

DAIRY PIPELINE

Dairy ingredients in cheese making—possibilities and problems

by John Lucey, assistant professor of Food Science, University of Wisconsin—Madison

Adapted from a presentation at the International Cheese Technology Exposition, April 2000

What will the cheese vat of the future hold? Traditionally, here in the US, the main dairy ingredient used to standardize milk for cheesemaking has been non-fat dry milk (NFDM). Now, Codex language implies that dairy-derived materials will be acceptable in cheese—although individual cheese standards may still prohibit the use of some of these ingredients in many types of cheese. If you are wondering which dairy ingredients might be suitable for cheese making then you are not alone.

In Wisconsin, cheese makers are experiencing a protein deficit, currently being satisfied by NFDM produced in other states. If Wisconsin dairy farmers can't produce more protein, cheese makers will continue to need milk protein sources for standardizing their milk.

Dairy derived ingredients can be divided into two main categories, concentrated milks and milk protein powders. Concentrated milks are usually in liquid form; as retentates, or concentrates, from membrane filtration, reverse osmosis, or evaporation. Milk protein powders are dried, and they have widely varying compositions depending on the liquid source and the processing steps involved in their manufacture.

Increasing cheese yield and standardizing milk composition is the most likely reason why the dairy industry is paying more attention to new ingredients. They want more yield because that means more profit. Yield is primarily determined by non-lactose milk solids; fat (90-93 %) and protein (about 75%) recoveries in cheese and the moisture content of cheese. The traditional Van Slyke cheese yield formula predicts a fat recovery of approximately 93%. That may not be true for all cheese operations, because processing steps, type of vat, and other factors can influence fat recovery. Adding an ingredient and changing the cheesemaking process could affect both fat and casein recoveries—which is the main method to change cheese yield.

Low concentration UF

Low concentration UF (concentration factor < 2X) is now used in a large number of companies. This technology is often included in many new plants that are going in around the world, including Cheddar and Mozzarella. The low concentration UF technology is not really an improved profitability issue in the sense of increased yield, it has more to do with processing issues. For example, some plants in Australia, New Zealand and Ireland are bursting at the seams during certain times of the year as they try to process all their seasonal milk supply. Low concentration UF is one way of removing some of the water from the milk before making cheese, allowing them to fill more vats during the day.

Since you must recover more casein or fat, or increase moisture content of cheese to increase yield, there is little or no yield increase associated with low concentration factor UF. However, in some places, low concentration factor UF is encouraged because it can help minimize

continued on page 4

What's Inside:

Dairy ingredients in cheese making—possibilities and problems	1
Controlling cheese flavor during accelerated ripening	2
Troubleshooting the Standard Plate Count (SPC)	6
News from CDR	8
Curd Clinic	9

Controlling cheese flavor during accelerated ripening

Overview and Summary

By R. C. Lindsay, Department of Food Science University of Wisconsin—Madison
Adapted from a presentation the International Cheese Technology Exposition, April 2000

Enzymic proteolytic and peptidolytic reactions are two of the biochemical & chemical processes occurring during cheese ripening that lead to characteristic mature body & texture. These same reactions also contribute to cheese functionality in processed foods—including melt and viscosity.

Proteolysis, or the breakdown of proteins into peptides and amino acids, is the “rate-limiting step” in cheese ripening or maturation—the step necessary for developing mature cheese properties. Although cheese flavor development “generally” parallels proteolysis & maturing cheese texture, we do have an adequate supply of amino acids for most flavor systems. Thus, primary proteolysis is not rate-limiting for cheese flavor development.

Protein-derived flavors

The amino acids derived from protein breakdown are precursors that are absolutely key to cheese flavor. But when you go to look at the actual products of proteolysis, you have a hard time finding any that are highly influential. They are necessary for background flavor, but they don’t allow us to distinguish varietal notes.

Primary proteolysis/peptidolysis influence background brothy flavors, perhaps via peptides and glutamic acid (or MSG). The sweet background flavors are influenced by the amino acids, including proline. Hydrophobic peptides are the source of bitter flavors.

Secondary protein-derived cheese flavors arise from the products of proteolysis, and then are further modified by microbial metabolism. For example, methional converted from methionine. Another route is partial microbial metabolism, or biochemical conversions, of amino acids, seen in the conversion of phenylalanine to phenethylamine, and 2-methylbutyric acid from isoleucine.

Milkfat-derived flavors

Primary lipolysis flavors, mediated by lipase, include the basic background cheesiness flavors influenced by collective short-chain fatty acids unique to milkfat. Another example is the distinct Italian-type flavors that are also produced from short-chain fatty acids, especially butyric acid.

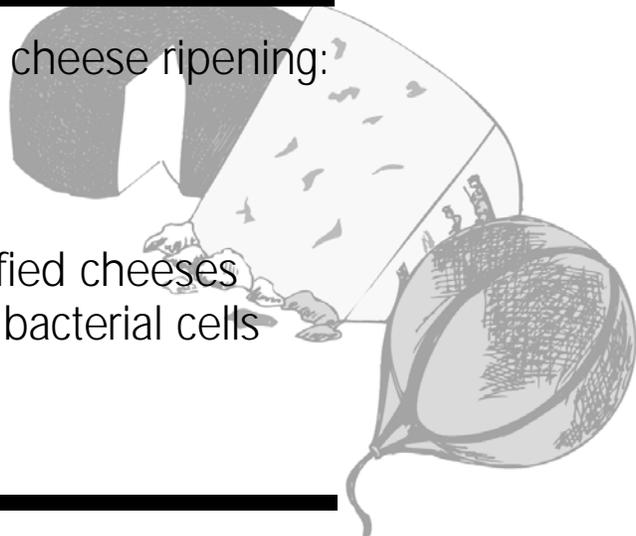
Microbial partial metabolism of fatty acids—methyl ketones are a good example—influence secondary milkfat-derived flavors. The hydrolysis of minor fatty acid precursors, for example, hydroxy-fatty acids that directly form lactones, are another secondary source of milkfat-derived flavors.

Microbial metabolism-derived flavors

Flavors directly linked to microbial metabolic products include succinic acid, which produces a brothy tone, and diacetyl, the source of dairy culture notes. Other reactions that influence flavor depend on microbial metabolism. Ethanol, esterified with free fatty acids to yield esters is one. Other reactions that we’ve focused include the mix of α -

Summary of methods to accelerate cheese ripening:

1. Elevated temperature ripening
2. Exogenous enzyme addition
3. Cheese slurries & enzyme-modified cheeses
4. Chemically/physically modified bacterial cells
5. Genetically modified starters
6. Adjunct cultures



dicarbonyls with amino acids to yield corresponding flavors, like methional from glyoxal and methionine.

Flavors from forages and grains

Alkylphenols, from forages and grains, contribute basic dairy, milky, feed-related flavors. In addition, European researchers have noted other plant metabolites (perhaps terpenes) that are associated with regional cheese flavors

Raising the temperature

Elevated temperatures for accelerated ripening are widely used, reasonably effective, and technically simple. This approach adds little cost, poses no legal barriers and you can combine it with other methods. On the down side, although the growth of nonstarter lactics (NSLAB) are accelerated the population balance changes. The result—intensified flavors but non-specific rate effects that easily lead to flavors that aren't balanced.

Proteolytic enzymes

Several microbial proteases have been commercialized for accelerating ripening. You may find it difficult to control uniform incorporation, which can produce defects in the cheese. Also, there is a limited choice of enzymes and legal barriers are an issue. Although the costs are relatively low, the results versus claims have been variable.

Lipase enzymes

Sources of lipase enzymes include rennet pastes, pregastric esterases, and some microbial lipases. These enzymes have been added successfully to strongly fatty acid-flavored cheeses, primarily Italian & blue-types. Variable results have been seen in Cheddar applications; it is difficult to control the reactions and rancid flavors can develop. However, lipases can provide generic cheesiness flavor.

Cheese slurries and enzyme-modified cheese ingredients

Cheese curd is mixed with proteinases, peptidases, lipases, and bacterial cultures, and then incubated for short periods. Although you often get intense, but unbalanced, flavors they are still useful ingredients in processed foods like crackers and sauces. There is a risk of microbial spoilage.

Chemically/physically modified bacterial cells

Attenuated or weakened starter cultures have been used to deliver more enzyme activity. Acid production is destroyed, leaving other cell enzymes active. Or lysozyme-treated cells that lyse, or break up in salted curd deliver the same effect. Heat- or freeze-shocked cells can also be used. Using modified cells is rather expensive for the limited effects produced.

Genetically modified starters

Starter strain selection for various ripening benefits is regularly practiced. Lactose-negative (Lac⁻) lactococci are also used because these cells possess protease/peptidase activity for ripening but do not interfere with acid production. The costs vary depending on the specific application, but this approach is reasonably beneficial overall.

Genetically engineered starters

Conceptually, this may be the most powerful approach to controlled accelerated cheese ripening and flavor development. However, the technology has had a slow start because we don't know which genes in an enzyme system to enhance or insert. Right now, the costs are still high and legal and consumer barriers loom.

Adjunct cultures

Practically, this is the most promising area for improving accelerated cheese ripening in the near future. It is possible to select combinations of nonstarter lactic acid bacteria (NSLAB) to carry out the complex sequential cheese flavor producing mechanisms. Lactobacilli associated with ripening of cheese show good genetic diversity for desirable flavor reactions and trials have produced encouraging results for accelerating specific cheese flavors.

Other approaches

Secondary adjunct cultures, including the use of *Brevibacterium*, *Propionibacterium*, and others, can add specific flavor notes to cheeses. However, when these cultures are introduced into cheeses, results have in general, been mixed. Adding free amino acids to curd as a shortcut to flavor producing mechanisms seems like a promising concept, but the results are not striking.

Looking to the future

In the near future, we should see distinct advances in combination-strain NSLAB (& other) adjunct culturing techniques. Look to the extended future for genetic engineering of both starter and non-starter adjunct cultures to offer a high degree of selectivity and control for a wide range of cheese flavors. Continued research on the details of flavor chemistry and flavor-producing mechanisms of cheeses will be needed to enhance and understand culture developments. ☺

seasonal variations in milk protein content, which, in turn, can help standardize rennet coagulation time, gel strength, and cheese yield. Most studies have found it has little or no impact on cheese quality.

There are various ways to use low concentration factor UF. You can concentrate the whole milk or skim milk up to the total solids content you want (either hot or cold); you can make a very high concentrated UF retentate and use it for standardizing and you can pasteurize prior to UF or possibly after UF. (You cannot currently use raw milk for “hot UF”). Legal issues related to using UF are currently awaiting clarification.

High concentration UF

High concentration UF has been around for quite some time, it is very common technology for the soft and fresh cheese varieties, for example it's been successfully used for UF cast Feta cheese in Denmark. The APV Sirocurd process was a major Australian effort to use high concentration UF milk to make Cheddar cheese. The whole venture probably cost around \$10 million (Australian) dollars, only to be shelved later. There were a lot problems going to that high factor concentration, including problems with quality and a lack of knowledge about how these retentates modify cheesemaking operations, such as syneresis. It's also difficult to get to the right texture for Cheddar cheese when there is such a drastic modification of the cheesemaking operation.

These high concentration retentates have a very fast coagulation ability, so people have tried to heat treat the retentates, which slows down coagulation. But, if you introduce a major heating step into your cheesemaking process, you are adding another factor that can change your process. For example, denatured whey protein in your cheese could decrease melting quite severely. If you heat treat enough, you might produce a no-melt cheese. There are also adverse influences on ripening and flavor development.

High concentration factor UF has been successfully used for a wide range of soft or semisoft cheeses. In some of these varieties, you can alter the make procedure to reduce high buffering, by preacidifying or using diafiltration. Cheese equipment manufacturers have devised several types of specialized coagulation equipment that might be necessary when using these retentates.

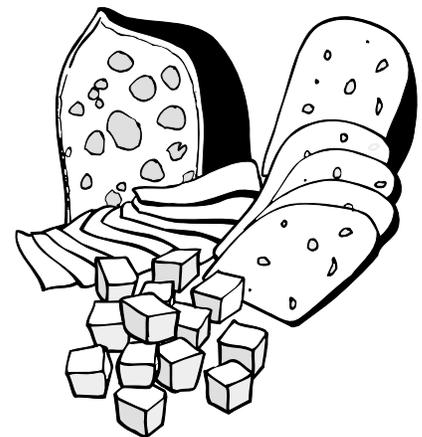
Efforts have been made to restore some of the functional properties of the final cheese produced from these high concentration factor UF products. For example, quite a bit of work has been done on Mozzarella to improve the melt. Danish workers have shown that adding enzymes can improve the melt but create flavor problems. Native whey proteins are soluble and lost in the whey. If whey proteins are denatured, particularly by heat treatment, there are some negative side effects. Denatured whey proteins inhibit rennet coagulation of the milk, and they inhibit curd fusion, which results in changes to the cheese texture. This is related to casein-whey protein interactions at cheese pH values. You may also alter ripening if you have a large amount denatured whey proteins in your cheese. This appears to be related to inhibiting rennet activity. Perhaps high concentration factor UF should be used for making “new” cheese varieties instead of traditional cheeses.

Microfiltration (MF)

Microfiltration (MF) is a relatively newer filtration procedure, but it is becoming more common. During microfiltration, large molecules such as casein micelles are

Possible sources of dairy derived ingredients

- F Whey proteins (native or chemically/physically modified)
- F Caseins
- F Caseinates (calcium caseinate and sodium caseinate)
- F Milk protein concentrates (MPC)
- F UF retentates (low, medium, and high)
- F MF retentates
- F RO concentrates
- F Other possible dairy derived ingredients include enzyme modified caseins or whey proteins; exopolysaccharides (produced by bacteria from lactose) and buttermilk powder.



retained by the membrane. Although skim milk is mainly filtered, if fat globules are present they will also be retained. Whey proteins and lactose are small molecules and they pass through. Thus, MF selectively concentrates casein and reduces the proportion of whey proteins. MF offers the possibility of separating casein and whey proteins, which might be desirable in some applications. In Europe, MF is used as an alternative to bactofugation (removing bacteria and especially spores) in some cheeses that are sensitive to defects caused by spores (eg. Swiss). In that process, bacteria are also retained and are given a high (UHT) heat treatment. As with UF retentates, there can be textural changes in cheese made from a cheesemilk that has a high casein content; probably greater demineralization of calcium is necessary to achieve a good texture.

Reverse osmosis

Reverse osmosis derived concentrates are not widely used for cheesemaking because lactose is concentrated and the osmosis plant is expensive. If whole milk is used, there may be damage to the fat globules during this processing. RO is used for whey processing.

Condensed milk can be produced by evaporation and is used as a standardizing material in several cheese varieties. The relatively mild heating process, coupled with reduced atmospheric pressure, in the evaporation of milk means that this material is highly soluble (unlike some milk protein powders). It contains few denatured whey proteins and, unlike retentates, no lactose is removed. This is a disadvantage since too much lactose in the final cheese can result in excessive acidity.

The possibility of incorporating whey proteins in cheese raises the question: Can whey proteins be modified to get them to act more like caseins? Yes, it is possible with some cheeses and in some instances to do that. It depends on the cheese—whether you need melt or flavor, and how long you age it. Codex language requires that the amount of whey protein in cheese not exceed the original ratio in milk.

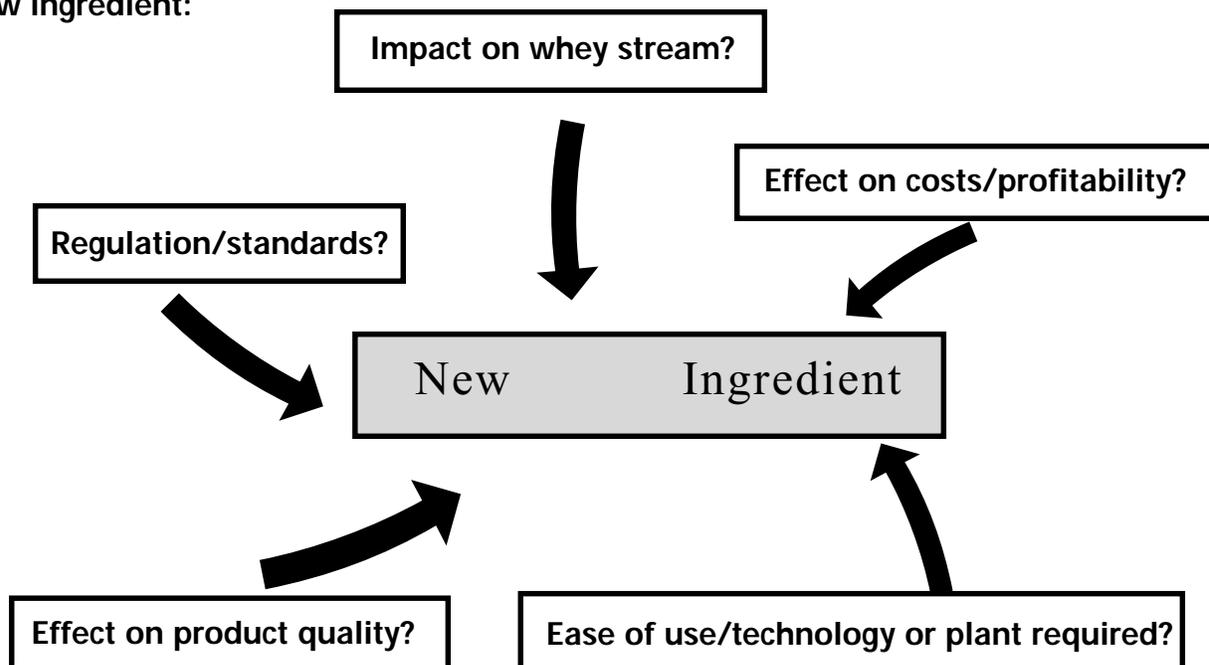
Milk protein powders

There are many milk protein powders on the market, but some may not be very suitable cheese as ingredients. There is an impression here in the US that, if the rules were relaxed, every cheese would have rennet casein, casein or caseinates added to it. That is not likely to happen. If you look at examples from other countries, such as New Zealand and Ireland where most of these powders are exported from, the market rules as far as whether the flavor is acceptable or not. So cheese makers should be more concerned about any modification to their process that might adversely influence either the texture or the flavor. Most likely it will end up that many of these ingredients are not going to be suitable or cost effective.

For example, rennet casein is widely used to make analog, or imitation, cheese. However, it's not very water soluble and there can be taste problems, depending on the source of the rennet casein. It is used in place of Mozzarella, for pizza, but its market share does not seem to be increasing. It may be viewed as inferior to “natural” cheese by some consumers, and marketing efforts to boost “real” cheese probably decreases the use of analog cheese.

next page

Cheese makers could ask themselves some questions when thinking about a new ingredient:



Troubleshooting the Standard Plate Count (SPC)

By Nigel B. Cook MRCVS

Clinical Assistant Professor in Food Animal Production Medicine, School of Veterinary Medicine

Every cheese maker knows that excellent cheese starts with excellent milk. Of course, clean milk means few bacteria, and the cleaner the milk, the higher the quality. Since quality milk is such a priority for cheesemaking, it's worth the effort to review a common tool for measuring the number of bacteria in milk—the Standard Plate Count.

Performing a standard plate count is relatively simple, technicians pour a measured milk sample onto a micro plate, incubate it and let it grow. Then they count the bacteria. A high bacteria count, for Grade A milk, is anything over 100,000 per ml of raw milk, which indicates that it's time for some detective work. You need to find the source of these bacteria.

Sources of contamination

There are three main sources of bacterial contamination. The obvious one is the udder. *Streptococcus agalactiae* and

Streptococcus uberis are the main culprits, since these bacteria are released in large numbers from infected quarters; 100,000,000 organisms per ml of milk at peak infection !

The teat skin can harbor two distinct groups of organisms. One group includes organisms that live on the teat skin, such as the coagulase negative Staphylococci and some Streptococci. The second group includes organisms that are on the teat skin because the environment is excessively dirty. Common culprits are coliform bacteria and the environmental Streptococci such as *S. uberis*.

Temperature resistant bacteria, including some species of *Pseudomonas*, can live in biofilms in the milking machine if cleaning is not effective. As milk passes through the pipes, these bacteria will contribute to the bulk tank bacterial load. In addition, very high numbers of bacteria will appear in the tank if refrigeration is slow or ineffective.

next page

Dairy ingredients, continued from page 5

Acid casein is another widely used food ingredient, particularly in countries such as New Zealand and Ireland. It's not very water soluble. Although it has some application in food products, such as a fortifying agent, it can also have many taste problems, depending on the type of acid used to make the acid casein.

Caseins are more soluble in the form of caseinates, including sodium caseinate and calcium caseinate. Because of their functionality, caseinates are widely used as a food ingredients, for emulsification, gelation, and in coffee whiteners. Although they are common in the food industry, you don't often find them in the cheese industry, except in some processed cheese spreads and possibly in starter culture media (where many ingredients are used!).

Milk protein concentrates (MPC) can be made in several different ways. Processing steps include concentrating skim milk by UF, diafiltration, and evaporation before spray drying. So it's really a high protein delactosed powder. Countries that make these products also make them with various levels of whey protein denaturation, i.e., during processing they can have a heat treatment step.

Countries like New Zealand and Ireland sell MPC mainly for cheese milk extension. MPC is widely used in some parts of

the world, such as Latin America, for fresh recombined types of cheeses. The water solubility of milk protein concentrate products is usually acceptable, except at high protein levels. In contrast to caseins and caseinates, the casein protein in MPC has not been precipitated.

Whey protein concentrates (WPC) and whey protein isolates (WPI) are unlikely to find uses in most natural cheese varieties since native whey proteins are soluble and would be lost in the whey during draining. In cheese varieties where the cheese milk is subjected to a high heat treatment, e.g. Quarg, then the denatured whey proteins become associated with casein and are retained in cheese. This often results in a smoother texture for these fresh, acid-type cheeses, although high levels of denatured whey proteins can cause other defects—such as graininess. WPC is widely used in yogurt manufacture to improve texture and water holding capacity since the milk is subjected to a high heat treatment in that process. You'll find WPC in pasteurized process cheese foods and spreads, too.

Remember that there is technology associated with some of these ingredients and processing techniques. Sometimes it's just solubilizing your dry ingredient, or using a membrane system. Very rarely can you just add a new ingredient straight into your vat without giving some thought to technology or even a processing plant associated with it. 

Coliform Count

	Low	High
L P C	Low	Teat Hygiene / Environment
	High	Teat Hygiene / Machine Hygiene / Incubation

How would you know if the bulk tank is your problem? You can culture a milk sample from the bulk tank to localize the source of the problem if your farm has high plate counts.

Localizing a SPC problem

The differential count of bacteria in the bulk tank can be used to indicate the likely source. High numbers of *Streptococcus agalactiae* will be coming from infected cows. A high environmental Streptococci and coliform count will suggest contaminated environment and manure covered teats. Large numbers of CNS bacteria will indicate poor teat preparation and dip coverage.

Two further tests will help differentiate the source of bacteria from the machine or the environment, the coliform count and a laboratory pasteurized count (LPC). Both tests take 48 hours to complete.

The coliform count is performed on a specialized media, such as violet red bile agar. High counts indicate an excessive amount of fecal contamination entering the milk from the teat skin. Note that clinical coliform mastitis does not usually contribute to the count.

The LPC is simply a plate count performed on milk which has been pasteurized at 145 °F for 30 minutes. This process will kill bacteria which live in the udder and leave only the thermotolerant—the bacteria which live at high temperatures and resist plant cleaning. The LPC count usually reflects machine hygiene and cleaning efficiency. Occasionally soil and silage contamination will also raise the LPC.

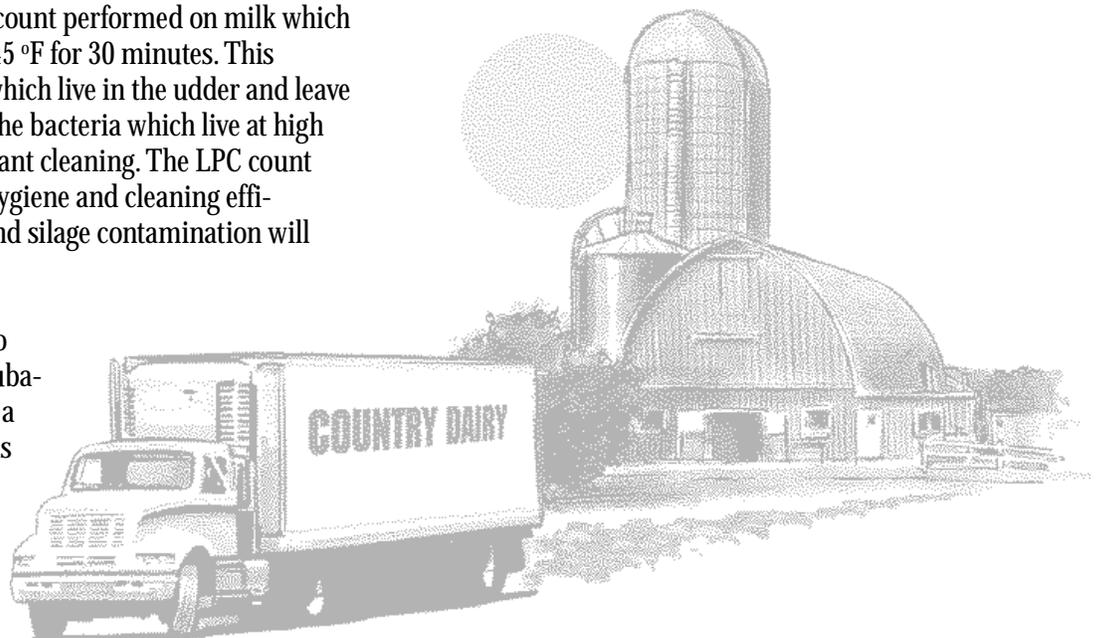
Some laboratories will also include a Preliminary Incubation Count (PIC), which is a plate count of milk that has been incubated at 55 °F for 18 hours. This process will promote the growth of the cold adapted

psychrotrophic bacteria and research indicates that this count correlates well with milk keeping characteristics. It is of little use in localizing problems on farm, but counts will be raised where incubation of milk occurs due to faulty cooling.

Localizing the source

A 2X2 table of Coliform count and LPC can be used to help localize the source of the high SPC. When both counts are moderately high, your main problem is usually poor teat hygiene. When both counts are extremely high, incubation must be suspected—indicating a faulty cooling process. A high coliform count with a low LPC will direct attention to cow environment and teat hygiene, whereas a low coliform count and a high LPC makes an investigation of machine cleaning a priority.

Bulk tank culture tests can be used to help solve SPC problems and they can also be used on a regular basis to monitor farm hygiene practices, so that problems can be rapidly identified and prevented. 



News from CDR...

It's official now...

Jim Path, CDR's cheese ambassador has been traveling again. The Foire Nationale Aux Fromages, a French cheese fair, drew him to Tours, France at the end of May. At the fair, Jim participated in the cheese judging—primarily judging soft goat cheeses. One of them, Valençay, was originally made in the shape of a pyramid. According to legend, Napoleon stopped at the castle in Valençay after returning from an unsuccessful campaign in Egypt. The shape of this cheese reminded Napoleon of the Egyptian pyramids, prompting him to chop off the top with his sword. Valençay retains its flat-topped pyramid shape to this day.

While in France, Jim was also interviewed by a French television film crew and perused the Tours cheese market. Although he doesn't speak the language, Jim notes that the French fair reminded him of home because "it was very rural, a lot like the La Crosse county fair that I went to as a child."

After a full day at the fair, Jim attended the awards banquet, where he assumed that the cheese makers would receive recognition for their cheeses. Jim was in the middle of taking photos of the ceremony, fingers on the camera and shutter seconds from clicking when he heard his name called. Minutes later he was on the stage, enrobed in a long scarlet cloak to join the Commanderie des Fromages de Sainte-Maure de Touraine.

Sainte-Maure de Touraine is an A. O. C. (Appellation d'origine contrôlée) goat cheese, which means its manufacture and area of production are defined in detail. And, now, by becoming a Commanderie des Fromages de Sainte-Maure de Touraine, Jim is an official "ambassador" for this particular cheese. 

Jim notes that the French fair reminded him of home because "it was very rural, a lot like the La Crosse county fair that I went to as a child."



Mixed-milk cheese seminar

Although cow's milk cheeses dominate the market here in the United States, you can find cheese made from sheep, goat, buffalo and even yak milk in other parts of the world. In some cases, milk is blended to generate unique flavors. If you are interested in blended milk cheeses, consider attending the next artisan seminar, "Mixed Milk Cheeses—Focus on Spain" This seminar, scheduled for Sept. 26-27 and jointly sponsored by CDR and the Food Science Department will cover milk composition, flavor, vegetable coagulants and manufacture of mixed milk cheese. Contact Jim Path (608/262-2253) or Bill Wendorff (608/263-2015) for information and CALS Outreach Services (608/263-1672) for registration. 

Curd Clinic

Q. My goal is to produce high quality cheese that is consistent from vat to vat. I know that consistent fat in the dry matter (FDM) is the solution, but how do I standardize milk composition to get there?

A. This is a complex issue because you need to focus on details, without losing sight of the “big picture.” That is, you need to consider cheese composition in more specific terms while paying attention to other factors, too. While it is important to control FDM, you also need to control moisture, salt, casein content of the dry matter and pH. Casein content of cheese is a major factor governing the physical properties of cheese. Moisture, fat and whey proteins act to separate casein aggregates in cheese and they also play a role in determining body and texture. Salt affects flavor and the perception of certain flavor components, as well as the growth of microorganisms. The pH has a profound effect on both flavor and physical properties of cheese through its influence on the hydration and arrangement of the casein molecules. In addition, cheese pH plays a role in the activity of enzymes and metabolism of microorganisms. It is the combined effects of composition, pH, enzyme activity, and microbial metabolism (both starter and contaminants) that govern flavor, body, texture and physical properties of cheese—including shred, slice and melt characteristics.

Producing the “same” cheese

Since your goal is to produce the “same” cheese each time you make this cheese, it is important that you consider two basic principles. You need to start with milk of consistent quality and composition and employ a consistent manufacturing regimen. Consistent milk quality means that the somatic cell count and microbiological load (preferably low) don't vary, and your milk supply has a steady composition; specifically the fat, casein and total solids content. The rate and extent of acid development, and your specific manufacturing protocols and times for cutting, heating and stirring the curd must also be consistent. It is easy to follow the same manufacturing protocols, but more difficult to produce the

Curd Clinic doctor is Mark Johnson, Wisconsin Center for Dairy Research

same cheese composition particularly if the milk composition varies or if the rate of acid development by the starter varies. Likewise, it is harder to control the pH of the cheese if the composition of the cheese or the activity of the starter varies. To produce consistent quality cheese, composition and pH must remain the same from one vat to the next.

Because milk composition delivered to your plant will vary, especially from season to season, it is prudent to adjust milk composition to a standard composition. That is, the milk should be standardized to have the same casein, fat and total solids content. Although it isn't feasible to standardize milk composition to all milk components, you should at least standardize, using the same method, to a consistent casein/fat ratio and total solids content. It is a must for certain cheeses, like Parmesan, part skim Mozzarella, and reduced fat varieties. However, manufacturers of full fat cheeses are also using milk standardization as a quality control measure. In addition, some cheese makers will standardize not only to a constant casein to fat ratio, but also to total casein, fat, lactose. Sometimes they also standardize to whey protein content (often introduced as a denatured whey protein through the starter media). This helps control the contribution of non-fat, non-casein solids to the dry matter of the cheese and thus helps to regulate pH. If the milk composition is standardized with the same ingredients (same composition also) and to the same composition you will produce a more consistent product. Standardizing both milk composition and the manufacturing process allows tighter control of yield (when necessary), composition (moisture, fat, casein and other solids) and pH. Then, you can control the physical attributes of cheese (body, texture, melt, color, shred etc.).

Milk standardization

First, you need to know the desired fat in the dry matter (FDM) of the cheese. This will establish the casein/fat ratio you need in the milk to produce the desired FDM in your cheese. To accomplish this, you'll need a yield equation that correctly describes the yield potential of your milk. This can be the most difficult part of the process, unless you have already established the equation with the cheese you want to make. We can use the Van Slyke cheese yield formula to standardize milk to a desired casein/fat (C/F) ratio. Although yield equations tell us how much cheese we can make, the most important feature of cheese yield equations is that they can tell us the composition of the cheese we want to make.

The Van Slyke cheese yield formula and the standardization process

The Van Slyke equation for predicting cheese yield is given below. If we rearrange the equation, you can also use it to predict FDM. Three factors are included in the equation and these numbers may be different for each cheese and each cheese maker. Table 1 lists these factors for a variety of cheeses. These numbers were calculated from yield experiments that we conducted at the Center over the last 20 years. You will also notice that there are a number of ways to calculate RF (retention value of fat) and

RS (retention value of solids). The method you choose will depend on the information available. You can even calculate a yield equation from milk and cheese compositional data without knowing the cheese yield.

Some of the biggest challenges you'll encounter when developing yield equations are obtaining accurate analytical data and collecting a representative cheese sample (especially for moisture). However, it is not an insurmountable problem to estimate the C/F ratio of the milk needed to produce the desired cheese. This is because you are developing a FDM equation and the FDM of a cheese does not vary much within a block of cheese, even if the cheese moisture does. We use both the Van Slyke and the FDM equations as a way to cross check the accuracy of the analytical data. The factors used in the yield equation are the same ones used in the FDM equation. Both of them must accurately predict the yield and FDM obtained experimentally before we are satisfied that the factors are correct. You will notice that both equations contain % fat in milk and % casein in milk—this means that you know the C/F ratio.

Predicting Fat in Dry Matter from the cheese yield formula

If the FDM equation does not accurately predict the actual FDM, something is wrong. It indicates that either the retention values or the milk composition values are not correct. Also, if the retention values are not correct, the

predicted yield will be wrong. In practice, the casein retention value is kept constant. Most errors result from an overestimation of fat recovery or an error measuring the amount of casein in the milk. Let's use reduced fat Mozzarella as an example. Using the factors in Table 1 for reduced fat Cheddar cheese with a desired FDM of .30, the calculation of the C/F of the milk needed is as follows. Since we are only interested in the C/F ratio, the actual amount of C or F is not needed. For ease of calculation put the value of 1 in for % milk fat and solve for % casein. When you do this, the % casein is the C/F ratio since % fat in milk is 1.

$$\text{FDM} = \frac{\text{Total fat retained in cheese}}{\text{Total solids in cheese}}$$

$$\text{RF (\% fat in milk)}$$

$$[\text{RF (\% fat in milk)} + \text{RC (\% casein in milk)}] \text{RS}$$

$$.30 = \frac{.88 (1)}{[.88 (1) + .96 (\% \text{ casein in milk})] \times 1.15}$$

% casein and C/F ratio is 1.74

If you know the milk composition from a vat of milk that produced the desired cheese composition (FDM) then you already know the C/F ratio. All you need to do is duplicate that milk consistently. You must decide how you want to standardize the milk, either by adding casein in the form of NFDM or condensed milk or removing cream.

Table 1. Factors used in the Van Slyke cheese yield equation

	RF	RS	RC	FDM	%H ₂ O
Cheddar	.92	1.09	.96	.52	37
Reduced fat Cheddar	.88	1.15	.96	.30	48
Reduced fat Mozzarella	.82	1.18	.96	.15	55
Havarti	.92	1.12	.96	.60	37
Swiss	.89	1.13	.96	.48	37

Table 1 lists some RF, RS values calculated for different cheese that we have made in our pilot plant. We always use .96 for casein conversion but that number is probably a little too high. If you do not know the milk composition, but do know the FDM desired, then you can use "ball park" retention values and calculate C/F.

Defining the terms

Van Slyke Yield Equation: % cheese yield =

$$\frac{[\text{RF} \times \% \text{ fat in milk} + \text{RC} \times \% \text{ casein in milk}] \times \text{RS}}{\% \text{ solids in the cheese}/100}$$

$$\text{RF} = \frac{\% \text{ fat in cheese} \times \text{total cheese yield}}{\% \text{ fat in milk} \times \text{total milk weight}}$$

RC is used as a constant = .96. Because of the loss of fines, RC is actually slightly lower than .96 but the RS factor corrects for that discrepancy. RC =

$$\frac{\% \text{ recovery of casein in cheese}}{100}$$

RS = Recovery of other milk solids and salt.

= RF (% fat in milk)

$$[RF (\% \text{ fat in milk}) + RC (\% \text{ casein in milk})] \times FDM$$

or
$$\frac{\% \text{ solids in cheese} - \% \text{ fat in cheese} - \% \text{ casein in cheese}}{\% \text{ fat in cheese} + \% \text{ casein in cheese}}$$

Other solids in the cheese include non-casein proteins, non-protein nitrogenous material, minerals, citric acid, salt, lactose (galactose) and lactic acid. If RS is calculated in this manner you can then use it to calculate RF using the FDM equation with the known milk composition and cheese FDM. For a crude estimation of casein in cheese:

$$\% \text{ casein in cheese} = \frac{\% \text{ nitrogen in cheese} \times 6.31 \times .99}{}$$

Example #1: Using Condensed Skimmed Milk (Rehydrated NFDM) to Standardize

The following calculations are used for any standardizing agent that adds casein to the milk, they are based on standardizing 100 pounds of milk, as received at the plant.

Condensed skimmed milk composition: 30 % total solids, 8.50 % casein, .23 % fat.

Whole milk composition: 13 % total solids, 4.32 % fat, 2.85 % casein

Desired FDM: .30 Required C/F = 1.74

C/F = 1.74

= casein in whole milk + casein in condensed milk needed
fat in whole milk + fat in condensed milk

X = amt of casein needed,

then $\frac{X}{.085}$ = amt of condensed milk to add

$$1.74 = \frac{2.85 + X}{4.32 + \frac{.0023 X}{.085}} \quad X = 4.90$$

$X = 57.65$ pounds of condensed milk to add

Of course, if the solids in the vat are too high after adding condensed milk, you should add water to produce the desired level of total solids in the standardized milk.

Adding water will not change the C/F ratio.

$$\% \text{ casein in standardized milk} = \frac{2.85 + .085 (57.65)}{100 + 57.14 + 57.65} = 3.61$$

$$\% \text{ fat in standardized milk} = \frac{4.32 + .0023 (57.65)}{100 + 57.14 + 57.65} = 2.07$$

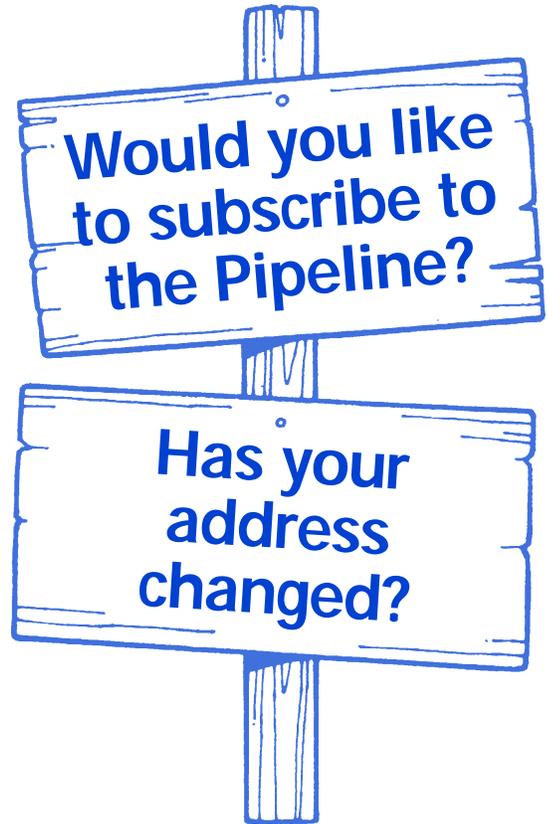
$$\% \text{ Total solids} = \frac{100 (.13) + .30 (57.65)}{214.79} = 19.22$$

To obtain 14 % total solids add 57.14 pounds water

$$\frac{214.79 (.1922)}{157.65 + \text{water needed}} = .14$$

157.65 + water needed

You can now calculate potential cheese yield from the new milk composition and determine the cost and benefits of standardization.



Please help us keep our mailing list current! Simply phone, fax or e-mail the information requested below to:

The Dairy Pipeline
Center for Dairy Research
1605 Linden Dr.
Madison, WI 53706
phone: 608/262-8015
fax: 608/262-1578

Name _____

Company _____

Street Address _____

City _____

State _____

Zip _____

Country _____

ADD

REMOVE

Calendar

Aug. 21-24 Milk Pasteurization and Process Control School. Madison, WI. Call Bob Bradley at (608) 263-2007 for information, or the CALS Conference Office (608) 263-1672 to register.

Sept. 26-27 Mixed Milk Cheeses-Focus on Spain. Madison, WI. Call Jim Path (608) 262-2253 for more details.

Sept. 27-28 Dairy, Food and Environmental Health Symposium. cosponsored by Wisconsin Association of Milk and Food Sanitarians, WI Association of Dairy Plant Field Reps, and WI Environmental Health Assn., Green Bay, WI. For more information, call Bill Wendorff at (608) 263-2015.

Oct. 11-12 North Central Cheese Industries Assn. Annual Convention. Brookings, SD. For information, call Dr. David Henning at (605) 688-5477.

Oct. 16-20 Wisconsin Cheese Technology Short Course. Madison, WI. Call Bill Wendorff at (608) 263-2015.

Nov. 7-8 Wisconsin Cheese Grading Short Course. Madison, WI. Call Bill Wendorff at (608) 263-2015.



The Dairy Pipeline
Center for Dairy Research
1605 Linden Dr.
Madison, WI 53706
phone: 608/262-5970
fax: 608/262-1578

Karen Paulus, Editor

Technical Reviewers:
Mark Johnson, CDR
Norm Olson, Dept. of Food Science
Jim Path, CDR
Marianne Smukowski, CDR
Tom Szalkucki, CDR
Karen Smith, CDR
Bill Wendorff, Dept. of Food Science

The *Dairy Pipeline* is published by the Center for Dairy Research and funded by the Wisconsin Milk Marketing Board.

To subscribe to the Pipeline simply phone, fax, or e-mail your request to CDR. (Form on page 11) We welcome your questions and comments. Send them to:

Karen Paulus, Editor
e-mail: Paulus@cdr.wisc.edu
phone: 608/262-8015

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



Wisconsin Center for Dairy Research
University of Wisconsin-Madison
1605 Linden Drive
Madison, Wisconsin 53706-1565

Nonprofit Org.
U.S. Postage
PAID
Madison, WI
Permit No. 658

ADDRESS SERVICE REQUESTED