Wisconsin Center for Dairy Research

DAIRY PIPELINE

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Cheese Defects in U.S Graded Cheeses

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Consumers and cheese graders approach the task of assessing cheese quality from two very different perspectives. While many consumers come from the "I can't tell you what I like but I'll know it when I see it" camp, most cheese graders know exactly what they don't like to see in cheese, and they know how to put a number on it.

Back in 1979 an Australian group of researchers compared these two approaches, finding no correlation at all between consumer preference and dairy graders' scores. (McBride and Hall, 1979) After canvassing 1754 respondents who qualified for the study by admitting a liking for Cheddar cheese, the researchers found significant differences between consumers under 20 and those who were older. It seems that the younger group was more discriminating when it came to cheese flavor, preferring the cheese that earned the higher grades. The older consumers were more accepting of the cheeses with flavor "defects," those with lower scores. Designing a grading system to measure consumer acceptance can be very challenging.

Regardless of consumer preference, the flavor and textural qualities of cheese do influence the value of cheese in the marketplace. That's because the 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.

If you want to know about the causes of cheese defects your search will be aided by the plethora of articles available in the scientific literature. (Bodyfeldt et al., 1988; McBride and Hall, 1979; Richards, 1984; Scott et al., 1998). However, very little information has been published on the prevalence of defects in natural cheeses. One study of 134 Trappist cheeses that were graded (Sabados and Rajsic, 1980), found 14.3% were first quality, 35.7% were second quality, 33.3% were third quality and 16.7% were substandard. Another group of researchers looked at 205 rennet-set cheeses produced in the USSR. (Baryshev, G.A., 1975) They noted that 88.7% were recorded as high grade and 8.8% as first grade cheeses. More recently, here in the U.S., Barnard (1992) reported that 53% of retail

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What's Inside:

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samples of Cheddar cheese had pronounced fruity/fermented, unclean, rancid or moldy flavor defects. Hansen and Keziah (2000) reported that of 250 retail Cheddar samples, 75% were acid, 45% were bitter and 40% had whey flavor. Even so, most of the information regarding overall quality of graded cheeses is proprietary information, retained by the major cheese manufacturers and marketers. The objective of our study was to survey the cheese industry to determine the prevalence of various cheese defects causing downgrades and to assess the economic impact of those defects.

Table 1. Number of cheeses graded during the six-month survey period.1000 kg samples

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

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 the volume of cheese manufactured or purchased, defects identified and grades established for each lot, and price decreases due to downgrades 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

In addition, we conducted a retail cheese survey by randomly purchasing two hundred samples of mild Cheddar cheese from 10 supermarkets in Dane county (Wisconsin) over a 3-month period. We selected cheeses that had at least 6 weeks or more remaining before the pull date listed. Cheeses were held at 5ºC, for a maximum of 5 days, until a trained sensory panel evaluated them. Our fourteen panelists were trained to identify defects in mild Cheddar cheese against the USDA grade standards (USDA, 2001). Potential defects included 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. Before sensory evaluation, cheeses were removed from cold storage and tempered to 10ºC.

Panelists evaluated ten cheese samples per tasting session. Cheeses were cut into 10x2x2 cm rectangular pieces, coded with 3-digit numbers and presented to panelists in random orders. We provided panelists with unsalted crackers, water and expectoration cups to cleanse the palate between samples. Napkins were provided for panelists to clean the hands between samples. Tasting ballots were collected and tabulated after each tasting session and testing was

Table 2. Percentage of various grades of Cheddar and Colby cheeses when graded at 4 and 10 days

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 cheeses	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	---

conducted twice a week for ten weeks. Defects were recorded if at least five of the panel members identified a defect as definite in intensity.

Industry survey: results

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 should be aged 10 days before grading and Swiss must be over 60 days old. However, some cheese plants with limited aging facilities will grade Cheddar, Colby and Monterey Jack cheese at 4 days, when the cheese is shipped out to aging warehouses. For official grade certification, those cheeses need to be graded again after meeting the aging requirements. 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 provided information regarding the decrease in cheese value due to downgrades in quality.

At 4 days of age, over 99% of the Cheddar cheese graded out as A Grade (Table 2). However, 5.7% of the Colby cheese graded at 4 days had both acid flavor and weak body defects. Colby cheese, with its higher moisture content in the final cheese, was probably more susceptible to faster development of excess acid and rapid body breakdown. 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, showing acid flavor and short body 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 rather than the chemical interactions that can contribute to body and flavor defects.

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

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 defects	% 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]	1.6	0.09	1.22
Flavor[1,2]	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

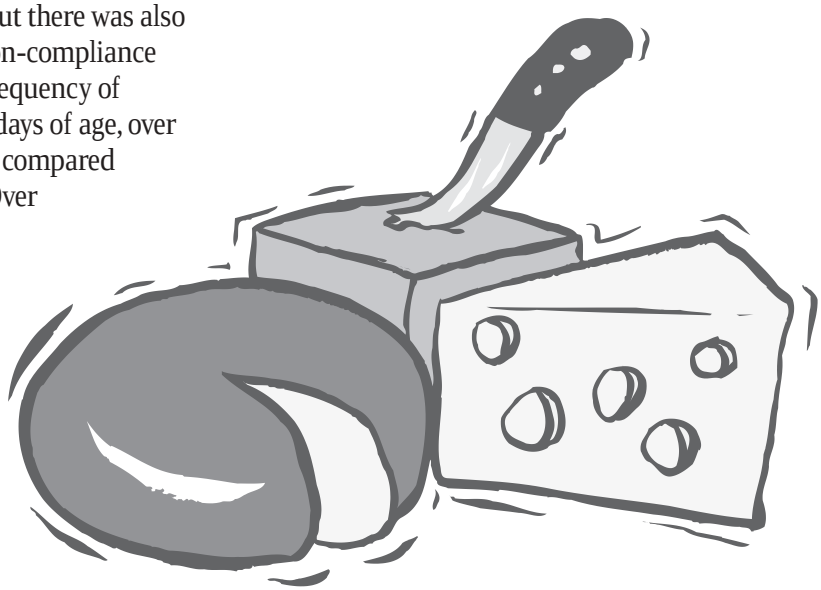
[1] Based on USDA grade standards for mild Cheddar cheese.

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/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.

Two factors emerged when 30-60 day Cheddar, Colby, and Monterey Jack cheeses were graded and evaluated at cheese processors. Not only was there a greater propensity to downgrade a cheese based on the USDA grade standards, but there was also the potential decrease in cheese value due to non-compliance with purchase specifications. Table 5 lists the frequency of downgrades for both of these factors. 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 important in 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 lacked the proper number of eyes (underset) for good quality Swiss cheese. Splits and cracks, overset and nutshell eyes were other common defects of eye formation in Swiss cheeses. The most common flavor defect in Swiss cheese was a utensil off-flavor.

Economic impact of cheese defects

To estimate the economic impact of cheese defects on the cheese industry, we assumed that the percentage of downgraded cheese in our survey represented cheese quality throughout the United States. The average price reduction for downgraded cheese (Table 8) was based on price reductions reported by 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

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> " We estimated that the cheese industry annually loses over 29 million dollars in value on Cheddar cheese, 10 million dollars on other American cheeses and 24 million dollars on 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] (%)	Avg 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.

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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 resulting from defects identified in the cheese. We don't know how much of this loss could be reduced or eliminated by improving cheesemaking practices and handling cheeses properly. However, cheesemakers should routinely evaluate cheese quality to determine which defects could be reduced or eliminated and thus reduce losses in revenue for their plants.

Retail Cheddar cheese survey: results

The flavor defects identified in retail cheeses are shown in Table 9. You will notice that the quality of mild Cheddar cheese at the retail market was significantly reduced from that observed at 30 to 60 days of age. A disappointing 91% of the retail cheeses would have been downgraded to B grade or lower due to flavor or body defects. Acid, flat, whey taint and bitter were the major flavor defects identified in the mild Cheddar cheeses. Our 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.

> "Cheesemakers should routinely evaluate cheese quality to determine which defects could be reduced or eliminated and thus reduce losses in revenue for their plants."

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 defect (body/textural)	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.

The occurrence of defects in natural cheeses can significantly influence the overall quality and value. 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 their cheeses throughout the aging process and during marketing if they want 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 and/or customers.

Acknowledgements
We wish to thank the cheese manufacturers and processors that provided grading information to us for this study. We also thank Brian Gould, Terry Lensmire and Noreen Ratzlaff for technical assistance in this study. This research was supported in part by the College of Agricultural and Life Sciences, University of Wisconsin-Madison and the Center for Dairy Research through funding from Dairy Management, Inc.

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Curd Clinic

Curd Clinic doctor for this issue is Carol Chen, Wisconsin Center for Dairy Research

Q. I have heard that researchers can influence the texture and flavor of cheese, tailoring it for specific functions. Does this mean a cheese manufacturer could alter the chewiness of cheese? I'm referring to mozzarella, which will be used as a pizza topping for a specific market.

A. Manufacturing protocols can indeed be adjusted to produce cheese that is less chewy. U.S. cheese producers are manufacturing for the preferences of an American market, which can be quite different than other world markets. We learned this firsthand from a group of Asian journalists and food scientists who toured the CDR several years ago. They thought that American made LMPS mozzarella cheese was too chewy for pizza pies.

The stretch and appearance of melted mozzarella cheese is very important, and so is the texture. One way to describe texture is chewiness, defined as the total energy or time required to masticate, or chew, a sample just before swallowing. Chewiness is influenced by hardness, springiness and cohesiveness (how the sample holds together in a mass) of the cheese. In general, as cheese ages, melted cheese becomes less chewy.

Researchers use sensory evaluation

During a research project at the CDR, trained panelists made melted cheese texture measurements using a sensory evaluation technique known as quantitative descriptive analysis. We did not find strong correlations between cheese composition and the chewiness of melted cheese. Because these factors are relatively easy to measure, many cheesemakers have relied on tinkering with cheese composition factors as the primary way to modify the chewiness of cheese. You can influence chewiness this way, but it isn't the most reliable choice. Instead, our study suggests that controlling proteolysis can help you control chewiness.

> "The major factor controlling chewiness is the degree of proteolysis."

Rather than compositional factors, we found that the measurement of 'flow rate' from the melt profile curve (See Figure 1, next page) correlated well with melted cheese chewiness for pasta filata and non-pasta filata LMPS mozzarella cheeses. The melted cheese flow rate depends on the number of protein interactions. Fewer interactions means the proteins are able to 'slide' past one another. Thus, cheeses with greater flow rates are less chewy—which leads directly to answering your question.

The major factor controlling chewiness is the degree of proteolysis, or the amount of casein that is broken down. A cheese that has undergone a higher degree of proteolysis will require less energy to soften and will flow at a faster rate due to the weakening of the protein matrix. You will find that this cheese is less chewy. Remember, less chewy, more chewy—neither is right or wrong. The choice depends on what your customers prefer.

Pasta filata vs. non-pasta filata mozzarella

Your approach to controlling proteolysis in pasta filata vs. non-pasta filata mozzarella should differ. For pasta filata mozzarella you control the degree of proteolysis by starter culture selection (use of cocci only, no rods) and/or a higher mixer temperature. Thus, to produce a chewier cheese use cocci as a starter because of they are lower in proteolytic activity. A higher mixer temperature also produces a chewier cheese since higher temperatures inactivate proteolytic activity.

Traditionally, mesophilic cultures are used with non-pasta filata mozzarellas, and no secondary heating steps are employed. In this case, further reductions to milk coagulant levels (i.e. rennet) as well as selecting a starter culture with a low protease activity are both strategies for limiting proteolysis, and thus producing chewier cheese.

Up to this point I have not mentioned pH, which also has a major impact on cheese meltability. It isn't a viable option for most cheesemakers though, since altering pH to control mozzarella texture requires pushing pH outside the optimal window of 5.0 to 5.4, adversely affecting overall cheese functionality. You are better off adjusting proteolysis and protein.

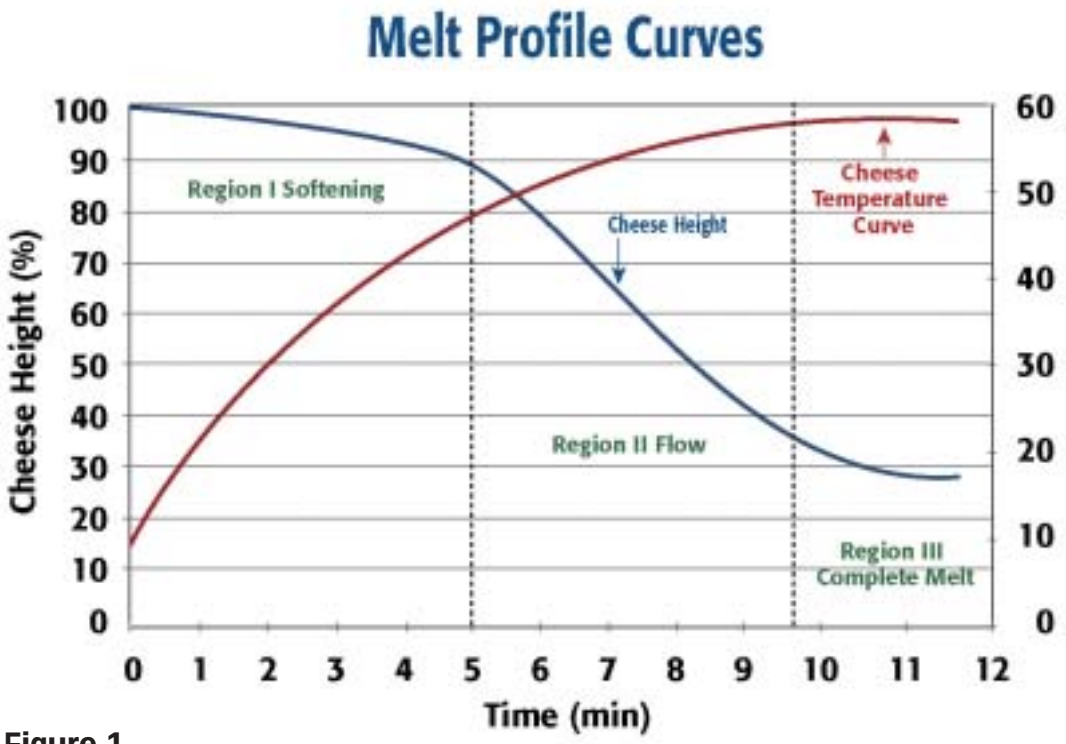
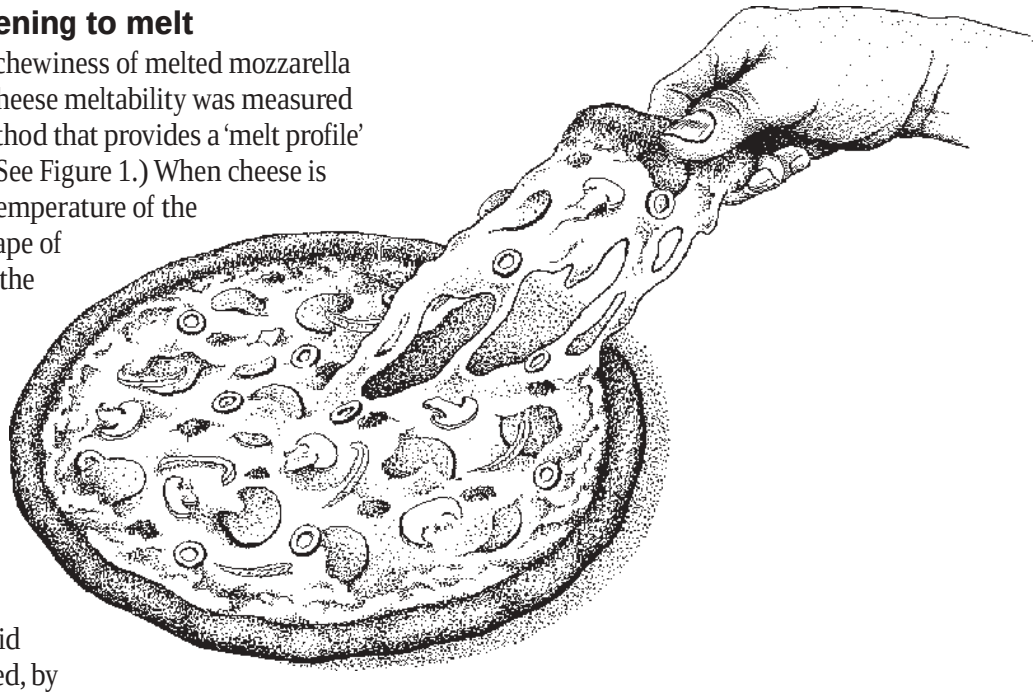


Figure 1.

Melt Profile—from softening to melt

Our research suggests that the chewiness of melted mozzarella relates well with cheese melt. Cheese meltability was measured by a modified squeeze flow method that provides a 'melt profile' of the phases during melting. (See Figure 1.) When cheese is initially placed in an oven the temperature of the cheese rises quickly, but the shape of the cheese does not change. As the cheese reaches a critical temperature—called the softening temperature—it begins to flow. At this point the cheese not only continues to rise in temperature, it is also changing shape. The cheese will decrease in height and will fuse together into one semi-solid mass. Flow rate can be measured, by calculating the slope of the best-fit line in a cheese height vs. time plot. Next, the melt profile reaches a third critical point called the complete melt point. After this point, there are only minimal changes in cheese height and the cheese temperature slowly approaches oven temperature.



Traditional methods of measuring cheese meltability measure the distance a disc of cheese spreads (modified tube, Schreiber) or decreases in height (Arnott) during heating. These types of melt tests describe cheese meltability using one measurement, and they relate to the complete melt of a cheese. With the exception of the degree of skinning, our research has found that the softening temperature and flow rate relate better to melted cheese chewiness, cohesiveness, and hardness than the complete melt temperature.

News from CDR

Cathy Lander

Kyungwha (Kate) Lim

Dean Sommer

Three new employees

CDR welcomes three new employees, pictured on the left. Cathy Lander, who is replacing Matt Zimbric in the analytical group, recently earned a Masters Degree from the University of Illinois—Urbana. Kyungwha (Kate) Lim is also a recent graduate, coming from the University of Missouri—Columbia. She earned a Ph.D. in Food Microbiology and Sensory Science and is replacing our former sensory expert, Alice Ping. We are also excited to have Dean Sommer with us, bringing years of experience earned at Alto Dairy. Dean is filling a new position at CDR, one that links CDR's scientists with "end users" of dairy products.

January symposium

CDR is organizing a symposium focusing on the issue of PDO cheeses and Geographic Indicators. The date hasn't been set but it will be some time in mid January, and it will take place in Green Bay, Wisconsin. Speakers from both U.S. Trade and Patent offices have been invited.

Labeling trans fats

On July 11, 2003, he Food and Drug Administration (FDA) published a final rule amending labeling regulations regarding trans fatty acids. Effective January 1, 2006 the FDA will require food manufacturers to list trans fatty acids on the nutrition label. Published studies indicate that trans fatty acids, created during the partial hydrogenation of oils, increase blood levels of low density lipoprotein cholesterol (LDL-C, or the "bad cholesterol"). For more information, check the FDA website at: http://www.cfsan.fda.gov/~dms/transgui.html

CDR in the teaching mode

The Wisconsin Center for Dairy Research has a mission statement that lists communication information as one of our main goals. This summer we fulfilled that goal by hosting several groups who benefited from custom designed courses.

When members of the U. S. International Trade Commission wanted to know more about milk proteins they came right to the source—Wisconsin. Warren Payne, Ron Babula, and Brad Gehrke traveled to Madison to spend a day with fellow economists and a second day following the trail of dairy proteins. That trail led from the whey pilot plant to process cheese and on to the myriad food applications for these proteins.

Smukowski chief judge at new cheese contest

After 20 years of sponsoring a cheese and butter evaluation clinic, Wisconsin Dairy Products Association added a new twist this year. They are holding the clinic at the World Dairy Expo on October 1, 2003. They also added a cheese contest, which was held at the Madison Area Technical College Culinary school. Congratulations to the North Hendren Co-op Dairy, which produced the Grand Champion winner, a Gorgonzola.

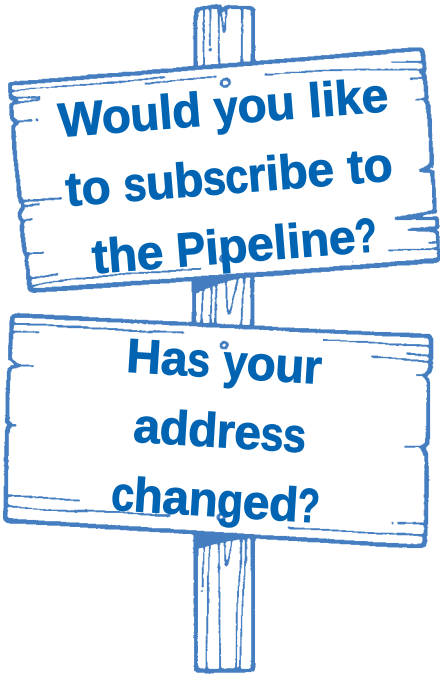
Education is a component of this new contest, since the students were able to observe the sampling and talk with the judges. In addition, part of the proceeds of the auction, held at 4 pm on Oct. 1, will be donated to the Education Foundation of the Professional Dairy Producers of Wisconsin.

Brad Legreid, WDPA executive director, said that he was "Extremely pleased with the first year of the contest." And he noted that the contest will grow since they plan to add yogurt and ice cream classes to the contest next year.

Marianne Smukowski, CDR, served as chief judge, alongside Dennis Butters, Stan Dietsche, Greg Kinate, Bill Novak, Mike Pederson, and Noreen Ratzloff.

Stan Dietsche, discussing cheese with MATC students

Noreen Ratzloff shares her trier with MATC students



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Calendar

Nov. 5-6 Wisconsin Cheese Grading Short Course. Madison, WI. Call Scott Rankin at (608) 263-2008.

Dec. 4-6 Premium Ice Cream Short Course. Madison, WI. Call Scott Rankin

Jan. 6-7 Milk Pasteurization and Process Control School. Madison, WI. Call Scott Rankin at (608) 263-2008 for information, or the CALS Outreach Services (608) 263-1672 to register.

Jan. 15-18 Ice Cream Makers Short Course. Madison, WI. Call Scott Rankin at (608) 263-2008 for information, or the CALS Conference Office (608) 263-1672 to register.

Feb. 10-11 Wisconsin Dairy Field Reps Conference. Madison, WI. Call Scott Rankin at (608) 263-2008 or Bill Wendorff at (608) 263-2015.

Feb. 24-25 Wisconsin Process Cheese Short Course. Madison, WI. Call Jim Path at (608) 262-2253 or Bill Wendorff at (608) 263-2015 for more details.

Mar. 29- Apr. 2 Wisconsin Cheese Technology Short Course. Madison, WI. Program Coordinator: Dr. Bill Wendorff, (608) 263-2015.

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