the Department of Agricultural and Applied Economics, University of Wisconsin to quantify the impact of MPC imports on consumers and producers. We will use the University of Wisconsin Interregional competition model (IRCM) for this analysis. The IRCM is a spatial equilibrium model of the U.S. dairy sector and has been used on many occasions to analyze the impacts of changes in U.S. dairy policy on the U.S. dairy sector and on the welfare of U.S. dairy product consumers.⁵ This model is based on the balancing of the supply and demand of the components of raw farm milk, imported milk products and commercial disappearance of dairy products. The milk components explicitly delineated in this model are fat, protein, and carbohydrates (mostly lactose). U.S. production of 9 processed commodities is simulated within the IRCM.

We propose to shock the IRCM with exogenous changes (both higher and lower levels) in MPC imports. These shocks will represent increased and decreased supplies of dairy proteins in the U.S. economy to be used in manufactured products. From the resulting simulations we will examine the impacts on key endogenous variables generated by the IRCM including but not limited to the classified prices for farm milk, the utilization of domestic milk components, and changes producer and consumer welfare.

A second major research effort within this component of the DMEP was devoted to the analysis of both domestic and international demand for dairy products. Since Mexico and Canada are two of the U.S.'s largest dairy product export market we undertook a number of analyses of retail demand for cheese, fluid milk and other dairy products in these two markets. These analyses were undertaken using a series of household surveys that contain diaries of household food purchases. The primary

objectives of these analyses were to determine how sensitive dairy product demand is to changes in price and household income. We also examine how dairy products compete with other foods in the allocation of a household's food budget, important information for U.S. firms attempting to market U.S. dairy products. The major output of the last year has been in the development of two database systems, one for Mexico and one for Canada, which contains a collection of household surveys from the early 1990's-2002. For each year and country we have detail dairy product purchase information for more than 10,000 households nationwide. In addition to purchase quantity and price paid, we have information as to each household's income, household composition, occupation of household heads, etc. We incorporated current and historical surveys into our database systems to provide information regarding the direction of dairy product consumption in these two countries. During 2004 we will undertake detailed econometric analyses of the determinants of dairy product consumption.

In the U.S., rising incomes, decreased family size, and increased dual career households have influenced the structure of food demand in the U.S. These changes have resulted in increased demand for value-added foods that are quick and easy to prepare and a greater reliance on Food-Away-from-Home (FAFH) as a food source. These trends have occurred simultaneously with the decreasing share of household income allocated to food. The following table provides a summary of both trends between 1950 and 2002.

These trends have had a tremendous impact on the way the U.S. consumer purchases dairy products. For example, approximately one-

Table 1. The increasing importance of food purchased away from home as a food source

Year	Allocation of Disposable Personal Income to Food (%)			Allocation of Food Expenditures (%)	
	Total	FAH	FAFH	FAH	FAFH
1950-54	20.3	16.8	3.5	77.1	22.9
1955-59	18.2	14.8	3.4	76.2	23.8
1960-64	16.5	13.1	3.4	74.4	25.6
1965-69	14.3	10.8	3.5	70.5	29.5
1970-74	13.5	10.0	3.6	68.3	31.7
1975-79	13.5	9.4	4.1	64.8	35.2
1980-84	12.7	8.4	4.3	62.2	37.8
1985-89	11.5	7.3	4.2	58.9	41.1
1990-94	11.0	6.8	4.2	56.7	43.3
1995-99	10.4	6.3	4.1	55.5	44.5
2000-02	10.2	6.2	4.0	55.5	44.5

Source: ERS.

Note: FAH represents food for at-home consumption.

third of U.S. cheese consumption occurs as a result of FAFH purchases. One of the major reasons for the low growth in commercial disappearance of cheese during 2003 is to a large degree the weakness of restaurant and fast-food purchases. Given the importance of the FAFH market for the U.S. dairy industry we undertook a study of what determines the level of FAFH purchases by the American consumers. We are using a series of household survey data sets to examine factors that have influenced the use of FAFH as a food source and how these factors have changed over time. The data used for the analysis is the U.S. Bureau of Labor Statistics', Consumer Expenditure Survey (Diary Component). We are using versions of these household survey data encompassing the years 1980-81, 1986, 1991, 1996 and 2001.

Our modeling approach consists of two related econometric analyses. The first model type (referred to as the food expenditure allocation model) consists of year-specific analyses of the allocation of total food expenditures on FAFH. Given the definition of our dependent variable and the fact that we use weekly household expenditure data, we need to be concerned with possible censoring of FAFH expenditures. Normally this would require the adoption of the traditional Tobit specification. However in the present application we need to be concerned not only with the possibility of censoring at 0 but also a 1.6 To account for this double censoring we adopt the Two-Limit Tobit model similar to that used by Gould, Saupe and Klemme (1989) and outlined in Greene (2003).⁷ From the estimation of this two limit Tobit model we examine how the influence of household income, composition, educational status, etc. on the allocation of food expenditures to FAFH has changed between the 1980's and 2000's. The second set of analyses (referred to as the FAFH allocation model) will then examine how FAFH expenditures are allocated across meal type. Three occasion-specific Tobit-type models will be estimated (e.g., breakfast, lunch and dinner). The unique aspect of the modeling approach used here is that instead of estimating three independent Tobit models, we instead estimate a system composed of the three Tobit equations similar to the procedure used by Cornick, Cox and Gould (1994).⁸ Using this system improves upon the efficiency of the resulting parameter estimates and allows for an explicit modeling of the interdependence of FAFH expenditures by eating occasion, as the 3 equation error terms are allowed to be correlated. Using this structure we can test for the independence of the occasion-specific purchase decisions.

This research is currently being undertaken and we have obtained micro-level data necessary for undertaking the proposed analyses. We have estimated a preliminary version of the above two-stage model using data for 2001. Our sample size consisted of 11,176 observations. The following are used as independent variables in the food expenditure allocation model: family size, household income, percent of household members that are children, percent of household members that are seniors, percent of household members that work outside of the home, urbanization, region of residence, household size, race, ethnicity, educational status of household heads, and life-cycle status of the household. In the FAFH allocation model where per capita household expenditure on the three meal types are used as the dependent variables, we hypothesize that the following variables impact FAFH allocation: household income, family size, percent of household members less than 18, percent of retired household mem-

bers, percent of adults working full-time and part-time, race, ethnicity, degree of urbanization, region of residence, education of household heads and seasonality. For both the budget allocation and FAFH allocation models income elasticity impacts have been calculated with respect to both the discrete (e.g., whether to purchase) choice and continuous (e.g., how much to spend) decision variables. These elasticity values are calculated for the sample as a whole as well as for households in specific income deciles.

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

Footnotes

¹ This software is available electronically by contacting the author, Dr. Brian W. Gould at the email address, gould@cdr.wisc.edu

² This workshop was held as part of an overall educational program for the dairy procurement group of a large purchaser of Wisconsin dairy products

³ As an example, the daily graphing of the history of Class III futures settle prices can be found at:

www.aae.wisc.edu/future/daily_settle_graph.htm .

⁴ A copy of the policy paper can be found at:

www.aae.wisc.edu/future/publications/MILC_M_P_82_v2.pdf .

⁶As an example, refer to Cox, T.L. and J.P. Chavas, 2001. "An Interregional Analysis of Price Discrimination and Domestic Policy Reform in the U.S. Dairy Sector", *American Journal of Agricultural Economics*, 83(1):89-106.

⁷ For example in the 2001 version of the data, 19.0% of the sampled households had zero FAFH expenditures and 6.5% allocated all of the food expenditures to FAFH sources.

⁸ Gould, B.W., W.E. Saupe, and R.M. Klemme, *Conservation Tillage: The Role of Farm and Operator Characteristics and Perception of Soil Erosion*, *Land Economics*, 62(2), May 1989. Green, W. *Limdep, Version 8.0 Users Manual*, 2003

⁹ J. Cornick, T. L. Cox and B.W. Gould, 1994.

Fluid Milk Purchases: A Multivariate Tobit Analysis, *American Journal of Agricultural Economics*, 76:74-82. This system estimator is similar to the use of the Seemingly Unrelated Regression procedure but applied to a model where the dependent variables are censored.

Specialty cheese applications program

Personnel

Jim Path, outreach specialist

Funding

Wisconsin Milk Marketing Board

Dates

January 2003 to December 2003

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 specialty cheese area continues to play an important role in the development of a reshaped Wisconsin cheese industry. In the years 2001-2002 specialty cheese production in Wisconsin increased by about 50 million pounds, from 233 million pounds to 280 million pounds. In total, specialty cheese represents about 12.5 percent of Wisconsin's total cheese output. Seventy one of Wisconsin's one hundred and sixteen cheese factories manufacture specialty cheese. The manufacture of specialty cheese has also created a great deal of interest at the farmstead level.

The CDR Specialty Cheese program continues to provide training for Wisconsin Master Cheesemakers and information regarding the manufacture of specialty cheese.

In April 16th, 2003 the Wisconsin Master Cheesemaker graduation ceremony was held at the WCMA/CDR Conference in LaCrosse, Wisconsin. Five new Wisconsin Master Cheesemakers were honored along with two Masters returning for additional cheese honors. Each master must specialize in a specific cheese. Cheeses for this group ranged from traditional cheeses such as swiss and colby to more specialized cheeses such as feta, queso blanco, provolone and butterkase.

Development of the World Cheese Exchange involves a database of cheeses containing information, collected from domestic sources and international dairy schools. The database contains information on over 1,400 cheeses, some with pictures and manufacturing information. It can be found on the CDR web site.

The Wisconsin Process Cheese Short Course was held on February 25 and 26. The enrollment for the course was 40 students. Almost one billion pounds of processed cheese, processed cheese foods and processed spreads are produced in Wisconsin.

A representative of CDR traveled to Milan, Italy to consult with the companies Gruppo Alce, Anidral, Cento Ricerche Casearie, and Professor Francesco Addeo of University of Naples, regarding the manufacture of various Italian types of cheeses. Local cheese factories were visited to gain an insight into manufacturing techniques used in Italian specialty cheese varieties. Of particular interest was a visit to a local Gorgonzola cheese factory. Cheese was purchased and brought back to the USA for evaluation. Information was gathered for the Italian Cheese Seminar held at UW Madison in September 2003.

The Masterpieces of Italy, part II seminar was held on September 23 and 24 of 2003. The course was attended by 25 participants. Varieties of Italian cheeses were evaluated and methods to produce them were discussed. A presentation was also given on the marketing of these cheeses by Dominique Delugeau. Dominique has been active in the specialty cheese industry and has a strong knowledge of both Italian and French cheese.

The cheese discussion was led by Lino Esposito, who manufactured cheese in Italy for many years before coming to the U.S.A. to continue his profession. His background help to fill in many of the practical questions regarding cheese manufacture.

During the “hands on lab,” provolone cheese, caciotta cheese, asiago cheese, mascarpone cheese and a green olive mozzarella cheese roll were produced. Lino also taught cheese makers to shape the “provolone pig” and other animal shapes from hot provolone curd. This is a specialty found in some areas of Italy.

Jim Path from CDR participated in the Wisconsin Dairy Artisan Steering Committee meeting May 14th, 2003.

Work continued on juustoleipä, the specialty baked cheese from Finland. It has now a limited distribution in the State of Wisconsin and it looks very promising.

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 2003 to December 2003

Objectives

CDR Communications (CDRC) support 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 enhance or maintain their competitive advantage.

The CDRC team goal is to provide information to Wisconsin's dairy industry through the most effective and efficient channels. We use a variety of communication tools to deliver our message including technical conferences, forums, short courses, training programs, publications and our web site. The information that follows is a sampling of the work done by CDRC.

Design and coordinate technical conferences, forums, short courses, industry events

2003 Wisconsin Cheese Industry Conference

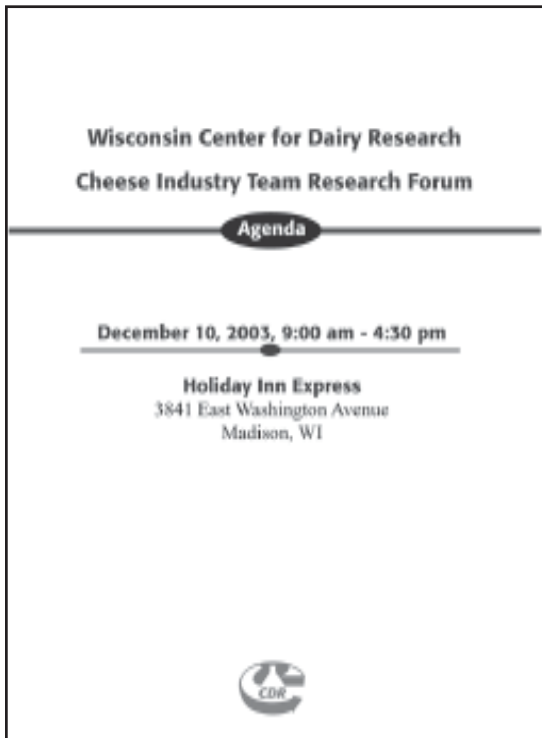
The Wisconsin Cheese Industry Conference (WCIC 2003) had a record attendance of 1061 participants. WCIC was held in LaCrosse, WI, April 15 & 16, 2003. The opening joint session dealt with trade concerns for global marketing of US dairy products, including Protected Designations of Origin. Speakers addressing the topic follow: Global Issues and Trade, Jerry Kozak, Senior Vice President, National Milk Producers Federation; European perspective/experience, Jüerg W. Rieke, J.D., Technical Legal Counsel, German Dairy Association; Canadian perspective/experience, Rejean Bouchard, Technical Leader, Canadian Dairy Industry; US industry perspective/experience, Tom Everson, Ph.D., Vice President of Technology, Grande Cheese Company; and Government/Regulatory View, Conrad Wong, Attorney/Advisor, Office of International Relations, United States Patent and Trademark Office.

Panel moderator David Burrington, Director of Marketing, Chr Hansen opened the technical session Cheese Flavor Development on day 2. Speakers addressing the topic follow:

What ever happened to those old time cheese flavors?, Bob Lindsay, PhD., Department of Food Science, University of Wisconsin—Madison; Culture characteristics for flavor



development, Jim Steele, PhD., Department of Food Science, University of Wisconsin—Madison; and Understanding cheese flavor development, Scott Rankin, PhD., Department of Food Science, University of Wisconsin—Madison. After a short recess, Peter Huth, PhD., Director, Nutrition Research and Scientific Affairs, Dairy Management Inc. addressed the group on the importance of cheese in child nutrition.

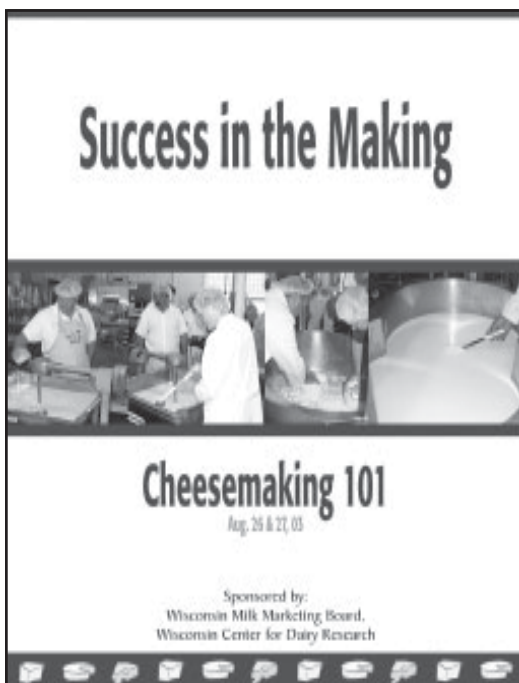


United States Senator Herbert Kohl briefly spoke to the WCIC attendees during lunch. The afternoon technical session, "The use of dairy proteins in cheese manufacture for performance," was introduced by Tom O'Connell, President, Marketing Concepts, Inc. Topics and speakers for the afternoon included: Cheese trends and markets, David Leonhardi, Director of Company Marketing Support, Wisconsin Milk Marketing Board; Science behind hitting the targets, Mark Johnson, PhD., Senior Scientist, Wisconsin Center for Dairy Research; and Use of dairy proteins to manipulate performance in natural and process cheese, John Lucey, PhD., Department of Food Science, University of Wisconsin—Madison.

The CDR exhibit during the WCIC featured the 2003 Wisconsin Master Cheesemaker class and a list/description of short course offerings at UW/CDR. CDRC coordinates the WCIC.

Forum

The fall 2003 Cheese Industry Team (CIT) Research Forum featured 14 principal investigators providing industry members updates and progress on their research. Industry attendance continues to increase. The Forum was held December 10, 2003 at the Holiday Inn – Madison East, Madison, Wisconsin.



Short courses

CDRC is involved in 30+ short courses or tailor-designed training programs each year. As example of a tailor designed training program is Cheesemaking 101 for Wisconsin Milk Marketing Board (WMMB) foodservice staff, dairy specialists and selected WMMB clients. Other groups receiving tailored training include American Dairy Products Association, Gordon Food Service, UniPro, IPAP, Wisconsin Association of Food and Nutrition Managers, US Dairy Export Council Trade Missions, and US International Trade Commission. CDRC was instrumental in the development of 2 new short course offerings for 2004, Cultured Dairy Products and Cheese Packaging.

Industry events

The "Tastes of Innovation – Dairy Check-off Works" booth at DMI, NMPF, UDIA and NDRPB national meeting was determined a success – that is what we were told and we believe it! 5 products in the marketplace (4 of the 5 developed at CDR) were featured at the exhibit: processed feta cheese,



juustoleipä, cheese & cracker pairing guide, dulce de leche and carbonated milks (eMoo and RPM). CDRC developed all the exhibit visuals and handled logistics for the booth. The event was held November 2 – 5, 2003, New Orleans. Attendance: 800+

Abstracts Center for Dairy Research

DAIRY PIPELINE

A Technical Resource for Dairy Manufacturers

June 2003, Volume 11 Number 2

Moisture migration in cheese—gauging the effects of moisture loss and moisture gain

By Mark Johnson, an associate, Wisconsin Center for Dairy Research

This information won't be completely new if you have ever taken the Wisconsin Cheese Manufacturing Short Course. In addition, chemical changes in cheese as a result of pH, temperature, production and time of moisture were outlined in previous Pipeline articles (Vol. 11, No. 1, Vol. 12, No. 1, and Vol. 12, No. 2).

The water molecule in a dairy case is a simple but complex, ubiquitous and yet elusive molecule. Its unique substance enables it to act but even people call it the universal solvent. Perhaps that is why most of the moisture, as water, in cheese is mobile. It can move if compelled to do so. The most obvious example is the way moisture shifts when required to do so. It usually does so unthinkingly, with positive results, other times it is not so fortunate. For example, moisture migration in retail packages of fresh-cut cheese is a common problem. How? Low & high humidity can create a local concentration of water in places from cheese to the surrounding air. This is accentuated when the cheese and the air in the package warm, for example when bright lights illuminate the cheese or when the dry air from the store heats the package film. Inside the package, moisture is lost to the air above the package since fresh water cheese is the most of the package is available to the cheese and

packaging material in the back seat remains cool. When the brand and make of the package meets the cold-dry air conditions, the cold cheese then absorbs the water and may become soft and poorly draining, for example in slices.

Another example is seen when cheese is packaged with other foods. Moisture will migrate from products with high moisture or some activity to low moisture products for even and cool products with lower moisture activity. So, in some cases, cheese gets soft while other items in the cheese draw out. This is why separating foods with different moisture and water activity is a good idea.

Packaged brined cheeses

The can also see moisture migration in packages of brined cheeses, like queso fresco or feta. The activity of the cheese is, of course, higher in salt. The high salt attracts moisture from the lower salt items in the brine of the cheese. Depending upon the moisture content level for the entire portion of the cheese may become overly and overly and more than what should be during shelf life.

The migration of cheese moisture to the water and anything else that is in—can result in moisture and pH gradients within a block of cheese. These gradients lead to variation in the physical characteristics of the cheese, influencing the shelf and milk characteristics and even eye development in Swiss. Some parts of a block of cheese may become too soft and putty—which presents challenges when taking samples that are representative of the entire block of cheese. Also,

University of Wisconsin-Extension
College of Agricultural and Life Sciences

Develop publications and other communication vehicles to deliver technical information

The quarterly newsletter, “CDR Pipeline” has 1800 subscribers. Lead articles for 2003 include Pasta filata to LMPS—the evolution of mozzarella cheese; Cheese Defects in US Graded Cheeses; Moisture migration in cheese; and A closer look at cream cheese

The biannual newsletter, “The Cheese Wedge” is sent to graduate Wisconsin Master Cheesemakers. The newsletter’s emphasis is on short courses, events and information pertinent to the Wisconsin Master Cheesemakers.

Manage the CDR Web site

www.cdr.wisc.edu is an information access program intended for use by the Wisconsin dairy industry. The site includes CDR News, technical resources, a calendar of short courses, meetings and events. The web page has an average of 1769 hits per month compared to an average 1603 hits per month for 2002.

The Cheese Wedge

For Wisconsin Master Cheesemakers

Vol 5 No 1 Spring 2003

2003 Wisconsin Master Cheesemakers

Shady Lohmeyer
Lohmeyer & Hilde Dairy, Inc.
Coley and Monterey Jack
"After going through the Master program, I met you and brought a milk can so that I can work with children on the transportation and registration," said Shady.

Robert Hilde
Hilde Valley Farms, Inc.
"I love every aspect of the job, whether it's good or bad," said Hilde. "You make the good with the bad—I learned that from Dad—you just make the best out of it."

Robert L. Wink
Cedar Grove Cheese, Glendale and Brewster
"We have only been CDR for a solid six years for making small quantities," said Wink. "Our people don't have any hesitation to start with, making cheese with us is a more or less than 100,000 lbs an hour."

James H. Melton
Main State Cheese Co., Rock and James Cheese
"Every year is a new challenge," said Melton.

Robert L. Kuch
Frago Foods, Inc.
"Moisture and pressure are two of the most important factors in making the cheese," said Kuch. "It's not just what you treat during the process, but what you treat after cheese taking to other cheesemakers and CDR staff."

*******WMMR Update*******

The Wisconsin Milk Marketing Board will have its 2003 meeting on Thursday, April 10th at the Grand Wisconsin Convention Center in Oshkosh, WI. In April 2003, the board will have your picture taken last year, or you would like a new one, please email to: info@wmmr.com

Table of Contents

- 2003 Wisconsin Master Cheesemakers - Page 1
- The Air Cheesing Cheese - Page 2
- Most Important of Dairy - Page 3
- Mark Johnson Book Cover - Page 3
- Just Cheese Cheese - Page 4

Wisconsin Center for Dairy Research
University of Wisconsin-Madison

Safety & Quality
Analytical Support
Marketing & Promotion
Cheese
Dairy Applications
Specialty Cheese

CDR News

- Abstracts
- Applications Programs
- Newsletters
- Technical Resources
- Conferences and Events
- Links

Dairy Profiles Document
Invited Reviews, Published in the Journal of Dairy Science
Food Labeling: Trans-Fats, Acids in Meat and Poultry Labeling, Nutrition Content Claims, and Health Claims
Dairy Economics and Marketing
Accept. Published in the Journal of Dairy Science
New Developments in Innovation, Dairy Checkoff Works
Cheese Science Update D&A
Food Safety, Export Wisconsin at 2004 Dairy Forum

News Archive

Home
Search
Contact Us
Microsites
Feedback

Copyright © 2003 - Center for Dairy Research

