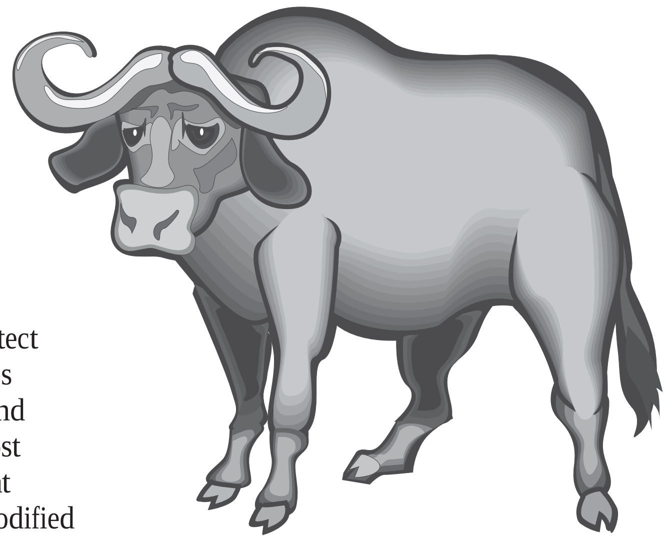
Wisconsin Center for Dairy Research

DAIRY PIPELINE

A Technical Resource for Dairy Manufacturers December 2003, Volume 15 Number 4

Pasta filata to LMPS—the evolution of mozzarella cheese

by Carol Chen, scientist, Wisconsin Center for Dairy Research



Did feta originate in Greece? What region of Italy nurtured the development of mozzarella cheese? Interest in these questions appears to be growing, perhaps it is a consequence of the attention garnered by the geographical indications (GI) issue. Like Roquefort cheese aging in the caves of Roquefort, a GI is essentially a link between a region and some particular product from that region. The European Commission is attempting to use geographical indications to reclaim and protect cheeses like feta, parmesan, and emmental. Most of the cheeses produced in the United States originated in another country and then traveled here with immigrants. Mozzarella, one of the most popular cheeses in the U.S. today is an example of a cheese that emigrated; taking on a different character as cheesemakers modified the product for new markets.

Early Roman writings, dating back to the 1st century A.D. link the production of mozzarella cheese to the water buffalo. Although raising water buffalo cows in the marshy low lands of the Campania region of southern Italy actually dates back to the 12th century, it wasn't until the 17th century that large scale milk processing began. Records from the 12th century describe a "mozza" or "provatura" as fresh cheese, which was consumed only within the region of Campania. By the 18th century, mozzarella's popularity spread to the much larger Lombardy region in the north.

Mozzarella di Bufala is porcelain white in color and has a springy texture and a pleasantly sour taste. As the production of buffalo and cow's milk mozzarella increased in northern Italy, it decreased in the south until the 19th century when most industrial cheese production was concentrated in the north. Although buffalo herd numbers continued to decline through the mid-1950's, promotional efforts of the northern Italian dairy industry increased consumer interest in authentic water buffalo milk mozzarella.

In 1979 the Italian government officially defined and recognized water buffalo milk mozzarella to protect the consumer from a common fraudulent practice of selling cow milk mozzarella at the higher price of water buffalo milk mozzarella. In 1993 mozzarella made from water buffalo milk became a "DOP" cheese, protected and regulated by the "Consortium of Mozzarella di Bufala Campana." In Italy, the origin and the traditional technology are guaranteed by a legal standard of identity. Only

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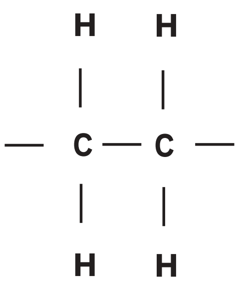
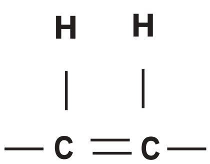
What's Inside:

FDA Reveals Phantom Fats

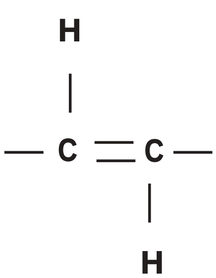


Saturated Fatty Acid



Unsaturated Fatty Acid

(cis fatty acid)



Unsaturated Fatty Acid

(trans fatty acid)

Ten years after nutritional labels first appeared on everything from canned peas to bran flakes the U.S. Food and Drug Administration (FDA) is making a major edit. By January 1, 2006 the nutritional label will also let consumers know the amount of trans fatty acids (TFA's) in food products.

Trans fatty acids are one of the by products of hydrogenation, which converts liquid fats to malleable, flexible fats that are used in shortening or margarines. The benefits of hydrogenation include the textural flexibility as well as the ability to delay rancidity thus allowing a longer shelf life. However, the effects of dietary trans fats first surprised scientists in 1994 and have now led to the FDA mandated label change. It seems that trans fatty acids may not only be linked to decreased levels of high density lipoproteins (HDL and yes, that's the "good" one) but they might also increase levels of low density lipoproteins, or LDL's (the bad one).

TFA's are often referred to as a phantom fat because the current, nutritional label lists only the amount of saturated fat and the total amount of fat in a serving. Trans fatty acids are found in ingredients such as partially hydrogenated fats or partially hydrogenated vegetable oil, which you may read in the list of ingredients, as required by the FDA. Most trans fatty acids are created by adding hydrogen atoms to the unsaturated sites (eliminating double bonds) on the carbon chains that make up fatty acids. (See diagram at left) By bonding on different sides of carbon chain, called the trans position, these hydrogen atoms essentially make a kink in the carbon chain.

Not all trans fats are created equal

Some researchers make a distinction between manufactured TFA's and those produced naturally, ie. the way cows do it, by bacteria in the ruminant gut. Scientists have noted that manufactured TFA's are structurally different than ruminant TFA in one important way—industrial TFA's might be made up of different combinations of fatty acids. Essentially, the hydrogen atoms find their way to a number of different polyunsaturated sites along the carbon chain in each fatty acid. Each combination may have a different effect cholesterol and triglyceride levels.

However ruminant TFA, and this includes the trans fatty acids in all dairy products, is mostly vaccenic acid, a part of which is converted by enzymes to conjugated linoleic acid, or CLA. You may have heard of CLA, it has puzzled researchers since Michael Pariza, food researcher at the University of Wisconsin—Madison, first noticed that it reduced the incidence of cancer in mice back in 1984. At the time he didn't know it was CLA, he just knew it was in hamburger. Four years later CLA emerged as the mystery agent and one of the richest dairy sources turned out to be Cheez Whiz. Several hundred animal studies later, CLA does indeed seem to offer an array of health benefits for lab rats, from anticancer effects to lowering triglyceride levels.

Given these positive indications from CLA, is it possible to separate the effects of manufactured TFA's from ruminant TFA? Well, not yet. Data from several large epidemiology studies has been analyzed to answer this question with mixed results. For example, a large and ongoing study of nurses continues to collect dietary information as well as detailed health data. This group did show a pattern of increased risk for heart disease linked with manufactured TFA's vs. ruminant TFA. (Think of it as margarine vs butter.) The same pattern showed up in several other studies, but it didn't hold up in all of them. So it really is too early to draw any final conclusions, but it is possible that ruminant TFA may in fact turn out to have some benefits.

Thus, for the dairy industry, the nutrition label edit mandated by FDA has some plusses and minuses. While it will require label changes, it is likely that most dairy foods will have very low levels of trans fat. In fact the levels will be so low that you will be able to put a zero in the trans fat line on the Nutrition Facts. Since conjugated fatty acids are omitted from FDA's definition of trans fat for labeling purposes, CLA and other conjugated trans fats will not have to be included in the amount of trans fat labeled.

For more information:

Food Labeling: Trans Fatty Acids in Nutrition Labeling, Nutrient Content Claims, and Health Claims. U.S. Department of Health and Human Services, Food and Drug Administration.
http://www.cfsan.fda.gov/guidance.html

Dietary Reference Intakes for Energy , Carbohydrates, Fiber, Fat, Fatty Acids, Cholesterol, Protein, and Amino Acids. National Academies Press.
http://www.nap.edu

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The influence of trans fatty acids on health, 4th edition. A report from the Danish Nutrition Council by Stender, S., Dyerberg, J. www.ernaeringsraadet.dk

Labeling trans fatty acids in dairy products

by Cary Frye, Vice President, International Dairy Products Association, IDFA

Will cheese makers have to measure the trans fatty acids in their products?

FDA allows the use of an "accepted" database as a source to determine TFA levels. IDFA plans to collect the information for a database in two phases. The first effort will begin early in 2004 when IDFA will be collecting milk, butter and anhydrous milkfat samples from processors in every region. TFA levels will be measured, along with TFA levels in samples of Swiss, mozzarella, and cheddar cheese to see if the amounts vary among cheese types. We will also look at the amounts of TFA transferred from milk to cheese and we see variation there we will analyze cheese.

What influences the amount of TFA in dairy products?

Trans fatty acids in dairy products are influenced by producer feeding practices. Thus it is possible that a special feeding program, such rotational grazing, might influence the amounts of TFA's. Seasonal variation has also been noted, however the variation probably isn't enough to influence the amount of TFA in cheese.

For more information contact Cary Frye at (202) 220-3543 or email at cfrye@idfa.org

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cheese made in specific areas with 100% water buffalo milk can be distributed with the consortium's logo.

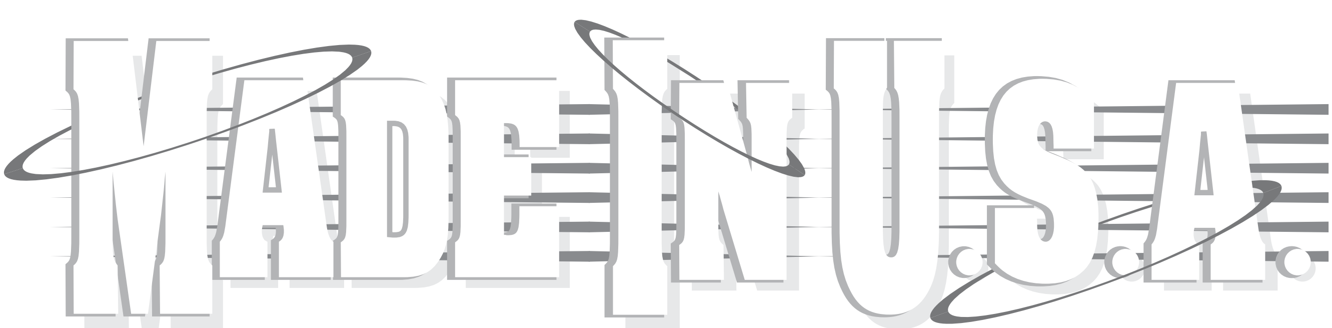
Meanwhile, here in the United States, the market for Italian cheeses increased with the numbers of Italian immigrants, from the early 1900's onwards eastern cities absorbed millions of Italians and most came from southern Italy. Ferris and Palmiter, in "Italian Type Cheese in the U.S.A", speculate about some of the obstacles early cheesemakers faced. They include inefficient equipment, horse and buggy transportation, rudimentary packaging, problematic water supplies, poor milk quality, no pasteurization, and a general dearth of scientific information regarding cheesemaking.

At the turn of the 20th century, Italian immigrants built small cheese factories to produce soft Italian cheeses, primarily because these high moisture cheeses could not stand the long sea voyage from Italy. Initially, this mozzarella closely resembled the high moisture cow's milk mozzarella of northern Italy. However, after changes in the manufacturing procedure, most mozzarella evolved into a firmer, less sour, milder flavored cheese, better suited for transport and cooking—especially pizza pies. Since the 1920's, production of mozzarella in the U.S. has increased from less than 50,000 lbs to 2.6 billion pounds per year (Ferris and Palmiter, 1987; Anonymous, 2002), and the vast majority is low moisture, part-skim mozzarella. The change primarily occurred in the Midwest, as Wisconsin cheese makers began to manufacture mozzarella for the metropolitan markets on the east coast. Here is how mozzarella evolved from high moisture to low moisture part skim, LMPS.

> "Here in the United States the market for Italian cheeses increased with the numbers of Italian immigrants."

The first U.S. mozzarella facilities

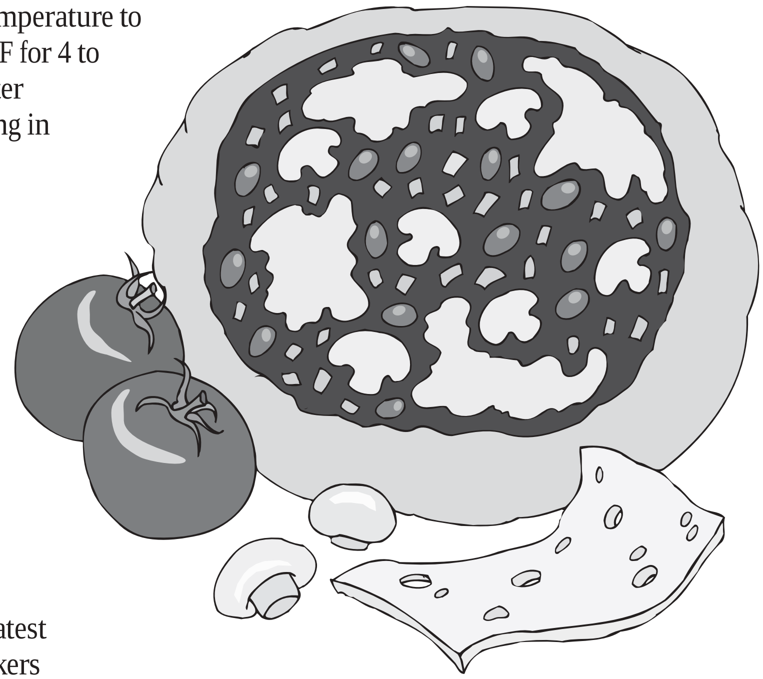
The first U.S. mozzarella manufacturing facilities, in upstate New York, made cheese from standardized milk with either no starter or low levels of starter culture. The starter cultures selected were either an active *S. lactis* at 0.05% (now called *Lc. lactis* subsp. *lactis*) or *S. durans* at 0.50% (now called *Enterococcus faecium*) (Christensen, 1966 #293; Kosikowski and Mistry, 1996). These mesophilic cultures do not produce an abundance of acid under the conditions of the high moisture mozzarella protocol. The milk was set, cut, (not cooked), drained, cut into small blocks, washed with cold water, and then bundled into cloth bags.



(Kosikowski, 1951) After storage at 40°F for 24 hours these bundles were shipped on ice to stores in the New York City market. It was crucial that acid production up to this point was minimal to maintain the stretching and melting characteristics of the cheese and it was not uncommon for acid development to require one to three days. The shopkeeper, or latticini operator, then brought the cheese into a warm room to reactivate the acid fermentation and allowed its pH to drop to about 5.3. At this point the curd was stretched in hot water, molded and brine salted for each customer.

Manufacturing protocols of early Italian cheeses

In a textbook called *Cheese Making* originally published in 1918, Professor J.L. Sammis of the University of Wisconsin-Madison described the manufacturing protocols of early Italian cheeses. The text outlines protocols for caccio cavallo and provolone, but not mozzarella. These two cheeses are drier cheeses (28-38% and 37-45% respectively) and made with one-third skim milk or whole milk, respectively (Sammis, 1946). Sammis describes adding starter (not specified, but presumably *S. thermophilus*) and rennet to milk, then cutting and raising the temperature to 125°F. Curd temperatures were maintained at 125°F for 4 to 5 hours in the summer or 8 to 10 hours in the winter until the proper acidity was developed for stretching in hot water. In the 1930's Professor J.L. Sammis and Louis Rossini, a cheese maker at Stella Cheese Company of Campbellsport, Wisconsin developed the starter culture concept further. Sammis and Rossini found that using *L. bulgaricus* in addition to *S. thermophilus* enabled them to make cheese the same day the vat was set (Ferris and Palmiter, 1987).



Italian immigrants to the Midwest also manufactured pasta filata cheeses and as dairying increased in the rich farmlands of Wisconsin, cheese makers had their eyes on those east coast markets. Of the 'spun' Italian-type cheeses, the greatest demand was for mozzarella. Wisconsin cheese makers found it difficult to maintain the quality of mozzarella manufactured using low acid producing mesophiles. Presumably in the 1950's, cheese makers switched from mesophilic to thermophilic cultures to facilitate the completion of mozzarella manufacturing in one day. It is unclear if this mozzarella is a modified version of caccio cavallo with its higher moisture or provolone, with its lower fat. To optimize acid development from the rod – cocci starter blend, curd was cooked between 114 - 116°F. The higher cooking temperatures produced a cheese with a lower moisture content than the east coast style mozzarella. Essentially Wisconsin cheese makers were now manufacturing to completion a low moisture mozzarella that could be shipped to new markets. Cheese made by this method was creamier and less

"Essentially, Wisconsin cheese makers were now manufacturing to completion a low moisture mozzarella that could be shipped to new markets."

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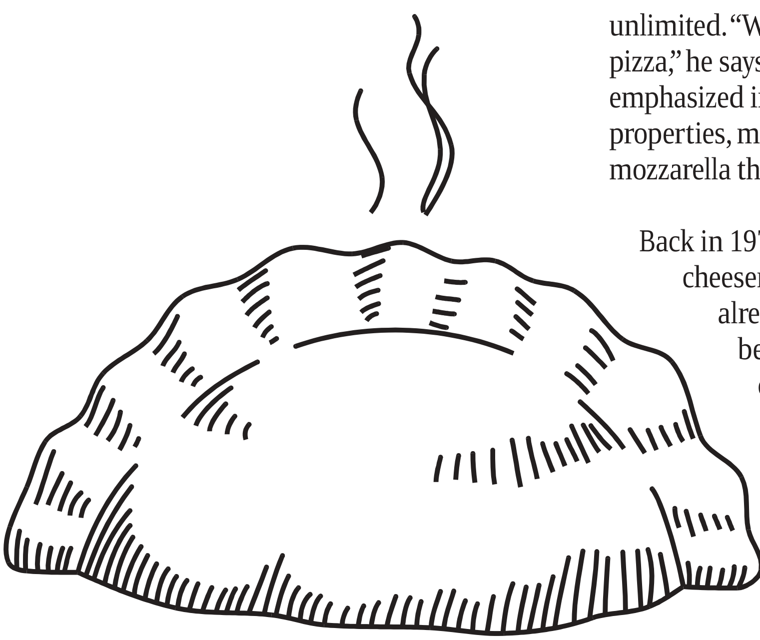
white, drier, and frequently displayed a slight provolone flavor. This cheese was not considered a table cheese, but a cooking cheese. Thus it was called 'Pizza cheese' until the USDA developed the Standards of Identity for Mozzarella in 1965.

A 1964 survey of randomly selected cheeses described New York mozzarella cheese as part-skim (~56% moisture, < 45% FDM) while Wisconsin mozzarella was a low moisture, part-skim cheese (~48% moisture, < 45% FDM) [Olson and Neu, 1964). Italian Mozzarella de Bufala Campania by definition has a minimum of 45% FDM. Why the switch to part-skim in the manufacture of U.S. mozzarella cheeses? We could not find any documentation describing why this changed occurred. Perhaps standardizing the milk to a lower fat content in both New York and Wisconsin originated due to the high value of milk fat for butter making at that time. Only Swiss and Italian varieties of cheese were legally allowed to standardize milk according to Wisconsin Legislation passed in 1926 (Price, 1956). In 1932 only about 15 percent of the cheese plants in Wisconsin manufactured Swiss or Italian (11 out of 2136 plants) cheeses.

Observing the changes

Norm Olson, Professor Emeritus of Food Science at the University of Wisconsin—Madison and the first director of the Center for Dairy Research, observed many of the changes in Italian cheese manufacturing and also was directly involved in research during the years of mozzarella's phenomenal growth. He notes that in the early years industry had more problems producing mozzarella cheese. "Starter cultures hadn't improved yet and there wasn't as much mechanization; cheese makers had a limited number of things they could do to regulate starter metabolism." However, mechanical molding machines were developed, which reduced labor and allowed expansion. In addition, Olson remembers the growing realization among many cheese researchers that uses for melted cheese were virtually unlimited. "We tried to pique their interest in going beyond pizza," he says of the Italian cheese makers. Thus, as scientists emphasized independent control of flavor and physical properties, mozzarella the cooking cheese developed into mozzarella the functional cheese.

"Mozzarella the cooking cheese developed into mozzarella the functional cheese."



Back in 1973, Olson made his predictions about Italian cheesemaking in the year 2000. Mozzarella cheese had already shown a nine-fold increase in production between 1957 and 1971, he predicted a projected per capita consumption of 3.5 lbs by 2000. However, the phenomenal growth did continue and in 2000 the per capita consumption was actually 9.3 lbs. Olson might not have gotten the numbers right, but he predicted the trend correctly and mozzarella has lived up to all expectations.

Julio Cappiello and Carol Chen work on their mozzarella critters

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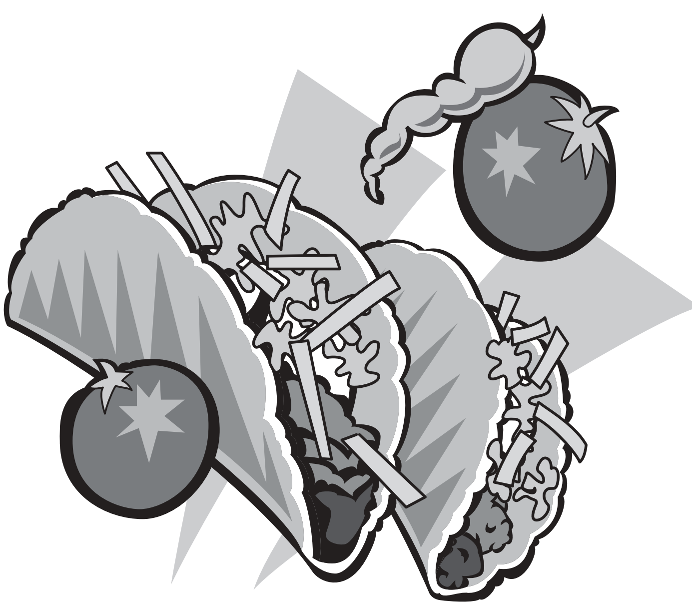


Check Out the New Short Courses in 2004

The University of Wisconsin—Madison Food Science Department and the Center for Dairy Research have planned two new short courses for May 2004. The first is a Cultured Dairy Products Short Course scheduled for May 4-6, 2004. This three day course is designed to cover the basics of manufacturing cream cheese, cottage cheese, yogurt and sour cream. By incorporating lectures, demonstration labs and evaluations the course will cover all aspects of producing high quality fermented dairy products. Discussions will include the latest research results in these product areas from the Center for Dairy Research and the Food Science Department. The course will also include discussions on the use of probiotics in cultured products for individualized nutrition.

This course is intended for all dairy and food processors interested in the manufacture and use of cultured dairy products. It is designed to deliver the latest technical information available to the processor and provide current information on extended uses of these products. This course qualifies as an elective course for the Wisconsin Master Cheesemaker™ Program.

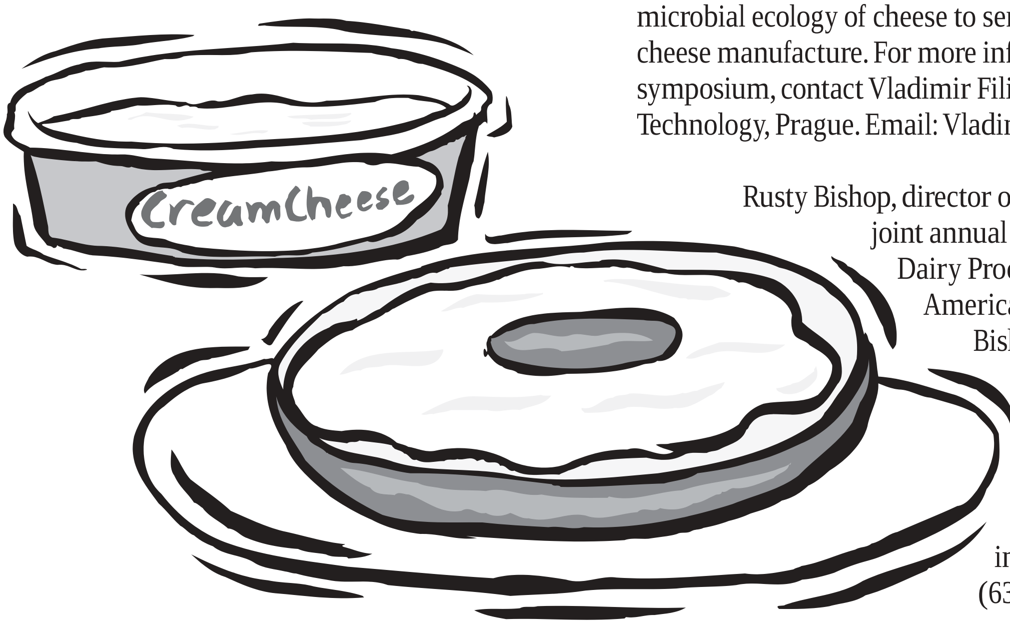
The second short course we have planned is the Cheese Packaging Short Course scheduled for May 25-26, 2004. The Cheese Packaging Products Short course is a two-day course that will cover all aspects of packaging natural and process cheese products. The course will incorporate discussions on packaging environments, packaging materials and equipment, and impact of packaging on distribution and marketing. Instructors will include industry representatives and staff from the Center for Dairy Research and the Food Science Department. The Tuesday evening reception will feature table top displays hosted by speakers representing the packaging industry.

This course is intended for all cheesemakers, cheese processors and distributors of cheese products. It will present the latest technical and product information available for packaging cheese products and it is an offering of the Master Cheese Maker series and qualifies as an elective course for the Wisconsin Master Cheesemaker™ Program.

Information on both of these new short courses is available on the CDR website at:
www.cdr.wisc.edu or you can contact Bill Wendorff at (608) 263-2015.

CDR scientists travel near and far

Rani Govindasamy-Lucey and Mark Johnson plan a March trip to Prague, Czech Republic to present at the International Dairy Federation (IDF) symposium on cheese. The program, entitled Ripening, Characterization, and Technology, will range from the microbial ecology of cheese to sensory analysis to economics of cheese manufacture. For more information about this symposium, contact Vladimir Filip, Institute of Chemical Technology, Prague. Email: Vladimir.Filip@vscht.cz



Rusty Bishop, director of CDR, will address the 2004 joint annual conference of the American Dairy Products Institute (ADPI) and the American Butter Institute (ABI). Bishop will share his expertise in international and domestic dairy standards when he delivers his address, "IDF and Its World Dairy Objectives on April 19th in Chicago. For more information on the meeting call (630) 530-8700.

CDR/US-IDF Geographic Indications Symposium "Impact of Geographic Indications on the U.S Cheese Industry"

Purpose of Symposium

The EU is seeking worldwide application, through WTO, of its internal regulation that reserves the use of certain food and beverage product names to producers tied to their historical geographic indications. So, what can we do to stem this tide for U.S.- made cheeses? The answer is simple – GET INVOLVED! Plan to attend the Wisconsin Center for Dairy Research/U.S. National Committee of IDF (USNAC), geographic indications symposium, "Impact of GIs on the U.S. Cheese Industry"

Who should attend

This symposium is intended for people interested in the future of the cheese & dairy business

When

Thursday, January 15, 2004, 8:00 am – 6:00 pm

Where

Radisson Hotel & Conference Center (Bear Room), 2040 Airport Drive, Green Bay, Wisconsin 54313 Telephone 1.920.494.7300 www.radisson.com/greenbaywi If driving from Interstate 43 or Highway 41, exit Highway 172 West. The Radisson Hotel and Conference Center is conveniently located across from the Austin Straubel International Airport.

Registration Fee

The fee of $200.00 covers registration costs, materials, breaks, lunch and reception

GI Symposium agenda

8:00 am	Registration	
8:45 am	Welcome/Introduction – Rusty Bishop, Wisconsin Center for Dairy Research	
9:00 am	Present Situation (EU, WTO, Codex, U.S., and others) - Jaime Castenada, National Milk Producers Fed.	
9:45 am	U.S. Government View and Status – John Doduas, U.S. Patent and Trade Office	
10:15 am	Break	
10:45 am	U.S. Political View and Status – Ben Miller, College of Ag and Life Sciences, UW—Madison	
11:15 am	Panel Discussion – Rusty Bishop, moderator	
11:45am	Adjourn for Lunch	
12:00pm	Lunch	
1:00 pm	Industry Case Studies	
1:45 pm	Industry Views	
2:30 pm	Panel Discussion	
3:00 pm	Break	
3:30pm	Break-out Sessions	> Strategy forward?
		> Where to draw the line?
		> Major target product and group?
		> Next steps?
4:15 pm	Reports from Break-out Groups	
4:30 pm	Next Steps	
4:45pm	Conclusions	
5:00 pm	Reception	

Symposium Contact: Mary Thompson, Wisconsin Center for Dairy Research

608.262.2217 thompson@cdr.wisc.edu

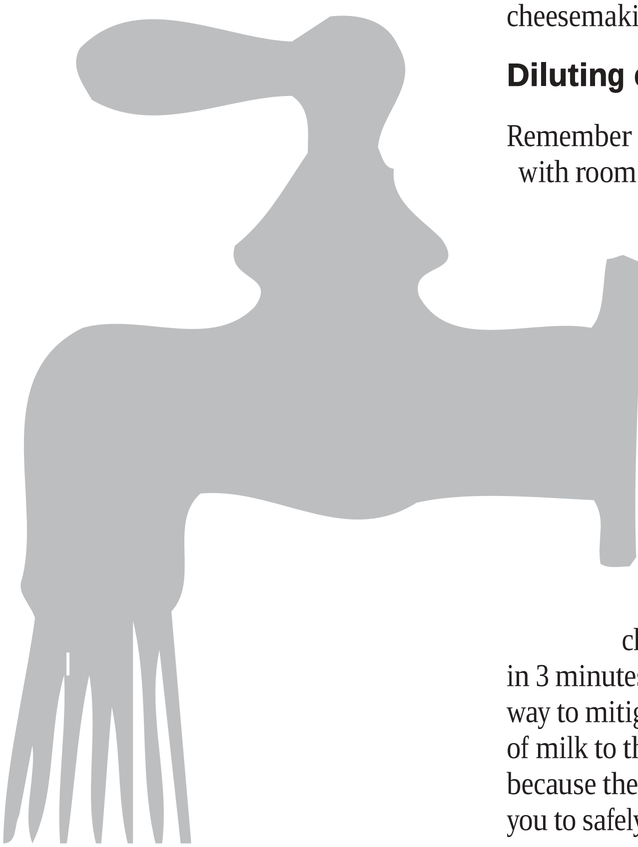
Curd Clinic

Curd Clinic doctor for this issue is Sandy Speich, Biochemist, Degussa.Bioactives

Q. During a recent short course at the UW-Madison a question came up about coagulants and dilution water. It makes sense to me that water quality influences the process but what is it about hard water that adversely affects rennet activity?

A. You are right, the water used to dilute coagulant can definitely affect the activity of the milk-clotting enzyme. The actual culprit is pH, because if the water is very hard the pH will be high, or alkaline, and it can have an adverse effect on the milking clotting activity. For example, most coagulants start losing activity at a pH above that of milk (6.6-6.7). Since it isn't unusual for very hard water to have a pH above 7 you can see how hard water can cause problems. The solution is simple, just acidify the water to a pH of 6.3-6.5 with lactic acid before using it to dilute your coagulant.

Hard water is only one avenue to the inadvertent inactivation of the milk-clotting enzymes. Water temperature and chlorine levels are other common complications that can reduce the activity of your coagulant, which in turn causes problems in cheesemaking.



Diluting coagulant

Remember that the coagulant should be diluted 20 to 40 fold with room temperature water because water that is too hot will inactivate the milk-clotting enzyme. This dilution will result in a more uniform addition of the coagulant to the milk. However, as soon as the coagulant is added to the water it starts to lose milk-clotting activity. Therefore, you should add the diluted coagulant to the cheese milk immediately after dilution.

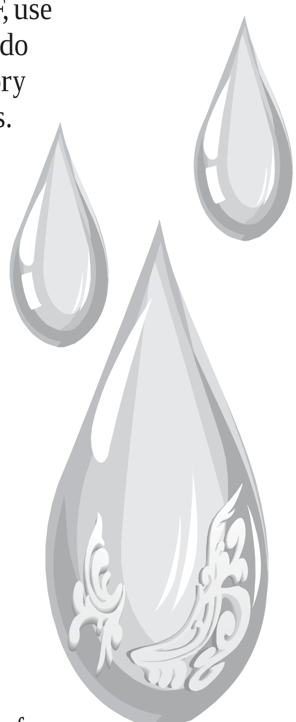
Chlorine in the dilution water can be a problem since it also reduces the activity of the milk-clotting enzyme. The chlorine concentration in treated water is 2-4 PPM. As little as 2 PPM of chlorine can reduce the milk clotting activity by 40% in 3 minutes. At 5 PPM the reduction is 60% in 3 minutes. One way to mitigate chlorine contamination in water is to add a cup of milk to the water before adding the coagulant. This works because the protein in the milk neutralizes the chlorine, allowing you to safely add it to the coagulant.

A charcoal filtering system in the water line is another common solution to the chlorine issue in cheese factories with chlorinated water. These filters are easy to install and maintain and effectively control any residual chlorine.

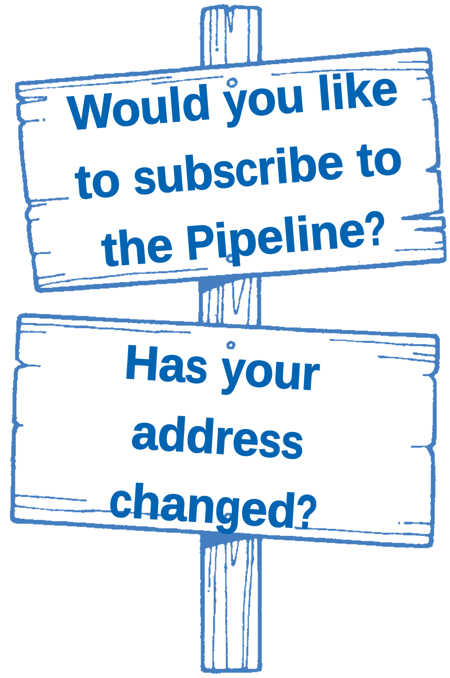
Pay attention to the container

In addition, you should pay attention to the container used for the coagulant. Don't sanitize it with a high concentration of chlorine because you could leave a chlorine residue, which will inactivate the milk clotting activity. Sanitizers that are acidic or contain peroxides can also inactivate milk clotting activity so those should also be avoided. Also, avoid reusing the container you used to add the cheese colorant, annatto. It is very alkaline and any residual color in the container could inactivate the milk clotting activity.

All coagulants will lose some of their milk clotting activity over time. The rate of activity loss depends on storage conditions. Coagulants should be kept cold, 40°F, use them on a first in first out basis and do not keep an excessively large inventory so you can be use it on a timely basis.



In conclusion, coagulants need to be used on a first in first out basis and kept cold. Coagulants need to be diluted with water no warmer than room temperature immediately before adding them to the cheese milk. The dilution container should be dedicated for coagulant dilution only and should be free of any residual chlorine. If you have to use hard water for dilution it should be acidified to a pH between 6.3 to 6.5 prior to coagulant addition with lactic acid. Chlorine in water can be either neutralized with a cup of milk or filtered out using a charcoal filter. Proper handling of coagulants is important to maintain maximum milk clotting activity.



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You can also find the Dairy Pipeline on our website: www.cdr.wisc.edu

Calendar

Jan. 6-7 Milk Pasteurization and Process Control School. Madison, WI. Call Scott Rankin at (608) 263-2008 for information.

Jan. 12-13 Producing Safe Dairy Products. River Falls, WI. Call Ranee May at (715) 425-3704 for information.

Jan. 15 CDR/US-IDF Geographic Indications Symposium. Green Bay, Wisconsin. Call Mary Thompson at (608) 262-2217.

Feb. 10-11 Quality Milk Conference (WI Dairy Field Reps). Madison, WI. Call Scott Rankin at (608) 263-2008.

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 Call Bill Wendorff at (608) 263-2015.

Apr. 20-22 International Cheese Expo, Madison, WI. For information, call Judy Keller at (608) 828-4550.

May 4-6 Cultured Dairy Products Short Course, Madison, WI. Call Bill Wendorff at (608) 263-2015.

May 11-12 Applied Dairy Chemistry Short Course, Madison, WI. Call Bill Wendorff at (608) 263-2015.

May 18 Wisconsin CIP Workshop, Madison, WI. Call Bill Wendorff at (608) 263-2015.

May 19 Dairy HACCP Workshop, Madison, WI. Call Marianne Smukowski at (608) 265-6346.

May 25-26 Cheese Packaging Short Course, Madison, WI. Call Bill Wendorff at (608) 263-2015.

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