

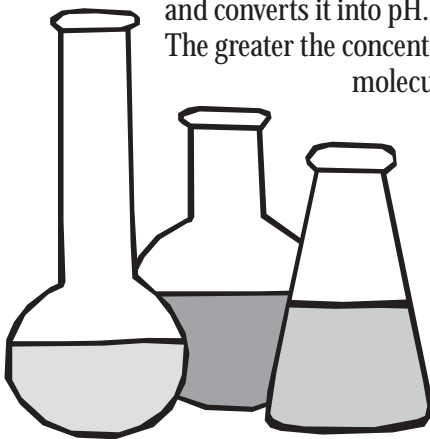
DAIRY PIPELINE

Cheese pH—What’s behind the rise and fall?

By Mark Johnson, Wisconsin Center for Dairy Research

What is pH? This measurement is rather complicated and if you want to understand it you need to understand water chemistry first. Most people recognize the familiar symbol, H₂O, as the chemical formula for water, but we need to delve a bit further to grasp the concept of pH. Since the oxygen atom has such a strong affinity for hydrogen atoms, water molecules usually exist as H₂O. However, in pure water a very, very small but finite number of water molecules dissociate or ionize. That is, a hydrogen ion, or proton, from one water molecule “jumps” to another water molecule. Since the proton is positively charged, one water molecule becomes H₃O⁺ and another becomes OH⁻. In fact, the protons are jumping constantly.

This is fortunate because we take advantage of the activity in order to measure protons. A pH electrode measures proton activity and converts it into pH. It also measures the amount of H₃O⁺. The greater the concentration of hydrogen ions, or H₃O⁺



molecules, the lower the pH. By convention, pH is described in mathematical terms as the negative log of the hydrogen ion concentration i.e. 1.0 x 10⁻⁵ hydrogen ions/liter = pH 5.0. At 25° C and a pH 7.0, there are precisely 1.0 x 10⁻⁷ moles of H₃O⁺ and an equal amount of OH⁻ per liter of water. There are very few ionized water molecules in pure water, it’s

mostly H₂O. At pH 6.0 there are 1.0 x 10⁻⁶ moles/L of H₃O⁺ but only 1.0 x 10⁻⁸ moles of OH⁻. However at pH 8.0 there are 1.0 x 10⁻⁸ moles/L of H₃O⁺ and 1.0 x 10⁻⁶ moles/L of OH⁻.

Temperature increases the ionization of water molecules, consequently the warmer the temperature of the liquid, or the cheese, being measured, the lower the pH. This is why pH meters have temperature compensators or, if you use the quinhydrone method to measure pH, the conversion charts include a temperature adjustment. So what else makes pH drop? Since pure water barely dissociates into H₃O⁺, and OH⁻, in order for the pH to drop we must add hydrogen ions. This is done by adding acid. Acids are chemicals that release hydrogen ions. Bases are chemicals that pick up hydrogen ions. However, all acids are not created equal, their tendency to release hydrogen ions varies greatly. For example, a strong acid, such as hydrochloric acid, or HCl, will rapidly and completely dissociate into H⁺ and Cl⁻ ions in water. Conversely, weak acids, such as lactic, acetic, amino, fatty or phosphoric acids, release hydrogen ions sparingly. They will release hydrogen ions more readily if the water contains fewer hydrogen ions, a high pH, and less readily if the pH is more acid, a low pH. The pH at which these acids release or pick up hydrogen ions also varies with the type of acid. This phenomenon of a weak acid being able to release or pick up hydrogen ions based on pH is called buffering.

Buffers in milk

Strong acids or strong bases are not buffers. The most prevalent and effective buffer in milk and cheese is calcium phosphate via phosphoric

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Lessons in Corporate, or is that Cooperative, Responsibility

by Bob Cropp, Director, UW Center for Cooperatives

The restructuring of cooperatives through bankruptcies, sales or conversions to stock companies, have frequented the headlines of the business media in recent months.

Farmland Industries of Kansas City, Mo., the nation's largest cooperative with interests in farm supplies, grain and meatpacking, filed for bankruptcy protection. Farm supply cooperative Agway of Syracuse, N.Y., did the same. North Farm Cooperative, Wisconsin's oldest wholesale food co-op, which just a few years ago had \$30 million in sales, has closed its doors and filed for bankruptcy.

Members of Minnesota Corn Processors sold their farmer-owned assets to Archer Daniels Midland (ADM). Agrilink Foods, the largest manufacture and marketer of frozen vegetables in the U.S. sold a majority equity investment to Vestar Capital. The investment firm Willis Stein Partners bought Roundy's, a 130-year-old Wisconsin-based wholesale and retail grocery that serves more than 800 supermarkets in 14 states and owns 12 Pick'n Save stores and Copps Food Centers. United Natural Foods, Inc. bought Blooming Prairie Cooperative, the largest volume distributor of natural foods in the Midwest.

The nine-year-old Dakota Growers Pasta Co., often used as an example of a successful new generation cooperative, changed its business structure to a public stock company. Cap Rock Electric Cooperative of Midland, Texas, converted to Cap Rock Energy, a public stock company.

Cooperative model in trouble?

These events have left some people asking whether the cooperative model is in trouble. Members of Congress are even questioning if cooperatives are too big, or lack proper management. The debate centers not just on traditional agricultural cooperatives, but consumer food cooperatives, electric cooperatives, credit unions and even the so-called new generation cooperatives.

While recent events may seem troublesome, they provide no evidence that the cooperative model is failing. To the contrary, there are many very successful cooperatives in business today.

Cooperatives, like any other business structure, experience problems, failures or structural evolutions. Any number of major public stock companies have closed their doors or been purchased by other entities, yet there is little talk that the public stock companies have failed.

There is nothing magical about the cooperative model. No business is guaranteed success. Events of the past year highlight the critical responsibility of boards of directors—at cooperatives or public stock companies—to provide vision and direction, monitor key performance measures, ask hard questions of management, hold management accountable, protect members' equity, and make sure major decisions are made in the best interest of member-shareholders.

In many ways cooperatives are harder to manage than public stock companies. Cooperatives must meet the needs of a diverse group of members, be profitable, and obtain necessary equity capital to maintain and grow the business. This is a real challenge, especially for cooperatives in the commodity business, (known for its tight margins and capital intensity), or businesses with relatively fast changing markets.

In the wake of business failures such as Enron, Congress enacted the Sarbanes-Oxley Act of 2002, a corporate responsibility statute directed at public companies registered with the Securities and Exchange Commission (SEC). Most cooperatives are not subject to this act as few register stock with the SEC. I would suggest, however, that all cooperatives consider the types of business conduct the act mandates.

Audit committee is a must

One example is an audit committee, which SEC requires public stock committees to have. Some cooperatives have an audit committee; many don't. An active and responsible audit committee

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Table 1. Number of dairy cooperatives and market share, 1940-2001

Year	Number of Dairy Cooperatives	Farm-level Share of Farm Marketings (%)
1940-41	2,374	48
1960-61	1,609	61
1980	435	77
2000	213	89

Source: USDA, RB-Cooperative Service



Salt Crystal Size and Salt Retention in Cheddar Cheese

by R.D. Rao and W.L. Wendorff

Though salt is a relatively minor ingredient (~2% w/w), it has a major influence on Cheddar cheese quality. Salt helps to control microbial and enzymatic activity as well as microbial growth, both of which influence the shelf-life of cheese. In addition, salt affects cheese ripening, flavor, and texture. Lactose utilization and lactic acid production by starter bacteria are also affected by the presence of salt (Kaufman and Olson, 1985), which in turn, will affect cheese pH. Salt, via its effect on proteolysis influences both cheese texture and protein solubility. Thus, a low salt content in cheese is often associated with a weak and pasty body whereas high salt levels can cause excessively firm and curdy textures (Fox, 1987). Salt has a role in syneresis of the curd, promoting flow and drainage of the whey from cheese.

Despite the factors listed above, it's possible that salt's greatest contribution to cheese quality comes through its direct impact on cheese flavor (Guinee and Fox, 1987). For example, low levels of salt are highly correlated with a bitter flavor defect in cheese (Guinee and Fox, 1987), one of the most common flavor defects associated with Cheddar cheese.

Traditionally, Cheddar cheese is salted by mixing dry salt crystals with cheese curds after curds have been milled and allowed to mellow. A mellowing period after milling allows whey and fat to exude from the surface, moistening the curd surface and helping to dissolve the salt crystals (Gilbert, 1979). Applying salt in three additions is a common practice used to help increase retention and insure uniform distribution of salt. When salt crystals dissolve on the curd surface they form a brine that diffuses into the aqueous phase of cheese (Gilbert, 1979). This brine toughens the surface of milled curd particles, reducing fusion of curd particles. Salt is usually added at a level of 2.25-3.25% w/w in an

attempt to achieve a final salt content in the range of 1.6-1.9% (Knox, 1978). This translates to a salt-in-moisture (S/M) content of approximately 4.8-5.0%. Salt-in-moisture is considered an important factor in cheese quality (Morris et. al., 1985) and you can calculate it by dividing the percent salt by the percent moisture and multiplying by 100.

Only a percentage of the salt applied to the cheese is retained in the curd and maximizing the efficiency of the process has been of considerable interest to the dairy industry. Not only does increasing salt retention make economical sense, but it also benefits the environment since chloride levels in whey are an issue. Disposing salty whey has been a problem for cheese plants in the past (Wendorff, 1996) and now high salt wastes are restricted in land applications and in discharges to waste treatment systems (Wisconsin Department of Natural Resources, 1990; Wisconsin Department of Natural Resources, 2000; Wendorff, 1993).

Many of these factors that influence salt retention have been investigated previously. For example, Sutherland (1974) reported increases in stirring time and the time between salting and pressing resulted in an increase in salt retention. Increases in salting rate, curd temperature, moisture content of curd, and depth of curd pile after salting all resulted in a decreased level of salt retention. O'Connor (1973) found that increasing the salting

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Cooperative *continued from page 2*

is a must in today's complex cooperative business world. An audit committee guards co-op members' interests, ensuring that fiduciary responsibilities are met. It provides independent checks and balances for the internal audit function and in liaison with external auditors.

The cooperative model is still a very viable business alternative. It is the responsibility of members and boards of directors to keep their cooperative successful into the future. Boards of directors and management must be receptive to new and innovative business approaches. It may mean innovative methods to acquire needed equity capital or build strategic alliances with other cooperatives and public stock companies to gain access to modern technology, value-added products or markets.

Such new approaches can be controversial. Some would argue that cooperatives using such tools are abandoning the cooperative principles. But, as long as the board of directors retains control and accountability of management, and is focused on the purpose of the business—to add value to the farmer-members in terms of products and services—the cooperative model remains solid.

In contrast, it is quite clear from recent events that a cooperative lacking a visionary board of directors and resistant to new ways of doing business is likely on a path of failure. If failure occurs, the farmer-member-shareholders lose.



Salt retention, continued from page 3

rate decreased the proportion of salt retained by the curd. Increases in surface area to volume ratio of curd particles were associated with improved salt retention. NaCl solubility and thus salt retention increased with increasing pH values (Kaufman and Olson, 1985). Other researchers also noted that increasing the time between salting and pressing lead to increased salt retention (Gilles, 1976; Breene et al., 1965; Kaufman and Olson, 1985).

Another factor in the salt retention debate is the particle size or grade of the salt crystal. The classic belief was that larger salt crystals would increase salt retention (Hoecher and Hammer, 1944; Tuckey and Ruehe, 1940). Since these crystals dissolve slower many people believed that more salt would be retained. However, Kaufman and Olson (1985) and O'Connor (1970) reported that higher retention levels could be achieved by using a finer grade of salt. We focused on this contradiction and conducted a study to reinvestigate how salt retention is affected by salt grade, comparing the absorption of four different grades of salt by Cheddar cheese during cheese production.

Cheddar cheese was manufactured according to the traditional method outlined by Bogenrief and Olson (1995). At the time of milling, four 21.8-kg lots of milled, unsalted curd were transferred from the vat to four separate small-scale vats. The vats were warmed prior to transfer to maintain curd temperature at 36.7°C. Each of the vats was then salted at a rate of 3.0% with one of four different salts: Alberger“ Coarse Salt, Alberger“ Special Flake Salt, Alberger“ Flake Salt, or Alberger“ Fine Flake Salt (Cargill Foods Salt Division, Minneapolis, MN). Solubility rate and crystal count per pound of each salt, as determined by the supplier, are reported in Table 1. Salt was applied in three applications over 15 minutes and mixed by

Table 1. Characteristics of salt types in study.

Salt Type	Solubility (minutes)	Crystal Count (per lb.)
Fine Flake	1.0	65,000,000
Special Flake	1.7	19,740,000
Flake	2.1	12,470,000
Coarse	3.6	1,370,000

hand. Salted curd from each vat was then divided in half and hooped into two 9.1-kg Wilson-style hoops. The blocks were then mechanically pressed at 2.1 kg/cm² for four hours and remained in the hoops overnight. The blocks were vacuum packaged and aged for 60 days in a 7°C cooler. This salting procedure was conducted on two separate days of production.

At one week, cheese was sampled by taking four randomly positioned trier plugs from each block of cheese. The plugs for each block were then ground and mixed into a homogeneous mass, constituting a representative sample of each individual block.

Table 2. Moisture and pH of Cheddar cheese produced with varied salt.

Salt Type	% Moisture	pH
Fine Flake	37.42	5.00
Special Flake	37.64	4.97
Flake	37.49	4.98
Coarse	37.55	5.00

Table 3. Mean salt content and retention of salt in Cheddar cheeses.

Salt Type	% Salt-in-Moisture	% Salt Retention (w/w)
Fine Flake	4.06a	50.84a
Special Flake	3.57b	45.16b
Flake	3.59b	44.82b
Coarse	3.81ab	47.71ab

a,b Means (n=4) within the same column without a common superscript differ (P < 0.05).

Tables 2 and 3 list mean values of pH, % moisture, percent salt-in-moisture and percent salt recovery. When you consider the variables analyzed, the variables in Tables 2 and 3 along with sensory evaluation, percent salt-in-moisture phase was the only factor to show statistically significant differences among mean values. The average percent fat was 33% for the first trial and 32.5% for the second. Subsequently, fat on a dry matter basis was 52.83% on the first trial and 52.02 on the second. Mean values were not significantly different between the types of salt.

The Fine Flake salt displayed the highest salt recovery percentage (50.84%) and percent S/M (4.06%). These values were significantly greater than those of the Special Flake and Flake salt. However, no significant difference was found between percent S/M and percent salt recovery of Coarse salt and all other salt types tested.




Larger crystal size has slower dissolving characteristics. The increased salt retention with the Coarse grade may have occurred because initial syneresis after salt application did not flush off as much of the large salt crystals from the curd surface when compared to the smaller crystals of Special Flake and Flake (Gilbert, 1979). The Fine Flake, however, may have been able to dissolve fast enough to diffuse into the curd before being washed off by the expelled whey. Percent salt-in-moisture values fell short of the optimum level of 4.8-5.0% S/M for desired Cheddar cheese quality (Knox, 1978). However, percent salt retention levels were within the expected range for cheese salted at 3.0% (w/w) (Gilbert, 1979).

Kaufman and Olson (1985) compiled a study combining the effects of salting type, salting time (salt to hoop), and salting rate on salt retention in Cheddar cheese. Salt retention was found to decrease with increasing salting rate and decreasing salting time. Salt applications were completed at 2.0% and 2.5% (w/w). Recoveries for these trials ranged from 61.17 - 64.07% at the 2.0% rate and from 53.22-54.91% at the 2.5%. This current study found salt retention to range from 44.82 - 50.84% following the trend expected for such a rate of application (3.0%). Kaufman and Olson also found greater salt retention occurred with a fine grade of salt compared to that of coarser grade salts. Common sensory defects found in the cheese at 7 days and 60 days of age are displayed in Table 4. Although mean sensory scores ranged from 96.5 to 97.6 at 7 days of age and from 96.8 to 97.6 at 60 days of age, there were no significant differences for any of the treatments. The slight pasty defect noted in samples at 60 days of age may reflect the relatively low salt content of the cheese samples. The relationship between low salt content and pasty, weak bodied cheese has been noted by a number of researchers (Fox, 1987; Kaufman and Olson, 1985). Salt content is inversely related to the extent of proteolysis that occurs in a cheese matrix (Fox, 1987). Thus, at low salt concentrations, such as those found in this study, much of the protein present in cheese has broken down to produce a pasty and weak bodied cheese.

Table 4. Common sensory defects observed in Cheddar cheese produced with various types of salt.*

	Flavor	Body and Texture	Color
Trial 1 - 7 Days	Slight Acid	Slight Curdy, Slight Grainy	Slight Mottled
Trial 2 - 7 Days	Slight Acid	Slight Curdy	
Trial 1 - 60 Days	Slight Acid, Slight Metallic, Slight Salty	Slight Pasty	
Trial 2 - 60 Days	Acid		

*Common indicates defects noted in 50% or greater of samples tested.

Our study found significantly greater salt retention using Fine Flake salt compared to Special Flake and Flake salts, but not Coarse salt. Choosing a finer grade of salt may be a useful method for increasing salt retention in Cheddar cheese, which will also help to decrease chloride levels present in whey and waste streams. 

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pH, from page 1

acid. When a buffer picks up a hydrogen ion, that ion is no longer measured by a pH meter. Phosphoric acid has the ability to pick up (or release) one to three hydrogen ions depending upon whether it is soluble or bound to casein or other molecules and each hydrogen ion has its own particular pH when it is released or picked up. This ability will become evident in young cheese especially mozzarella or washed curd cheeses. The pH of these cheeses may increase by as much as .3 units (i.e. pH 5.1 increased to 5.4) in as little as a day. The pH of cheese is influenced by two major factors; how much acid is formed and how much calcium phosphate, or other buffers, remain accessible in the cheese. In milk, the buffers act relatively rapidly to pick up hydrogen ions and only when the amount of hydrogen ions released exceeds the ability of the buffer to pick them up will the pH decrease. In cheese, the buffering effect may take a few days.

However, the effect of buffering on the pH of cheese also depends on how the cheese was made. In part skim mozzarella cheese, or washed curd cheeses, you'll see limited or even no acid developing after the mixer step, or after the curd is hooped. The decrease in pH is a race between the amount of acid developed and the rate at which the buffer can pick up the hydrogen ions. In mozzarella cheese, the race is won by a fast rate of acid development. Consequently, the pH may decrease rapidly only to increase later when the calcium phosphate buffering effect eventually kicks in and picks up hydrogen ions. Then we see a pH increase. However, in Cheddar cheese, where there is a considerable amount of acid formed during pressing and even during storage, the amount of hydrogen ions released exceeds the amount that can be picked up by the calcium phosphate. Thus, the pH may actually decrease. It does not increase until much later during ripening, but then because of other chemical reactions.

Calcium phosphate in cheese

The amount of calcium phosphate in cheese is directly related to the pH at which the milk is clotted and the pH at drain. The lower the pH at these points, the less calcium phosphate remains in the curd leading to less buffering in the cheese. Indeed, a tried and true method for making an acid cheese involves either increasing the lactose concentration or draining at a low pH. As Cheddar

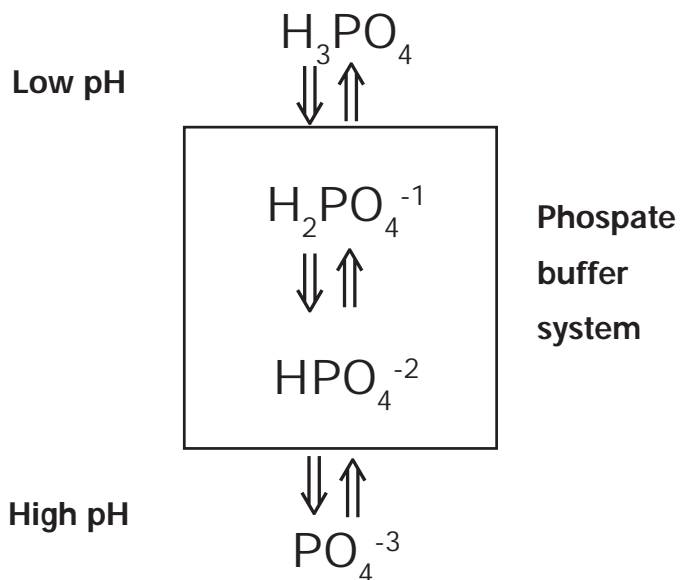
cheese ages there will be a tendency for the pH to increase slightly, depending on the amount of acid formed initially. Some of this increase will be due to the metabolism of lactic acid into weaker acids or other compounds that will pick up hydrogen ions. Proteolysis, or the breakdown of protein, forms ammonia and this can also increase pH, although it takes time .

Both proteolysis and the metabolism of acids are reactions that are very prevalent in mold or surface ripened cheeses. In Camembert, Blue and Limburger cheeses the pH at day one may be as low as 4.7 but as the mold or yeasts grow, the pH at the surface will rapidly increase to over pH 6.0 or higher in a matter of only a few days. It will take longer for the pH in the interior to increase since it takes some time for the lactic acid to move to the surface where it is metabolized into CO₂ and water and the ammonia seeps into the cheese interior.

Phosphate exists in three general forms in milk. Soluble phosphate is found in the serum, organic phosphate is permanently bound to the casein, and colloidal calcium phosphate is linked to the permanently bound phosphate. Only a small proportion of the total phosphate in milk is organic. The other two forms are at equilibrium which shifts due to the concentration of each, temperature, ionic strength, and pH.


The positively charged calcium acts to neutralize the negative charge on the phosphate molecules. This is important for the interaction of casein molecules since the calcium phosphate acts as a bridge (some have compared it to a "glue") between casein molecules. This is not necessarily a good thing—a lot of colloidal calcium phosphate makes for a tough, curdy, non-meltable cheese.

What really happens when acid/base is added: Buffering



All three forms of phosphate can act as buffers, although as a consequence of the buffering activity the colloidal calcium phosphate becomes soluble and calcium dissociates from the molecule. As a result we see changes in the interaction of casein molecules with each other and these changes influence the cheese. (See Pipeline articles in Volume 12, No.1 and Volume 11, No.2 on how casein colors cheese and the melt and stretch of cheese) The cheese gets softer, smoother, melts better, absorbs and holds free serum trapped in the curd at pressing, the curd knits or fuses more readily, and the color of the cheese may even become less white and more yellow.

Why is pH measurement so important? In addition to the effect that pH and colloidal calcium phosphate have on the physical properties of cheese, pH and acid content also play a major role

in flavor perception and development. They also influence the growth and types of bacteria that will survive in cheese. Some pathogenic bacteria, and strains that potentially cause defects, do not survive in an acid environment and will actually die in cheese over time if the pH is low enough (below 5.4). In surface and mold ripened cheeses the pH increases rapidly to over pH 6.0. Thus, there is a risk that bacteria once held in check with the initial low pH of the cheese may now grow when the pH increases. If these cheeses are contaminated post manufacture there is one less hurdle to prevent growth of the contaminant. So now you know, pH influences all aspects of the quality and safety of cheese. 

Measuring the pH of cheese

You can measure the pH of cheese in a variety of ways. The most common method is direct measurement with pH electrodes linked to a pH meter. The electrode is pressed down on the cheese surface (surface electrode) or speared (spear tip) into the cheese. Some cheese makers start by grinding a sample of cheese with a small amount of deionized water and then use the electrode. This helps to ensure a good water contact with the electrode. Keep in mind that you are measuring activity of hydrogen ions in water i.e. H_3O^+ .

Another type of pH measurement is called the quinhydrone method. A small amount of powder (quinhydrone) is mixed with cheese and the mixture is put into a small tube. A gold tipped probe is speared into the cheese and the combination is placed in a saturated KCl solution. The apparatus is linked to a pH meter set on the millivolt scale (not all pH meters are designed to give a millivolt reading). The millivolt reading is converted to pH (there are tables based on a given temperature of the KCl solution).

With any electrode system you must know the temperature of the mixture and make appropriate adjustments.

Ignoring temperature compensation can influence consistency, thus different laboratories may measure a different pH for the same cheese. Also, the meter and the electrodes must be standardized with solutions of known pH to ensure the accuracy of the system. The quinhydrone method often gives a pH reading lower than the other pH electrodes, especially when measuring process cheese or cheese food. I do not know why, but I suspect it may be due to the lack of good contact between the cheese and the electrodes or interferences with other compounds like fat or solubilized proteins that

could clog the membranes in the electrode. Indeed, the most common problem encountered when using electrodes is fouling. The electrode becomes slow to respond or the pH reading is not steady.

Unfortunately pH electrodes and pH meters can be expensive. Many cheesemakers realize that pH measurement is perhaps the most important cheese making management tool, even if they can't afford the equipment. For them there is an alternative method to measure pH. They can use pH paper, specially designed paper that changes color in response to pH. The paper is pressed onto the surface of the cheese and the color is compared to a reference chart. This is the least expensive method to measure pH and is commonly used by farmstead cheesemakers.



News from CDR

Congratulations to Norm Olson

The 2002 recipient of the University of Wisconsin's College of Agricultural and Life Sciences Distinguished Services Award is none other than Norm Olson, the first director of CDR and one of the main people responsible for CDR's very existence. Norm Olson is already well known among readers of the Pipeline, he is renowned for his research, teaching, and service to the University and the dairy industry. Congratulations Norm.

2003 Wisconsin Cheese Conference

Mark your calendars for the 2003 Wisconsin Cheese Industry Conference. The morning session on April 15th has an international focus, with presenters from Germany, Canada, and the US Office of International Relations. This panel will discuss "Trade Concerns for global marketing of US dairy products, including Protected Designations of Origin." Join us on April 16th for a full day of technical topics ranging from the cost of cheese defects to child to nutrition to dairy proteins in cheese manufacture. La Crosse is the location for the 2003 conference, more details available soon.

GMP Update

The GMP taskforce is on a mission. They want to improve the specially designed but onerous diet followed by people with phenylketonuria, or PKU. People with PKU have to avoid phenylalanine, one of the 20 amino acids that make up most proteins, including meat, fish, and dairy products.

The GMP taskforce is a unique collection of people linked by an interest in GMP, or glycomacropeptide, the only known natural peptide without phenylalanine. GMP, a product of curd coagulation during cheesemaking, is found in whey. Thus the taskforce includes representatives from the dairy industry, food scientists, businessmen, nutritionists and parents of children with PKU. The

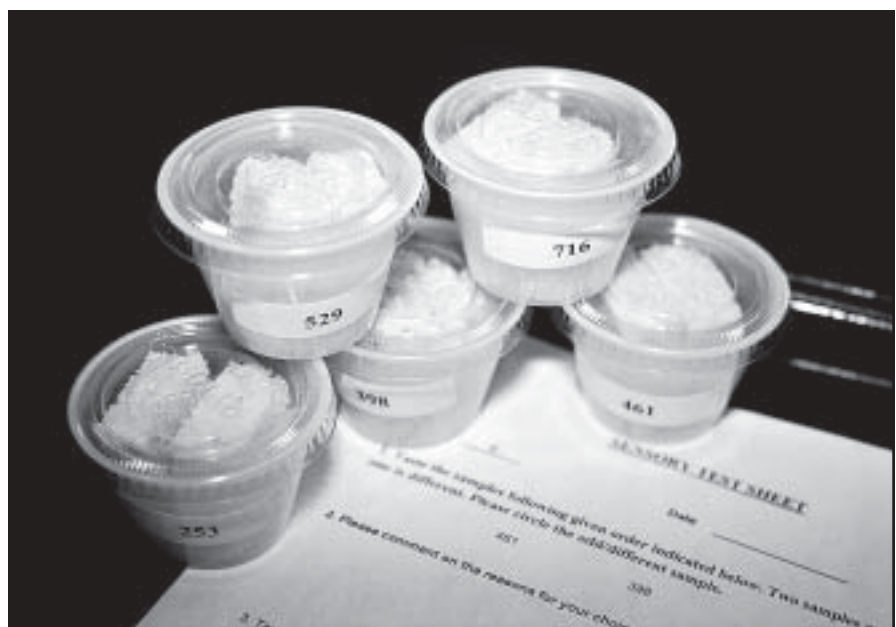
group met on September 25th at the Waisman Center on the University of Wisconsin campus with a goal of evaluating the role of GMP in PKU diets.

Mark Etzel began by discussing his work using process chromatography to separate GMP from whey, Anand Rao, of Davisco Foods, followed with a presentation on other potential applications for GMP—including toothpaste to prevent cavities, treatment for hypertension, and appetite suppressants. Although the volume of GMP needed to improve the PKU diet is very small, Dr. Rao is interested in the PKU application and plans to take it on as a personal project.

Kathy Nelson, CDR, presented samples and sensory testing results for the GMP applications she has been working on; offering samples of bread, pancakes, vanilla pudding, and apple juice. Kathy discussed the performance issues of GMP, for example, how to use it in a bread recipe while producing a browned loaf that holds its shape.

Members of the taskforce discussed the possibilities of using GMP in the PKU diet. It may find an invaluable niche as a supplement to the PKU formula, adding needed protein. Kids with PKU want to be just like other kids, and they want to share their food with their friends, and this type of drink is something they could share. Perhaps GMP could be packaged like a sports drink, and sold in cans or bottles.

GMP in the PKU diet does present several issues. GMP contains high amounts of several amino acids, including threonine, glutamine, proline and isoleucine. Also, some essential amino



GMP update, *continued*

acids are low or missing, like tyrosine and tryptophan. Will this be a problem if GMP is used in the diet? Right now, no one knows. However a feeding study with animals might be the first step to gather data.

Another issue with GMP is the off-flavor it imparts to food. Is this flavor, described as “stale” or “chemical”, an artifact of processing or is an inherent part of GMP? What can we do about it? Masking flavors are available and they will be tested in the future. It’s also possible the flavor can be improved by further processing that uses activated carbon adsorption.

GMP, as currently produced by Davisco, still contains some phenylalanine. Dr. Rao suspects that further processing could bring the levels down. CDR’s Whey Applications program has a process chromatography column that will be used to remove residual phe from the Davisco GMP. At the same time, the GMP

content needs to be boosted. For example, a sports drink for kids with PKU needs a higher amount of GMP and a lower phenylalanine content.

The functional qualities of GMP surprised some of the scientists working with the product. For example, a solution of GMP gels at 60°C. In addition, if you shake it to produce foam you will find the foam is stable at a low pH. Can these qualities be used as an advantage?

This meeting stretched into the early evening hours and task force members left with assignments to work on and a lot of information to process, but also with slowly building enthusiasm.



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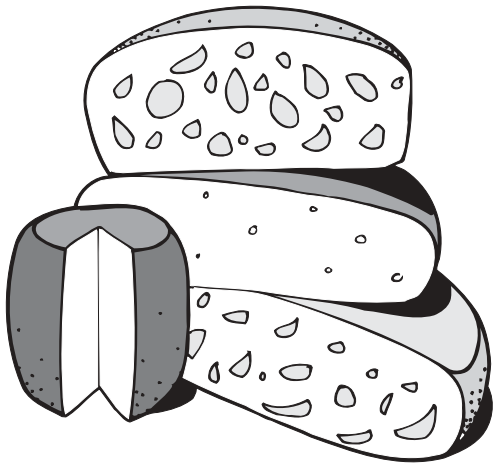
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Curd Clinic

Curd Clinic doctor for this issue is Lorraine Heins, Center for Dairy Research

Q. I would like to try some new approaches to standardizing cheese milk using membrane filtration. I have heard that either RO or UF can work for this purpose. What do you recommend?

A. First, let's review RO and UF milks. RO, or reverse osmosis, is a process that removes water from skim milk, thus the permeate stream is almost pure water. UF, or ultrafiltration, removes water, lactose and other small compounds. UF processing essentially concentrates only the protein fraction of milk and the permeate contains mainly water and lactose. When using either process, the amount of whey produced during cheese making is decreased.



However, at comparable total solids levels, RO milk contains less casein but more lactose. Consequently, the yield of cheese will be higher when you use UF milk. (See Table 2.) Since there is more lactose in milk concentrated by RO, there will be more lactose in the cheese. This can lead to either higher residual sugar or, if the lactose is fermented, it will lead to a lower pH (i.e. a high acid cheese).

	Control, 12.5% total solids	UF 13.5% total solids	RO 13.5% total solids
% Lactose in Serum Phase, Milk	4.80	4.80	5.20
% Lactic Acid in Cheese	1.52	1.52	1.70
% Lactic acid in Serum Phase (Cheese, 38% H ₂ O)	4.0	4.0	4.50

	*Solubility of L(+) Lactic Acid	Solubility of DL(±) Lactic Acid
39°F	4.2g/100ml water	2.9g/100ml water
50°F	4.5g/100ml water	3.0g/100 ml water

Table 2

Cheddar Cheese Yield				
		Casein	Fat	Yield (@ 38% moisture)
16% TS	RO	3.00	4.40	12.26
16% TS	UF	3.45	5.07	14.11

It is important to pay attention to this because too much lactose in cheese can cause several problems. For example, the extra sugar can cause excessive browning in pizza cheese. It can also cause problems for people with lactose intolerance. As mentioned above, bacteria will ferment the extra lactose in the cheese, producing an acid cheese and contributing to calcium lactate crystal formation.

Calcium lactate crystals begin when lactose is fermented to lactic acid. Most starter culture bacteria will produce the L-form of lactic acid. However, non-starter lactic acid bacteria (NSLABs), often present as a contaminant in cheese, can convert the L-form of lactic acid to the D-form of lactic acid. Both forms of lactic acid will bind to calcium to form a salt, calcium lactate. We have found crystals of calcium L(+) lactic acid and crystals containing equal amounts of L(+) and D(-) calcium lactate. The D-form of calcium lactate is not as soluble as the L-form, but both forms can produce small white crystals on the outside of cheese if the solubility is exceeded.

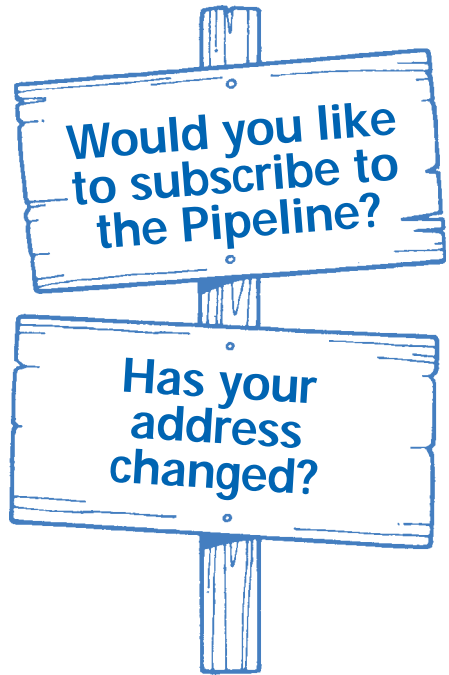
Lactose and lactic acid are in solution in the serum phase (aqueous phase) of the cheese or milk. Below is a table showing how concentrated lactic acid in the serum phase can surpass the solubility level, and precipitate as calcium lactate crystals. (Cao et al, 2001 Korean J. Chem Eng)

Additional factors to consider

If you are standardizing with RO or UF milk you should consider these additional factors. The higher solids level means that you will have to adjust your cheese make. You may need more starter, or you may need to preacidify your milk before adding coagulant. Calcium chloride may be needed, especially when using UF to standardize.

Coagulation will occur at a faster rate. The faster clotting process may mean that the cheese is overset by the time the cutting process is completed. To slow the coagulation rate, the setting temperature can be lowered (87-89°F), or you should start cutting when the curd is less firm.

Also, more cheese is produced. This is obviously beneficial, but it's possible that more cheese produced might overwhelm the capacity of your plant (i.e. draining tables, etc.).



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phone: 608/262-8015

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

Calendar

Jan. 7-8 Milk Pasteurization and Process Control School.

Madison, WI. Call Scott Rankin at (608) 263-2008 for information.

Jan. 15-18 Ice Cream Makers Short Course.

Madison, WI. Call Scott Rankin at (608) 263-2008 for information.

Feb. 11-12 Quality Milk Conference (WI Dairy Field Reps).

Madison, WI. Call Scott Rankin at (608) 263-2008 or Bill Wendorff at (608) 263-2015.

Feb. 25-26 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. 24-28 Wisconsin Cheese Technology Short Course,

Madison, WI Call Bill Wendorff at (608) 263-2015.

Apr. 15-16 Wisconsin Cheese Industry Conference,

La Crosse, WI. For information, call Judy Keller at (608) 828-4550.

Apr. 22-25 Cheesemaker's Workshop and License Short Course,

River Falls, WI. Call Rane May at (715) 425-3704.

May 6-7 Dairy and Food Plant Wastewater Short Course,

Madison, WI. Call Bill Wendorff at (608) 263-2015.

May 13-14 Applied Dairy Chemistry Short Course,

Madison, WI. Call Bill Wendorff at (608) 263-2015.

May 20 Wisconsin CIP Workshop,

Madison, WI. Call Bill Wendorff at (608) 263-2015.

May 21 Dairy HACCP Workshop,

Madison, WI. Call Marianne Smukowski at (608) 265-6346.



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