UW Dairy Pipeline

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Measuring Cheese Acidity —

The relationship of titratable acidity and pH in cheesemaking

By Norm F. Olson, Ph.D.

Measurement of titratable acidity of milk and whey is a commonly used and relatively accurate method of estimating acidity development during cheesemaking. Although methods for pH measurement have been available for some time, wide-scale commercial use of this technique in the cheese industry has occurred only recently. Use of this method provides more stringent control of functional properties of cheese and will increase control over the cheesemaking process.

Principles of pH Measurement

pH is a measurement of the concentration (more accurately, activity) of hydrogen ions in a solution. Compounds called acids release hydrogen ions into water, whereas other compounds called bases combine with the hydrogen ions. The concentration of hydrogen ions in most foods is very small. For example, one liter (approximately 1.1 quarts) of milk at pH 7.0 contains one ten-millionth of a mole of hydrogen ions. A mole is a unit quantity used in chemistry. To simplify the expression of the concentration of hydrogen ions, a numbering system (pH values) was developed which defines pH as the logarithm of the reciprocal of hydrogen ion concentration or as the negative logarithm of hydrogen ion concentration. As indicated earlier, milk at pH 7.0 contains one ten-millionth (0.0000001) of mole of hydrogen ions which is shown in the following formula:

pH = logarithm of 1/0.0000001 = 7.0

If an acid was added to the milk to lower the pH to 6.0, the milk would then contain one one-millionth (0.000001) of a mole of hydrogen ions as shown in the following formula:

pH = logarithm of 1/0.000001 = 6.0

The above examples illustrate two important points about pH measurement:

1. As a solution becomes more acidic, its pH decreases.

2. For every one unit change in pH, there is a ten-fold change in hydrogen ion concentration.

In dilute solutions, pH values are expressed in a range between 0 and 14. This range is based on the extent of release of hydrogen ions in water. A solution is said to be neutral if it has a pH of 7.0. Acidic solutions have pH values less than 7.0; alkaline or basic solutions have pH values greater than 7.0.

pH Measurement

The pH of liquids or solids is measured with special electronic circuitry and glass or quinhydrone electrode systems. Glass electrodes are used most commonly in the dairy industry but the quinhydrone system may be more useful for measuring pH of cheese, especially those varieties with low moisture contents.

In This Issue:

Glass Electrode System

A pH meter equipped with a glass electrode system consists of the pH glass electrode (a glass stem with a tip of thin pH sensitive glass), a reference electrode, and an electronic potentiometer to measure the electrical potential between the two electrodes. These electrodes can be made either as two separate units or combined into one unit known as a combination electrode.

Use of Glass Electrode pH Meter

A pH meter is a delicate instrument and will not be accurate if it is not maintained or used properly. Always follow the manufacturer's instructions in using and maintaining the instrument. Certain general procedures can be recommended as follows:

* Do not allow the glass electrode to dry out. Keep it immersed in distilled water or a buffer as recommended by the manufacturer.

* The meter should be allowed to warm up and be brought into electrical balance according to manufacturer's instructions.

* The pH meter should be standardized with two standard buffer solutions. Their pH values should be above and below the pH values of the solutions being tested. The temperature of the buffers should be within 2˚C of the temperature of the test solutions.

* Electrodes should be rinsed with distilled water after immersion in buffers or test solutions. Blot water from the electrode with tissue, but do not wipe the electrode as this may create static electricity on the electrode.

Quinhydrone Electrode Meter

The quinhydrone system consists of a potentiometer, gold electrode and a reference (calomel) electrode. A sufficient amount of crystals of quinhydrone is mixed with cheese to give the cheese a gray color. The cheese is packed in a tube and the gold electrode inserted in the cheese so that the gold tip is completely surrounded by cheese. The tube is then placed in a saturated solution of potassium chloride; the reference electrode is also placed in this solution. The electrical potential is read on the potentiometer 90 seconds after mixing the cheese and quinhydrone. The potential reading is converted to pH using a chart.

Maintenance of Meters

Lack of maintenance of pH meters is undoubtedly the greatest source of error in their use in cheese plants. The electronic circuitry of meters should be checked routinely according to manufacturer's instructions.

A build-up of milk protein and fat on the glass electrode is probably the most common problem with this system. This film will cause erratic readings and a sluggish meter response. It can be removed by soaking the electrode for two hours in a mixture of one part concentrated hydrochloric acid and five parts water. The acid solution should cover the tip and lower portion of the electrode stem. Then soak the treated electrode in distilled water for 24 hours.

It may be helpful to place the electrode in a pH 7.0 buffer for an additional 24 hours prior to use. It may be necessary to repeat the above process. The reference electrode can also be fouled by milk protein and fat.

Titratable Acidity

The titratable acidity of milk or other liquids is determined by an incremental addition of a sodium hydroxide solution (sometimes called base or alkali) to raise the pH of the milk to about 8.3. An acid-base indicator, phenolphthalein, is used to estimate the endpoint pH of 8.3 (solution changes from colorless to pink). The strength of the sodium hydroxide solution (0.1 normal) and amount of milk (9 grams) are chosen so that the quantity of base required for titration can be converted to percentage of lactic acid in the sample. One milliliter of base equals 0.1% lactic acid.

There is no real basis for expressing titratable acidity of milk as lactic acid since there is practically no lactic acid in fresh milk. This system of expressing acidity is not followed in Europe, which can cause confusion when comparing cheese making processes. Whereas pH is a measure of "free" hydrogen ions, titratable acidity is a measurement of any constituent that will react with and neutralize the sodium hydroxide.

Several components in milk will combine with the base in addition to the small amount of acids that might be present. These constituents that make up the solids-not-fat portion of milk include the proteins, phosphates, citrates and carbon dioxide. Proteins and phosphates influence titratable acidity to the greatest extent, with carbon dioxide also playing a fairly significant role. The direct effect of the concentration of these milk constituents is illustrated in Table 1.

Table 1. Relation of Milk Composition to Acidity (1)

Fat in Milk	Solids Not-Fat in Milk	Titratable Acidities of milk: Fresh	of milk: at Set	of whey at: Cut	of whey at: Drain	of whey at: Pack	of whey at: Mill
3.0	8.3	.15	.155	.10	.12	.16	.40
3.5	8.54	.16	.165	.11	.13	.17	.41
4.0	8.73	.17	.175	.12	.14	.18	.42
4.5	8.8	.18	.185	.13	.15	.19	.43

Table 2. Changes in Titratable Acidity and pH Values During Manufacture of Cheddar Cheese (1)

Cheesemaking Operation	Time	Titratable Acidity	pH
Add Starter	**8:15**	**.16**	**6.6**
Add Rennet	**9:00**	**.17**	**6.55**
Coagulation	**9:12**	**—**	**—**
Cut Curd	**9:30**	**.10**	**—**
Steam on	**9:45**	**.10**	**—**
Steam off	**10:15**	**.11**	**6.4**
Drain whey (settling)	**11:00**	**.13**	**6.2**
End draining	**11:30**	**.15**	**6.0**
Pack	**11:45**	**.17**	**5.9**
Pile 2 high	**12:30**	**.25**	**5.7**
Pile 3 high	**1:00**	**.32**	**5.5**
Mill	**1:30**	**.45**	**5.45**

The titratable acidities of the various milks vary directly with the concentration of solids-not-fat. The effects shown in Table 1 have some implications in cheese manufacture. Slight compensations would have to be made in acidity levels desired at various stages of cheesemaking if the milk solids concentrations varied widely, or if the milk was pre-concentrated, or if the milk was fortified with solids-not-fat. The effect of higher concentrations of solids carries over to the whey as shown in Table 1. Slightly higher acidities must be attained to reach equivalent pH values in curd and whey from the high-solids milk.

Acidity Changes During Cheesemaking

Acidity development during cheesemaking depends on the activity of the lactic starter which is added to the milk and is then trapped in the curd. As shown in Table 2, the pH of the milk and curd decrease fairly uniformly during cheesemaking. Titratable acidities exhibit a more erratic pattern.

Acid produced by the starter raises the titratable acidity of the milk slightly before rennet is added. The curd is then cut, and whey acidity is measured. Immediately after cutting, a dramatic decrease in acidity of whey, as compared to milk, is caused by removal of some of the base-combining constituents of the milk. Casein and some of the phosphates, which are titrated in milk, are trapped in the curd and are not titrated in the whey. The titratable acidity increases uniformly from the time of cutting until the whey is drained from the curd, as shown in Table 2 . Consequently, this measurement can be used as an indicator of acidity development.

The relationship between acidity and pH values becomes erratic during the period from settling the curd to the end of draining (Table 2). The pH of the curd decreases fairly uniformly during this time and reflects production of acid by the starter.

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News from Extension

By Bill Wendorff, Ph.D.

Centennial Celebration

Graduates and former staff celebrated the centennial of the first dairy manufacturing short course Sept. 27. A historical booklet detailing the development and growth of the dairy school over the century has been published with the help of the following sponsors:

American National Can, Auro Tech, Cheese Market News, The Cheese Reporter, Chr. Hansen's Laboratory, Damrow Company, Foss Food Technology Corp., G/H Products Corp., Galloway West Company, Garver Mfg., Gist-brocades Food Ingredients, Klenzade, Kusel Equipment, Marschall Products, Nelson-Jameson, Pfizer Dairy Products, Sanofi Bio-Industries, Sani-Matic Systems, Stoelting, Tri-Clover.

Copies of the booklet are available from the UW Department of Food Science, 1605 Linden Dr., Madison, WI 53706.

Cheesemaker's Short Course Video

The videotape series of the Wisconsin Cheesemaker's Short Course has been available from the Cooperative Extension Media Collection since July. Demand for the videos has been high, and the two sets in the Media Collection are currently booked for loans until March.

With support of the Centennial sponsors, an additional set of the videotapes will be added to the Media Collection. To borrow the videotape series for a two-week period, ask your local county extension agent to order the "*Wisconsin Cheesemaker's Short Course Videotape Series*" from the Cooperative Extension Media Collection.

Copies of the videotape series are also available for purchase. The set of five two-hour tapes and a manual are priced at $150. They can be ordered from Agricultural Bulletins, 30 N. Murray St., Madison, WI 53715, phone (608) 262-3346. Just three months after their release, more than 50 sets have already been sold.

New Cheesemaker's Short Course

In response to the heavy demand for the Wisconsin Cheesemaker's Short Course, we are planning to offer an additional short course each year. A new Beginning Cheese Short Course is being planned for farmsteads and personnel who have little cheesemaking experience. The three-day course will have a greater emphasis on applied cheesemaking techniques than does the current short course, and will spend more time in practical lab sessions. The first session of the Beginning Cheese Short Course will be held in April.

The current five-day Wisconsin Cheesemaker's Short Course will be renamed to denote its more technical approach. Called the Wisconsin Cheese Technology Short Course, it will remain as the course recommended for apprentice cheesemakers preparing for their state cheesemaker's license exam. The structure of the short course will remain the same as before, except for some minor changes to keep pace with the cheese industry. It will be offered in March and September of each year.

Details on the new Beginning Cheese Short Course will be included in the next issue of the *Pipeline.*

Questions or comments on the UW Dairy Extension Service? Call Bill Wendorff at 608-263-2015

CDR Resource Center

These video selections and more are available for loan or purchase from the CDR Library. Call Sarah Quinones at 608-262-2217 or FAX 608-262-1578 for information.

Relation Between Volatile Sulpher Compounds and Cheddar Cheese, M.A. van Boekel, Ph.D.
Pediococci — The Cheese Starters for the 21st Century, Morsi El-Soda, Ph.D.
Milk Protein Content Measurement using Infared Spectrophotometry, M.A. van Boekel, Ph. D.
Getting the Most out of Your Whey Components, UW Dairy Manufacturer's Conference Proceedings
Eliminating Crystal Formation in Packaged Cheese, UW Dairy Manufacturer's Conference Proceedings

CDR Cheese Research and Technology Conference

March 6-7, 1991, Holiday Inn West Towne, Madison, Wisconsin

Opening Remarks, *Norm Olson, UW*

I. Milk and Cheese Quality — Impact on cheese marketing

"Tests You Should Be Using in Your Milk Monitoring Program," *Bob Bradley, UW*

"Taking Control of Communications with Your Producer," *Daryl Johnson, DVM, Weyauwega, WI*

"Microbiological Cheese Standards Used by the Canadians — How they've worked,"
Carl Weiss, Canadian Bureau of Microbial Hazards

"Specifications from the Buyer's Perspective," *Jeff Giffins, Master's Gallery*

"How Will the New Labeling Laws Effect the Cheesemaker," *Floyd Gaibler, NCI*

II. Cheese Technology and Research

"Avoid Cheese Defects by Getting Back to the Basics of Cheesemaking," *Norm Olson, UW*

"Computer-Aided Cheese Manufacture," *Peter Linklater, Sydney, Australia*

"Making Quality Lowfat Cheese," *Mark Johnson, UW*

"Cheese Tasting/Evaluation of Current Lowfat Cheese Problems," *Robert Lindsay, UW*

Banquet Presentation: "Effects of the EEC Economic Unification on the National and International Dairy Foods Industry," *Dave Hammer, director, Agri-Business Center, Wisc. Dept. of Ag.*

III. Considerations for Profitability in the Cheese Industry

"Milk Quality and Cheesemaking Profitability," *Ed Jesse, UW*

"Use of a Computer Program to Evaluate Cheese Standardization and Yield," *Dave McKenna, Foss Food Technology Corp.*

"Development of a Computer Program for Economic Analysis of Cheese Plant Operations,"
Brian Gould, UW

"Economics of Whey Processing — Summary of Research," *Dave Barbano, Cornell*

IV. On the Research Horizon

"Anticarcinogenic Components in Cheese," *Mike Pariza, UW*

"The Milkfat - Protein Issue — Research into the production side," *Ric R. Grummer, UW*

"What to Expect from Future Cheese Cultures," *Jim Steele, UW*

"Controlling Body and Texture of Mozzarella Cheese," *Craig Oberg, Weber State College, Utah*

For registration information contact Sarah Quinones, Center for Dairy Research, 1605 Linden Drive, Madison, WI 53706, or call the CALS Conference Office at 608-263-1672.

The Curd Clinic

Question: Bubbles/blisters form under the plastic wrap and paraffin I use to package my Cheddar and Colby cheeses. What could be causing this?

Answer: Bubbles under packaging films may be a symptom of contamination by gas-producing bacteria in the cheese. Bacteria in the cheese can produce gas which then migrates to the surface and gets trapped under the film. The best solution is to eliminate the source of the contamination. Cooling the curd quickly after pressing will reduce unwanted bacterial growth and may help correct the problem. Other possible causes of blistering with paraffin coatings are excess surface moisture on the cheese when the film is applied, or moisture in the wax itself.

Question: How can I keep the moisture content of my cheese consistent? I maintain consistent manufacturing procedures, but the moisture level in my cheese sometimes varies by as much as two percent.

Answer: Cheese moisture content is determined by a complex series of interrelated factors including curd size, rate of heating, stir-out time, and pressing temperature. If you are keeping these factors constant and are still having trouble controlling cheese moisture, the problem is likely caused by inconsistencies in either milk composition or the rate and extent of acid development during cheese manufacturing.

Please send your questions to:
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UW Dairy Pipeline
1605 Linden Dr.
Madison, WI 53706
FAX: 608/262-1578

Milk composition is an often overlooked factor affecting moisture content in cheese. If all other factors remain constant, milk with a low casein-to-fat ratio will yield cheese higher in moisture.

Milk can be standardized before cheesemaking to ensure that the casein/fat ratio remains steady from one batch to the next. This can be accomplished by removing cream or by adding nonfat dry milk or concentrated skim milk to the cheesemilk until an appropriate composition is reached. However, because high-temperature treatment denatures whey proteins in the milk, add only dry or concentrated milk that was treated with low heat. Denatured proteins interfere with casein coagulation during cheesemaking, and lead to a higher moisture content in the finished product.

Small manufacturers who draw their milk from a relatively small pool should be particularly aware that milk with a high proportion of mastitic or late-lactation milk is likely to be low in casein and rich in whey protein.

Another common cause of inconsistent moisture content in cheese is variability in the rate and extent of acid development during manufacturing, particularly at drain. Inadequate acid development will result in excessive moisture retention in the cheese.

Acid development should be monitored closely by testing pH. Some cheesemakers may use titratable acidity to monitor acid development, but this method can be unreliable (see "Measuring Cheese Acidity," page 1). Because milks of differing composition will have different initial titratable acidity levels, it is the change in titratable acidity rather than its actual value that correlates with acid development. Using pH to determine when to drain will help the cheesemaker avoid these pitfalls.

If the time required to reach the desired pH varies significantly, the cheesemaker should suspect the difference originated in using a too-fast or too-slow starter culture. This should be corrected, since the rate of acid development will also influence moisture content.

The Curd Clinic Doctor for this issue is Mark Johnson, CDR senior scientist.

Cheese Acidity

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The titratable acidity of whey increases rapidly from the point of settling curd (start of whey drainage) to the end of draining. This is caused by differences in dilution of acid being produced in the curd by the starter bacteria. Prior to draining, acid diffusing from the curd into a full vat of whey will be diluted so that the acidity of the whey will not be affected greatly. Once this large volume of whey is removed, acid diffusing from the curd is diluted only by the small volume of whey draining from the curd, and will have a greater effect on the acidity of this whey.

After whey drainage, the titratable acidity of the whey again shows a uniform increase up to the point of milling. Care should be taken to obtain a sample of whey which runs directly from the draining curd. Whey caught in puddles between slabs of curd or on the deck of the vat will not reflect the true acidity of the curd. It is imperative that sampling of whey be systematic in any mechanized or manual cheesemaking process.

Properties of cheese curd are related to and are affected directly by the pH of the curd. Curd with high pH will be rubbery and curdy, whereas curd at low pH will be brittle and mealy. With such direct effects on the quality of the cheese, care should be taken to systematically measure pH throughout the process.

<u>Reference</u>

l. Price, W.V., H.E. Calbert and N.F. Olson, 1971. Making Cheddar cheese from pasteurized milk. Wisconsin Agricultural Experiment Station Research Bulletin 464.

UW Safety and Nutrition Research Projects

Numerous research projects are underway at the UW-Madison Center for Dairy Research. The following are those concerning the safety and nutrition of dairy products.

1. Behavior of *Listeria monocytogenes* during the preparation of lactic starter culture in raw milk inoculated with lactic acid bacteria. Dr. Elmer Marth, Department of Food Science.

2. Behavior of *Listeria monocytogenes* in ultrafiltered milk with and without added lactic acid bacteria. Dr. Mark Johnson, CDR.

3. Milk: A point of entry into the human diet for mevalonate-suppressive plant secondary metabolites. Dr. Charles Elson, Department of Nutritional Sciences.

4. Effects of heat treatment and cheesemaking variables on pathogen survival and growth. Dr. Eric Johnson and Dr. John Nelson, Food Research Institute.

5. Identification of environmental sources of *Listeria monocytogenes* in dairy product manufacturing plants and development of HAACP programs designed to prevent Listeria contamination of dairy products. Dr. Eric Johnson, Food Research Institute.

6. Generation of and roles of proline in providing flavor and pathogen protection in cheese. Dr. Eric Johnson, Food Research Institute.

7. Growth inhibition of milkborne pathogens by fatty acids. Dr. Eric Johnson, Food Research Institute.

8. Surveillance and risk assessment to strengthen safety systems for dairy foods. Dr. John Nelson and Dr. Eric Johnson, Food Research Institute.

9. Behavior of foodborne pathogens in the presence of lactic acid bacteria. Dr. Elmer Marth, Department of Food Science.

10. Behavior of *Listeria monocytogenes* during manufacture and ripening of cheese. Dr. Mark Johnson, CDR.

11. Fate of *Listeria monocytogenes* during pasteurization and cheesemaking. Dr. Elmer Marth, Department of Food Science.

12. CLA: A newly recognized anticarcinogen isolated from dairy products. Dr. Michael Pariza, Food Research Institute.

13. Relationship between milkfat short-chain fatty acids and lipoprotein metabolism in the rat. Dr. Denise Ney, Department of Nutritional Sciences.

Calendar of Events

Jan. 14-18 ***Chemistry, Microbiology and Technology of Cheese.*** College-level course. For information call UW-Madison Dept. of Food Science, 608-262-3046.

Jan. 10 ***Controlling the Physical Properties of Mozzarella Cheese.*** Seminar with Paul Kindstedt, University of Vermont. For information call Sarah Quinones at 608-262-2217.

Jan. 7-11 ***Ice Cream Short Course***. Contact Robert Bradley, 608-263-2007, or the CALS Conference Office.

Jan. 14-17 ***Pasteurization and Process Control School***. Contact Robert Bradley, 608-263-2007, or the CALS Conference Office.

March 6-7 ***CDR Cheese Research and Technology Conference***. Holiday Inn, Madison, WI. For registration information contact the CALS Conference Office at 608-263-1672.

March 18-22 ***Wisconsin Cheese Technology Short Course***. Contact Bill Wendorff, 608-263-2015.

May 22 ***UW Dairy Manufacturer's Conference***. Wisconsin Rapids. Contact Bill Wendorff, 608-263-2015.

This and That . . .

Tom Szalkucki has been named CDR administrative officer. Szalkucki, who started in the newly-created position in August, was formerly director of technical service at Finnsugar Bioproducts. As administrative officer, his responsibilities will include coordinating and administering segments of the Center's research program development. He will also function as an industry liaison to help complete the link between CDR research and the dairy and food industries.

UW-River Falls Food Science Professor **P.C. Vasavada** has been elected a fellow of the American Academy of Microbiology. Members are selected to the prestigious national academy on the basis of excellence and originality in their work. A UW-RF faculty member since 1977, Vasavada is active in planning and presenting extension programs on the safety, microbiology, and technology of cheese and milk. He is initiator and coordinator of the University's international Food Microbiology Symposium. Vasavada recently returned from a sabbatical spent at the Australian dairy research organization CSIRO. He is now "back in the saddle" at UW-RF, and is once again available to help with questions on dairy microbiology (Phone 715-425-3150).

A long-time leader in the field of food microbiology, UW-Madison Professor of Food Science **Elmer Marth** is putting the finishing touches on his 41-year career. Dr. Marth and his wife, Phyllis, left for San Antonio, Texas, in October, where they will enjoy a well-earned retirement. During his career Marth studied a number of foodborne pathogens affecting the dairy industry. His work with *Listeria monocytogenes* during the past decade is particularly well known. In addition, he guided more than 30 doctoral students through their studies, and received the Kraft Teaching Award in 1988. Marth expects to publish his latest work, a book on *Listeria monocytogenes*, in 1991.

The *UW Dairy Pipeline* is published by the Center for Dairy Research at UW-Madison to update the Wisconsin dairy manufacturing industry on recent research and technology developments. We welcome your questions and ideas on how to make this a more effective publication.

Sarah Hundt Quinones , Managing Editor
David Gaeuman, Editor

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