Wisconsin Center for Dairy Research

DAIRY PIPELINE

A Technical Resource for Dairy Manufacturers March 2002, Volume 14 Number 1

An Overview of Cheese Flavor, Part 2

Influence of the Manufacturing Process

by Mark E. Johnson, Wisconsin Center for Dairy Research

What's behind the remarkable diversity of flavors in cheese? Remember that cheese is a dynamic, ecological environment, consisting of microorganisms deliberately added and "visitors" that have gained access to the milk (or cheese) at the farm or cheese factory. The ecology of cheese contributes to flavor through microbiological metabolism, which both influences and is influenced by the chemistry of the cheese environment. A thorough knowledge of all aspects of cheese manufacture is necessary to determine the relationships between chemistry, metabolism of microorganisms and the activity of enzymes that interact to influence cheese flavor. Also, the ripening process involves the production of flavor compounds derived from the breakdown of casein, fat, citric acid, and lactose as well as physical changes to casein (99% of the cheese protein). These changes are brought about through interrelated changes in pH, loss of calcium and proteolysis. The cheese maker controls these changes through the manufacturing protocol.

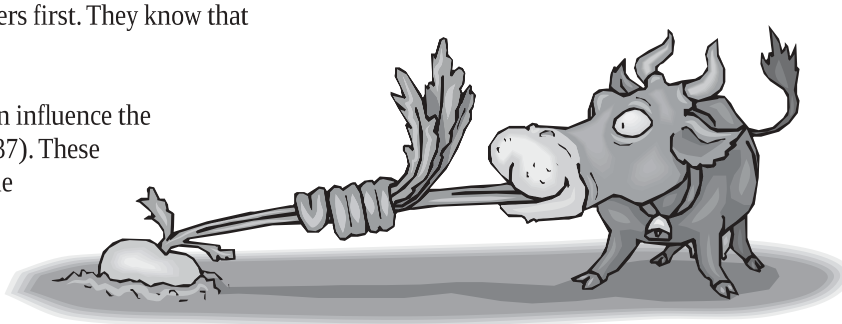
Milk supply

Many cheese makers believe that cheese making begins on the farm. If you attend an award ceremony at a cheese contest, you'll notice that champion cheese makers always seem to praise the farmers first. They know that there is no great cheese without good milk.

What, when and how much the animal eats can influence the flavor of milk (Roadhouse and Henderson, 1937). These flavors carry through to cheese, especially if the flavor compound is fat soluble or is absorbed by the casein. In addition, the actual chemical composition of the fat may be altered (Kaylegian and Lindsay, 1995) resulting in a different flavor profile following lipolysis. Some European cheese varieties are traditionally made from milk produced from specific animals that have grazed in a specific region, or even a particular hillside and at a certain time of the year. Particular flavors of cheese may be due to the presence of a specific forage plant in the area, one that contains unique flavor compounds. Some feeds are even forbidden for certain French cheeses (Masui and Yamada, 1996).

Milk enzymes

Other factors that contribute to the flavor of milk, and thus cheese, include the activity of indigenous milk enzymes like lipoprotein lipase and plasmin, a proteolytic enzyme. Of particular concern, especially to cheese makers with a limited number of producer farms, is the susceptibility of the milk to



"spontaneous rancidity," or the development of rancid flavors in milk from factors in the milk itself—especially milk from cows with mastitis. This is in contrast to "induced rancidity," a preventable cause of rancid flavors in cheese. Lipolytic enzymes in milk are at a level sufficient to cause significant lipolysis and impart noticeable rancid flavors to milk and cheese. Yet this does not happen in normal milks (Downey, 1980). Milkfat is surrounded by a protective layer, or membrane, that prevents contact with the lipoprotein lipase.

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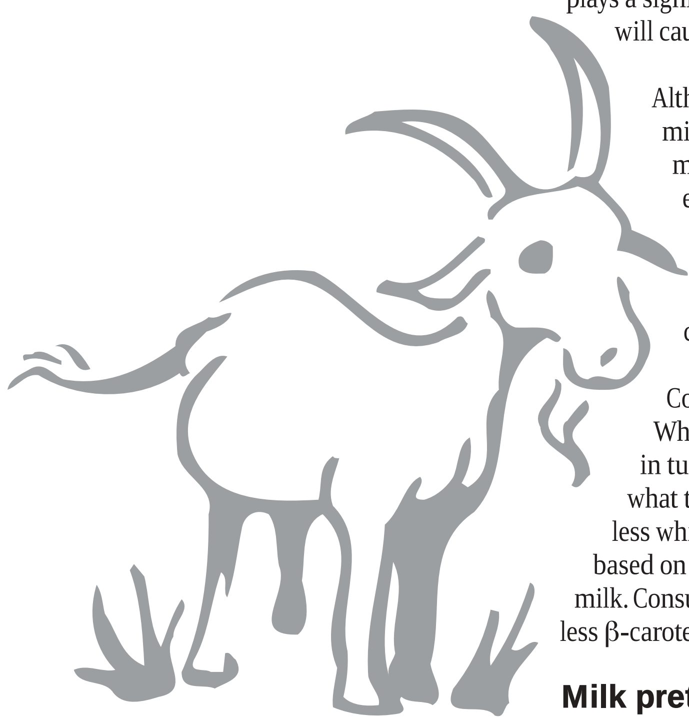
What's Inside:

Lipoprotein lipase is associated with the casein micelles, not the fat globule membrane. Lipases act at the water-fat interface. Lipoprotein lipase is the only major lipolytic enzyme in milk and may represent a spillover from the mammary tissue. During mastitis, blood is leaked into the milk and there is a higher level of enzyme present in the milk. Since all milks contain sufficient levels of lipases to cause rancidity something must disrupt the membrane thereby allowing contact of the milkfat with the lipase enzyme. In induced rancidity, there is a mechanical disruption of the membrane caused by excessive agitation, pumping (especially with inclusion of air) or homogenization. In spontaneous rancidity, lipolysis develops without any agitation. The exact mechanism that allows lipase to gain access to the milkfat is not known, the milkfat globular membrane does not seem different when you compare milks that undergo spontaneous lipolysis to those that do not (Downey, 1980). It has been suggested that certain milk components, especially macrophages, are involved (Azzara, and Dimick, 1985). The macrophages "poke" holes in the milkfat membrane, allowing contact between fat and lipase.

"Color is another factor that may have an influence on the flavor perception of cheese."

It's possible that factors relating to feed, stage of lactation, estrous, and mastitis may make milk more prone to spontaneous rancidity (Downey, 1980). In addition, these milks may contain elevated levels of plasmin, or alkaline milk proteinase, which hydrolyzes caseins, important in the degradation peptides with a propensity towards bitter flavor. Most of the plasmin activity is associated with the casein micelles and is activated (plasminogen to active plasmin) by the heat–treatment given milk or curd during cheese making (Farkey, 1995). Since plasmin is most active at higher pH, and in the case where there is sufficient residual coagulant, some have questioned whether this enzyme, at the levels in normal milk, plays a significant role in the development of flavor in cheese. However, it will cause milk to become bitter (milk is pH 6.6).



Although cheesemakers do not measure lipases or proteinases in milk, the levels of somatic cells and microbial content are measured and indicate the potential for high levels of these enzymes. Some have argued that the destruction of lipoprotein lipase is a contributing factor for lower flavor intensity in cheeses made from pasteurized milk. On the other hand, over activity of this enzyme clearly can cause rancidity in cheese.

Color may have an influence on the flavor perception of cheese. Whole milk and cheese is partially colored by β-carotene, which in turn is influenced by the animal which produced the milk, and what that animal ate. Goat milk is very white, sheep milk is a little less white and cows milk will be more yellow. The differences are based on the β-carotene content and how much of it gets into the milk. Consumption of fermented or dried feeds by the cow will result in less β-carotene content of the milk.

Milk pretreatment —prior to starter addition

For most cheese varieties the composition of the milk arriving from the farm is adequate to produce the desired cheese. For other varieties, the milk is too high or too low in fat or too low in casein to produce the desired cheese composition. In these cases, milk composition is standardized. To create the exact ratio of casein to fat desired in the cheese, the milk composition is altered by either adding or removing fat or adding casein. For example, cream is added to milk to produce creamy Havarti while it is removed when producing Parmesan or part skim mozzarella. Reconstituted nonfat dry milk, condensed or concentrated (via membrane filtration, ultrafiltered-UF, reverse osmosis-RO, or microfiltration-MF) skim can also be added to produce reduced fat cheeses since they are the only legal sources of casein. For some cheesemakers, economics is the major factor in determining the method used to adjust the milk composition, while for others it is product quality. Any ingredient added to milk for cheese making has the potential to affect the flavor of the cheese. For instance, we have seen cheeses made from improperly produced UF milk (milk that is over-pumped or agitated too much) that have an oxidized flavor, one characterized as cardboardy or tallowy.

A stale flavor is one of the most common flavors imparted to cheese when non-fat dry milk (NDM) is added. It is a problem generally seen in old NDM (used because the price is cheaper). Depending upon the severity of the heat-treatment used to produce non-fat dry milk, or condensed milk, a cooked flavor may develop in cheese. Thus, cheesemakers must be careful to use fresh, very low heat powders. Non-fat dry milk or condensed milk can also be added to increase the moisture content of cheese. However, lactose makes up more than 50 % of the solids in NDM and condensed skim milk and you might produce cheese with more acid and lower pH if you don't add water.

Heat treatment

Some cheeses are produced from milks given no heat-treatment at all. However, most cheesemakers do heat milk before adding starter. The reason for heating milk is to kill bacteria and the severity of the heat-treatment used depends upon the intent of the cheese maker. Heat-treatment of milk for cheese making can be divided into two categories, thermization or pasteurization. Thermization treatment (140-145º F/ 15-20sec) is used to kill most bacteria found in milk but it does not kill all pathogenic bacteria, spores or most non-starter lactic acid bacteria. The latter are considered essential for the development of fine flavor in aged varieties of cheese. Pasteurization (145º/ 30 min or 161º/15 sec minimum time and temperature requirements) is used to kill most pathogenic microorganisms in milk. Although not the intent, pasteurization can also destroy some of the indigenous enzymes—especially lipoprotein lipases. In the case of mastitic milk, the concentration of enzyme could be enough to cause rancidity in cheese (Ma et al. 2000). As milk is heated there is also a shift from soluble calcium and phosphate to colloidal calcium phosphate (casein bound calcium phosphate) an increase in buffering capacity of casein and a slight decrease in milk pH.

Homogenization

Induced lipolysis in milk is usually caused by some form of mechanical agitation that disrupts the fat globular membrane. Examples include excessive rate of stirring, inadequate sized pump for moving milk, and the incorporation of air during pumping. The fat is protected from lipoprotein lipase by this membrane, thus without it the fat is more susceptible to lipolysis. Homogenization deliberately breaks the large fat globules into smaller globules. Since there is not enough of the original fat globule membrane to cover the new particles, serum proteins attach to the new fat globules. These new globules may be even more susceptible to lipolysis because casein micelles, to which the lipase is attached, can associate with the newly formed fat globule.

Cheese manufacturing

Starter cultures are used in cheese making to produce acid and the key to the entire cheese making process is controlling the rate of acid development. Selection of the type and amount of starter is based on the rate and extent of acid development desired and, in some cheeses, the potential for flavor development. The amount of starter used also depends upon the activity of the starter, which is determined by the growth conditions used to produce the starter.

Why is the rate and extent of acid development important for developing cheese flavor? Cheese flavor develops from enzyme activity, metabolism of microorganisms, chemical reactions and the formation of particular compounds. Each factor, even substrates for a particular enzyme, is affected by the environment, i.e. pH, ionic strength, redox potential, moisture and a_w. In the case of microorganisms, intracellular enzymes may be potentially active but they are "protected" within the cell unless the cell lyses. Controlling the rate and extent of acid development is important because the pH should decrease at a specific rate and sugar should ferment at a specific stage in the manufacturing process. If the pH drops too early, or if there is too much or too little sugar in the curd after the whey has been removed, the cheese may be too high or low in pH or too high or too low in redox potential. Residual sugar influences fermentation.

Rate of acid development, acidity and pH

The amount of acid that develops and the buffering capacity of the cheese determine the pH of any cheese. These factors are influenced by the activity of the starter, when acid develops in the curd and the composition of the milk. Both inorganic and organic phosphates, lactic acid and casein (aspartic and glutamic amino acids in the intact casein) are the most important buffering agents in cheese (Singh et al. 1997). The pH will change as the amino acids are metabolized and ammonia is released, or as the type and amount of acid is altered.

The buffering capacity of cheese is influenced by the rate of acid development and the pH of the curd at the time the curd and whey are separated. As the pH of the curd drops, colloidal calcium phosphate is solubilized with a concomitant increase in the protonation of the phosphate and release of ionic calcium. Thus, the lower the pH at the time of whey separation the lower the colloidal calcium phosphate and the lower the buffering capacity of the curd. However, there are other consequences to the casein and this influences the aggregation and association of the casein micelles with each other. In turn, they influence the body and texture of the cheese which could affect flavor release during

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mastication of the cheese. When charged groups on the casein molecule become protonated there is also an increase in the solubility or hydration of the casein molecule. We have assumed that the caseins are now more susceptible to proteolysis by the residual coagulant and microbial proteinases. Indeed, cheeses with an increase in solubilized casein show an increase in the rate of softening and an increased tendency towards bitter flavor.

There is also an opposing reaction that is favored at pH of 5.0 or lower or if the ionic strength (addition of salt) of the cheese is increased. The hydration of the casein decreases and the molecules of casein organize into larger aggregates and serum collects between these aggregates. This occurs in Camembert, cottage, and blue cheese.

Growth of microorganisms is influenced by pH, and the type of acid. Consider the rate of growth of coliform bacteria. Some coliforms do not grow well at a pH of less than 5.4, thus the longer the cheese or milk is at a pH higher than 5.4, the better contaminating coliforms will grow. Conversely, the faster the pH drops to 5.4 or below the fewer the number of coliforms. Although coliforms shouldn't be present in pasteurized milk, they are occasionally found in cheese, especially when the curd/whey mixture is diluted with water which means less acid in the cheese and a higher pH.

If the starter is not fast enough and the cheese is cooled to a temperature limiting starter growth, there may be residual sugar. The pH may be higher than desired, and the non-starter lactic acid bacteria can ferment the residual sugar—with undesirable consequences. Coliforms and other heterofermentative bacteria will produce ethanol and CO_2 from lactose. Ethanol will react with fatty acids (especially butyric acid) to produce ethylbutyrate a sweet, fruity flavored compound.

Cooking the curd (with stirring)

To enhance syneresis and thus control moisture, the curd and whey mixture is heated and stirred. The temperature and time used is cheese and culture dependent. The cook temperature can be used to slow the rate of acid development and microbial growth. It can also decrease the activity of chymosin (if very hot > 48°C) but it may stimulate the activity of plasmin (Farkey, 1995).

Modifying the lactose content

In the manufacture of some cheese varieties (Gouda, Baby Swiss, Colby, and brick), the cheesemaker controls pH by modifying the lactose content. The most common way to do this is to either add water, or first drain some of the whey and then add water or simply rinse or soak the curd in water. The latter can be used to not only remove lactose but also to cool the curd. Cooling curd slows syneresis and the cool curd also absorbs water, but most of it is lost during pressing. The net result is that there is less lactose in the cheese. Another consequence of using these techniques is an increase in calcium (Ca-phosphate) loss from the curd. This loss can be accentuated by adding a small amount of salt to the whey and curd mixture. The casein becomes more easily hydrated and the cheese is softer. Lactose reduction will influence redox potential.

Curd and whey separation

At some point the curd will have to be separated from the whey. How and when (for example at what pH) this is done will influence flavor development in cheese. The major effect is on the incorporation of air (oxygen) and the potential influence on redox potential. The amount of residual lactose at the time of pressing and the amount of oxygen incorporated in the curd will influence the redox. The more lactose there is to ferment, the more oxygen is used up. The more oxygen incorporated in the curd, the more lactose that needs to be fermented to consume the oxygen.

Salting

Salt directly contributes to flavor and it is also influences the perception of other flavor compounds. Salt affects enzyme activity, the growth and metabolism of microorganisms, and, due to its effect on casein, will decrease proteolytic activity. Without the contribution of enzymes or microorganisms capable of metabolic activity at the salt concentration in the cheese, very little flavor will develop. Cheese very low in salt may be more prone to develop bitterness and a softer texture.

The method of salting will affect the distribution of salt within the cheese. Salt can be directly applied to the curd prior to pressing or added later by soaking the pressed cheese in brine or by rubbing salt on the cheese. The latter two methods result in a substantial salt gradient that may take many months to reach equilibrium. Thus, there can be a difference between the "layers" within the cheese as to the growth of microorganisms. Layering is probably most important in regards to starter metabolism and fermentation of residual sugar.

Curd pressing: moisture and temperature gradients

Once the whey is removed and the curd placed into a box for pressing, moisture and temperature gradients may develop— particularly in large blocks of cheese. Salting methods also affect the moisture gradient. Curd cools from the outside in. Moisture moves from the warm interior to the colder exterior. The rate of movement depends on the temperature of the outside of the cheese. There is always a certain amount of whey trapped within the curd and it is eventually absorbed by the casein network, however the rate and extent of this process depends on the colloidal calcium phosphate content and pH. Curd washing, whey removal, salt content and temperature of the curd will also influence absorption of the entrapped moisture. Since there are temperature, moisture, and salt gradients within the cheese, the potential for different rates of microbial metabolism and growth of microorganisms remains.

Curing the cheese: Packaging and temperature also fluctuates

Once the cheese block, wheel or brick has been formed and salted, the cheese is cured. The process may be simple—vacuum wrap the cheese and let "nature" take care of the rest. On the other hand, curing may be an elaborate ritual involving the spreading of microorganisms on the outside of the cheese or, in the case of blue cheese, poking holes in it to make sure the molds have sufficient oxygen to grow. The ripening of these cheeses is done under strict control of humidity, airflow and temperature. The type of curing i.e. vacuum packaged vs air-ripened will alter the flavor of the cheese. Cheeses may be air-ripened and then vacuum packaged. Air-ripened cheeses are often allowed to develop the surface growth first and then the cheese is moved to rooms of lower humidity. This slows or inhibits the ripening process and allows for a protective rind to develop around the cheese.

Conclusion

The influence of the manufacturing process on the ripening of cheese can range from subtle to complex. However, the major influence on the development of flavor in cheese is related to microorganisms and added enzymes. The diversity of flavors in cheeses is a complex issue and the study of flavor development must include, no matter how seemingly unimportant, all aspects of cheese manufacture, from the cow to the consumer.

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Wisconsin Master Cheesemakers Graduate

On Thursday, April 25, six more cheesemakers will officially achieve the status of Master Cheesemaker. In addition, three previous Masters, Kurt Heitmann, Kerry Henning, and Bruce Workman will be adding new cheeses to their Master certification.

Wisconsin's Master Cheesemaker ® Program is a unique opportunity for Wisconsin cheesemakers to add coursework and formal training to their extensive years of cheesemaking experience. Those years are indeed impressive, adding up the cheesemaking experience of the six graduates in the 2002 class gives a rough estimate of of 187 years, almost two centuries!

When you talk with Wisconsin cheesemakers about their work several themes surface in almost every conversation. The first one is the respect they all have for hard work. There is pride in that work too, pride that shows when they talk about the cheese they produce. And you can't rack up those years of experience without starting fairly early, like the Masters who learned to make cheese from their parents in the family cheese plant. Several cheesemakers in this graduating class started working at cheese plants within days of getting a drivers license—their plans to pay for a car steering them towards a satisfying career, too! Congratulations.

Ken DeMaa
Alto Dairy

Sid Cook
Carr Valley Cheese, Wisconsin's Pride Cheese

Allan Scott
Land O'Lakes, Denmark

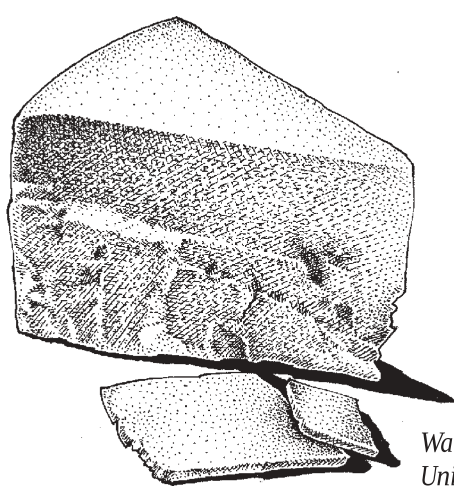
Jamie Fahrney
Chalet Cheese

Gary Grossen
Prairie Hill
Cheese

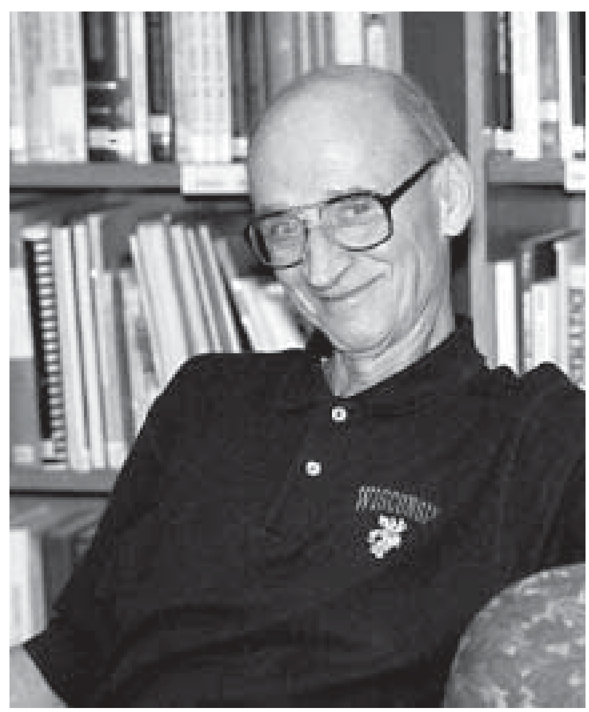
Do you know a future Master?

If you have been a licensed Wisconsin cheesemaker for at least ten years you can apply to the program. Before you are accepted into the program you need to attend the Wisconsin Cheese Technology Short Course, along with one other cheese short course.

It's not too early to start thinking about applying for the Wisconsin Master Cheesemaker® Program, the deadline is May 15th, 2002. If you, or someone you know, is interested in the Master program please give Jim Path a call, 608-262-2253.



Walt Brandli
University of Wisconsin
Dairy Plant



Join us at the

International Cheese Technology Exposition 2002

April 23-25, 2002 at the Alliant Energy Center in Madison, Wisconsin

Technical Session presented by the
Wisconsin Center for Dairy Research
April 24th 8:30 am to noon

8:35 a.m.
Fractionating the components of whey to maximize value, Karen Smith, CDR

8:55 a.m.
Future of handling whey for small plants
Bill Wendorff. Dept of Food Science

9:15 a.m.
Impact of milk standardization on whey composition
Mark Johnson, CDR

9:45 a.m.
Impact of milk standardization on whey composition
John Norback, Dept of Food Science

10:30 a.m.
Nutrition is the Future: Nutritional improvement through whey components, KJ Burrington, CDR

11:00 a.m.
Markets and value of whey components
Marty Davis, Davisco Foods

Q & A for all speakers

And in the exhibit hall...

You'll have more opportunities to talk with John Norback, Mark Johnson, John Jaeggi and other CDR researchers. A poster exhibit of CDR's current research will be on display, stop by to discuss cheese yield, cheese defects, and the research possibilities that are possible in CDR's whey pilot plant.

Skimming the Shelf—

What's New in Print?

Cheese
The Making of a Wisconsin Tradition
by Jerry Apps
published by Amherst Press, Amherst, WI

Jerry Apps was awarded a Book Award from the State Historical Society of Wisconsin for his book on the history of cheesemaking in Wisconsin—and it is easy to see why. This book is filled with photographs of vintage cheese plants, modern plants, equipment both new and retired, and cheesemakers. Apps, and his son Steve Apps who took the present photographs, includes historic photos of farmers delivering milk and cheesemakers during many steps of the process. You'll also find a portrait of Katharine Feldmann, the first female cheesemaker in Sheboygan County and a snapshot of Albert Deppeler, an influential icon in the world of Wisconsin cheesemakers. It's likely you'll see a few people you know. In fact, there are so many photos in this book that you can find one on almost every page.

I don't mean to ignore the heart of this book, which is reams of research presented in a lively, easy to read format. In the very first chapter, Apps, who grew up on a small farm, describes the sounds, smells and taste of his first visit to a cheese factory, when he was twelve. Throughout the book he parses out information gleaned from dozens of people he interviewed to present the history of cheesemaking in Wisconsin. He shares stories of building cheese factories, working in cheese factories, the closing of cheese factories, and of course, information about the cheese itself.

If you are like me, I always grab some Wisconsin cheese before I head out of town to visit family and friends—particularly friends who have moved out of Wisconsin. Jerry Apps book would be a lovely complimentary gift!

News from CDR

Congratulations

Accolades for Mark Johnson

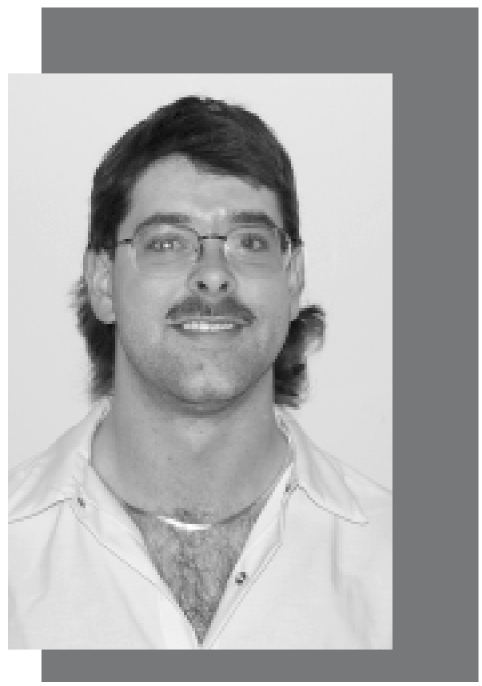
CDR is pleased and proud to announce that our own Mark Johnson was chosen to receive the Chancellors Award for Excellence in Research from the University of Wisconsin-Madison. Honorees, who are nominated by their peers, are judged on their excellence, creativity, interactions and achievement. I'm sure that anyone who has worked with Mark can understand why he was singled out to win this award and I'll bet you feel the way we do—pleased but not really surprised—and happy to congratulate him!

Lights, camera…

CDR might show up on your television screen in the future—a film crew from Discover Wisconsin spent March 13th and 14th filming the cheesemaking process, featuring star cheesemakers John, Bill and Nate. Look for interviews with both John Jaeggi and Mark Johnson. The whey applications program was also highlighted, including an interview by KJ Burrington. Filming caught some of the dairy demos for John Lucey's Food Science class, along with demos of membrane processing and buttermaking. Watch for a viewing some time in April or May.

Welcome Nate

Nathan Leopold, research cheesemaker, has joined CDR to work with Bill Hoesly and John Jaeggi. Nate, who was born and raised in Brodhead, brings experience from previous positions at Wisconsin Whey and Roth Kase. Although he once spent a month making cheese in Switzerland, Nate has no allegiance to any particular type of cheese, claiming he hasn't found a cheese that he didn't like.



Nathan Leopold, research cheesemaker, CDR

McSweeney Seminar

Dr. Paul L.H. McSweeney, Dept. Food Science, Food Technology and Nutrition, University College, Cork, Ireland visited CDR in February. Along with individual consultations with the staff, Paul presented a seminar on his research, "Biochemistry of cheese ripening & flavour development."

Congratulations to Rae Dawn Ripchen

Congratulations to Rae Dawn Ripchen, Food Science graduate student and contributor to the Pipeline (December 2000, Volume 12 Number 4, A Review of factors influencing salt retention). Rae Dawn was recently awarded the graduate student scholarship by the Wisconsin Institute of Food Technology (WIFT).

CDR's exhibit features Master Cheesemakers

CDR participated in the WMMB Producer Value Showcases. The Showcases are held for Wisconsin dairy producers throughout Wisconsin. The 2002 locations included, Watertown, Tomah, Kiel and Marion, Wisconsin. CDR's exhibit featured the 2002 class of Wisconsin Master Cheesemakers.

Curd Clinic doctor for this issue is Lloyd Metzger, assistant professor at the University of Minnesota and featured speaker at a recent University of Wisconsin Process Cheese Short Course.

Curd Clinic

Q. One of the most common questions I get from cheesemakers is "What will happen to the characteristics of my process cheese if I change an ingredient or add a new ingredient to my formula?" For example, changes could include using a different natural cheese, enzyme modified cheese (EMC), color, or emulsifying salt. Sometimes the modification involves simply changing the amount of an ingredient.

A. In some cases, previous research or experience makes this question is easy to answer. However, most of the time, the only way to predict the effect of varying your formula is to make a batch of process cheese and evaluate the new process cheese.

Obviously, in a production setting this isn't always an option. Process cheese is typically produced on a large scale and any break in production to test a new formula is expensive. Additionally, the formulation change may adversely affect the product quality and result in rework or disposal problems. To avoid problems, formulation changes are usually evaluated on a small scale. A pilot scale Blentech twin-screw horizontal cooker is shown in Figure 1. This small-scale batch cooker is capable of producing process cheese in 10 lb batches and provides a cost effective method of evaluating formulation changes.

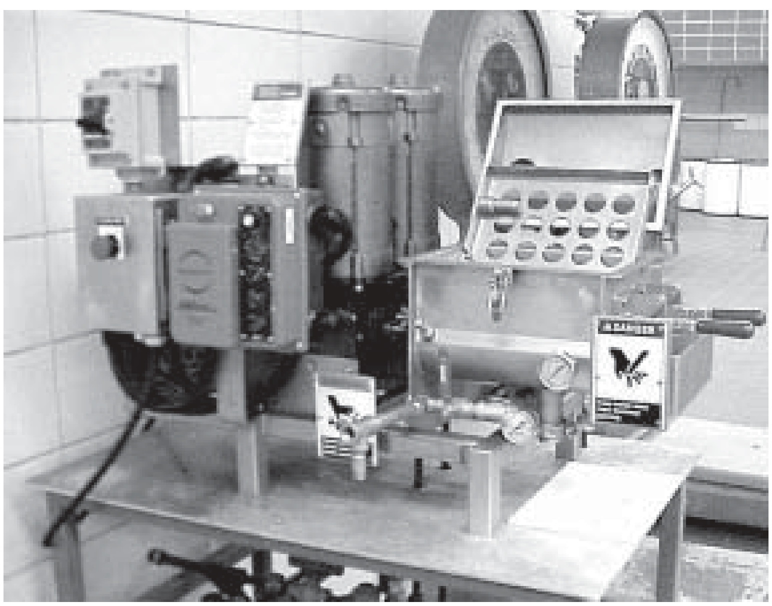


Figure 1.

However, sometimes even a 10 lb batch of process cheese is too large. For example, in one of my current research projects I am attempting to determine how the characteristics of natural cheese influence process cheese quality. In this project, I am preparing model natural cheeses that have specific characteristics (i.e. specific levels of proteolysis and different forms and levels of calcium and phosphorus). It is impossible to produce this model natural cheese on a 10 lb scale. It is possible to go smaller though and as a result I have produced process cheese on a very small scale (25-30 g) using a Rapid Visco Analyzer (RVA). The RVA is shown in Figure 2.

Newport Scientific developed the RVA to rapidly analyze the cooked viscous properties of flour and starch. It uses disposable canisters and stirring paddles and is capable of controlling temperature between 32 and 210°F, stirring speeds between 0 and 1500 rpm, and it continuously measures the apparent viscosity during testing. Using the RVA, I have produced process cheese in 25 g batches equivalent to process cheese produced on a larger scale. A process cheese after manufacture is shown in Figure 3. You do need to be aware that manufacturing process cheese on a small scale presents its own set of problems. For example, you need to take special care to weigh ingredients accurately. Also, since you are producing a minimal amount of process cheese, the amount and types of analyses that you can perform are limited.

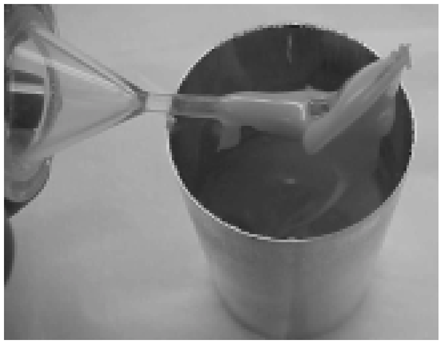


Figure 2.

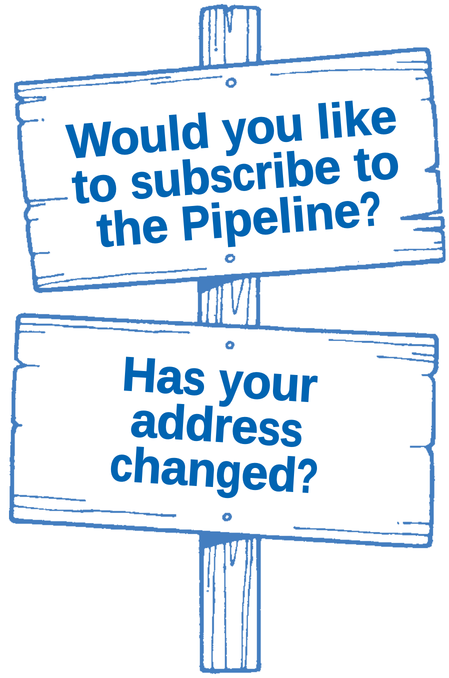
Solving the problem

Often the only way to evaluate a process cheese formulation change is to produce and evaluate process cheese using the new formulation. I hope I have demonstrated that several scales of production are available to evaluate a formulation change. The appropriate production scale you use will depend on several factors, including production costs, time, product disposal, and availability of ingredients and equipment.

Figure 3.

Editors note:

If you are a Wisconsin cheesemaker interested in product testing, CDR has a variety of process cheese cookers available. Contact John Jaeggi at (608) 262-2264 for more information.



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

Calendar

Apr. 23-25 **International Cheese Technology Exposition**, Madison, WI. For information, call Judy Keller at (608) 255-2027.

May 7-8 **Whey and Whey Utilization Short Course**, Madison, WI. Call Bill Wendorff at (608) 263-2015 or K.J. Burrington (608) 265-9297.

May 14-15 **Applied Dairy Chemistry Short Course**, Madison, WI. Call Bill Wendorff at (608) 263-2015.

May 21 **Wisconsin CIP Workshop**, Madison, WI. Call Bill Wendorff at (608) 263-2015.

May 22 **Dairy HACCP Workshop**, Madison, WI. Call Marianne Smukowski at (608) 265-6346.

June 4-5 **Wisconsin Cheese Grading Short Course, Madison**, WI. Call Scott Rankin at (608) 263-2008 or Marianne Smukowski at (608) 265-6346.

June 5 **Controlling Allergens in the Food-Processing Environment**, Madison, WI. Sponsored by WI Assn. of Milk & Food Sanitarians. For further information, call Neil Vassau at (608) 833-6181.

June 15-19 **IFT Annual Meeting**, Anaheim, CA. For information call IFT, (312) 782-8424.

July 22-25 **American Dairy Science Association Annual Meeting**, sponsored by American Dairy Science Assn. Quebec City, Quebec. For more information call ADSA, (217) 356-5146.

Aug. 1-3 **American Cheese Society Annual Meeting**. Washington, DC. For info, call (502) 583-3783.

Aug. 20-22 **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.

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