Wisconsin Center for Dairy Research

DAIRY PIPELINE

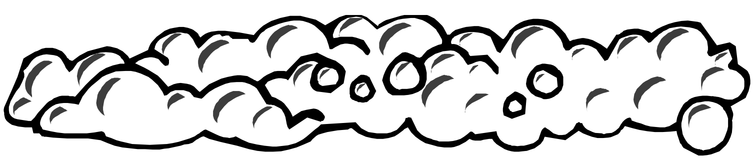
A Technical Resource for Dairy Manufacturers Volume 17 Number 2

Food Applications for Whey Permeate

By Kimberlee J. Burrington, Wisconsin Center for Dairy Research

In the last issue of the Pipeline, Karen Smith discussed the composition and production of permeate. Since permeate is not a well recognized term in the food industry, Karen also noted that permeate can be labeled in many different ways; deproteinized whey, dairy product solids, modified whey, reduced protein whey, or permeate. Many processors of milk and whey have been making permeate and drying it into a powder for years. During the 1970's, whey was the by-product ingredient that needed a higher value application than land spreading or animal feed. Now, permeate has taken on that role. Many companies sell their permeate for animal feed, which has turned out to be a good outlet for using large volumes of permeate. However, food use is considered a higher value target, thus this article will focus on food uses.

Looking over the history of whey utilization might offer some insight into how permeate can be used in food applications. Comparing the composition of whey and permeate will trigger some ideas on potential uses for permeate. Most of the whey sold today is dry sweet whey with a composition of about 12% protein, 73% lactose, 1% fat, 4% moisture, and 8.5% ash. Most of the permeate sold today is produced from sweet whey and has a composition of about 4% protein, 75% lactose, 0.5% fat, 4% moisture, and 8.5% ash. The main difference between the two ingredients is the amount of protein. Permeate contains primarily non-protein nitrogen compounds like urea, creatine, creatinine, uric acid, orotic acid, and ammonia. Commercial products will label this non-protein nitrogen as true protein.



Functionally, these nitrogen compounds do not behave like the whey proteins found in dry sweet whey. For example, whey proteins have multiple functionalities such as foaming, gelation, emulsification, water-binding, and high solubility. Permeate will not provide the same level of functionality as sweet whey. However, the similarities in composition are hard to ignore. Historically the dairy industry has been very good at cannibalizing its own ingredients. It is no accident that the first commercial whey protein concentrates contained 35% protein (WPC34), the same level found in nonfat dry milk (NFDM). WPC34 instantly became a NFDM replacer. It's not surprising that some companies today are marketing their permeate as a whey replacer. Knowing that the functionality of the protein will not be the same between whey and permeate, it is important to take a look at the remaining components to give some insight on what permeate could provide to a food application.

Lactose dictates functionality

Since seventy five percent of permeate is lactose the functionality of permeate is really dictated by the lactose content. The ash level is similar to whey, so flavor issues such as saltiness won't occur at typical use levels for whey. The ash contains calcium, phosphorus, and other

continued on page 2

What's Inside:

Pound Cake with Permeate

INGREDIENTS	(%)
Butter, unsalted	26.67
Eggs, whole	21.25
Cake Flour	20.21
Sugar	20.00
Milk, whole	5.46
Whey Permeate	5.00
Vanilla	0.87
Baking Powder	0.54
Salt	-
TOTAL	100.00 %

Procedure

1. Cream butter (room temperature) in mixing bowl for 1 minute at medium speed.

2. Add sugar gradually, creaming for 4 minutes at medium speed.

3. Slowly add beaten egg in 4 portions, scraping down bowl after each addition. Beat at medium speed for at least 30 seconds after each addition.

4. Combine dry ingredients (cake flour, whey permeate, baking powder) and add alternately with milk and vanilla, beginning and ending with dry ingredients.

5. Weigh out 775 g for each prepared pan (greased, parchment-lined 9" x 5" loaf pan).

6. Bake in conventional oven 180º C (350º F) for 55-65 minutes, or in a commercial reel oven at 148ºC (300º F) for 45 minutes.

Yield for batch size: 1-9" x 5" loaf

valuable minerals, which will contribute to the overall mineral profile of a food product. Fat content in permeate is very low so there is no added functionality from the fat.

Use permeate where lactose or whey are used

Technically speaking, one could use permeate in many of the applications where lactose or whey are used. A reality of the food industry is that cost is the most important factor when determining ingredient use. The more functionality a food manufacturer can get for the same cost or equivalent cost, the better. Some companies list the potential uses for permeate on their promotional literature. "Whey and lactose replacer" is commonly listed, along with bakery products, dry mixes, snack foods, and milk replacer. A look at the 2003 ADPI Utilization and Production Trends report notes that food uses of lactose include infant formulas, confectionery industry, nutraceuticals, pharmaceuticals, special dietary use, prepared mixes, dairy industry, baking industry, and chemicals. Over 65% of the lactose is used for infant formula and confections.

ADPI also lists the food uses for whey. They include dry blends and prepared mixes, the baking industry, the confectionery industry, margarine manufacturers, nutraceuticals, pharmaceuticals, special dietary uses, soup manufacturers, institutional uses, and all others.

The dairy industry uses 39% of the whey, 20% is used on dry blends and prepared dry mixes and 15% is used by the baking industry. If you put these two lists together, there are many potential food uses for permeate. Breaking some of these categories

High protein cheezy snack, ready for IFT 2005

down and discussing specific products—and what permeate could provide in terms of functionality or benefits—might trigger some new ideas for those of you who make permeate and those of you who are thinking about using it.

Most of the applications listed benefit from the following characteristics of lactose: contributes to browning, is a crystallizable sugar, is less sweet than sucrose, absorbs volatile flavor compounds, attracts and absorbs synthetic and natural pigments, and has a low affinity for moisture. In the dairy product area, applications such as dips, process cheese food, cheese sauces, and ice cream could include permeate. As long as usage falls within the standards of identity for the dairy product, permeate can be a good source of solids. Baked products like breads, crackers, cookies, snacks, and sweet goods will benefit from the browning that permeate contributes. Browning not only enhances appearance but it also adds pleasant caramelized flavors. Retaining moisture is also an added benefit in baked products. Icings, coatings, and non-chocolate candies can use permeate to reduce sweetness, while providing important crystallization characteristics. Dry mixes are another product category that could benefit from permeate. In addition, seasoning mixes for meals and sauces, macaroni and cheese mixes, and seasoning blends for salty snacks could use permeate to help deliver the flavors while providing a clean dairy flavor for these savory applications.

In our work with whey, lactose, and permeate at the CDR, we have evaluated these ingredients in dairy applications, baked products, confections, sauces, and many others. Below are a couple of formulas that include permeate. Please contact us if you have questions related to permeate or other dairy ingredients.

High Protein Cheezy Snack
IFT Formula 2005

INGREDIENTS	PER CENT(%)
All-Purpose Flour	28.36
Extra Sharp Cheddar Cheese, grated	21.13
Unsalted Butter	19.56
Reduced Lactose Concentrated Whey-60% Protein	9.78
Whey Crisps™(smallest size)	7.82
Whey Permeate	5.87
Water	5.09
Supernatural Cheese Blend, Cheddar Type #80821 (EMC)	2.35
Cayenne Pepper	0.04
TOTAL	100.00 %

Procedure

1. Place all ingredients in a bowl and mix on low speed until ingredients come together to form a ball.

2. Sheet to 10 mm thickness, cut into small pieces (approximately 1" x 1") and place on parchment-lined cookie sheet.

3.Bake 25 minutes at 325˚ F.

4. Cool on cookie sheet and store in the freezer until needed.

Do on-farm feeding systems influence flavor, texture, and composition of cheese?

Preliminary results from a study conducted by D. K. Combs , J. Lucey and S. Rankin of the University of Wisconsin–Madison, along with D. S. Banavara and M.A. Drake suggest bovine feeding systems do indeed influence milk and cheese. The researchers used an experimental design requiring that feeding and cheese-making trials were repeated several times during the grazing season. The first season, 2003, yielded some successes, however due to the drought and resulting loss of grazing forage, the trial was postponed until the 2004 season. In 2004, they increased the number of replicates, thus the number of milk samples and cheeses manufactured were doubled.

Feeding treatments

Milks were received from three separate feeding systems: grazing based (GBC), grazing with a corn-grain supplementation G+G, (a common supplement to increase milk production) and a silage-based Total Mixed Ration feed (TMR).

Milk production

The cattle pasturing was conducted at the UW Arlington research station, which is set up for pasture-type studies (e.g. Reis and Combs, 2000). Mixtures of "Endura" kura clover with "Park" Kentucky bluegrass were established in pastures at the Dairy Cattle Research Center in March, 1999. Cattle were managed on pasture with a Management Intensive Grazing (MIG) system. To control the quality and amount of herbage, portable front and back fences were used. Fresh pasture was offered twice daily on the paddocks by moving a front fence, and a back fence was moved three times a week to limit grazing of re-growing forage. To allow uniform re-growth and to maintain pasture quality, the paddocks were divided into three sections that were mechanically clipped at 28, 21, and 14 days, respectively, before the start of the trial to stage pasture re-growth. Thus, cows grazed on forage that is between 14 and 21 days of re-growth.

Animals and experimental procedure

Fifteen multiparous lactating Holstein cows were used in a replicated 3 x 3 Latin Square statistical design. Cattle and treatments were randomly assigned within each square. All cows received all treatments by the completion of the study.

Milk collection and processing

Milks were sampled and production measured for four consecutive days (eight milkings) at the end of each 21-day experimental period; individual milk samples were analyzed for fat, true protein, somatic cells and lactose by near infrared analysis (AgSource, Appleton, WI). For cheese making, a composite of the milks in each treatment was used. Thus, there were three cheeses made at the end of each experimental period. Laboratory scale (5 gal) cheese vats were used for cheese making. In 2004, cheddar cheeses were made two times on each trial (3 trials) over a period of approximately 2 months.

Cheese composition

Cheese composition varied as a result of several factors. Although the compositional data on the raw milk has not been reviewed, obviously the milk composition altered the cheese yield. Cheese yield of GBC was 10-15% lower as compared to TMR and G+G. No significant difference in protein or moisture content of cheese was observed as a result of treatment. There was some experimental variation, primarily due to the manufacture of cheese in small cheese vats where pressure, whey drainage, cutting are more difficult to control than in larger equipment. Milk and cheese showed significant color differences based on feed. GBC manifests a different color than the TMR cheese; GBC's are darker, redder and yellower than the TMR counterpart (cheese color evaluated with a colorimeter; data not shown).

Flavor perception

Flavor perception of cheeses was significantly different; for example, GBC exhibited more of a feed-like odor. The cheeses were aged between two and four months, then sent to MaryAnne Drake's lab at North Carolina State University for evaluation by a panel trained to use a cheddar cheese lexicon. Feed source influenced six attributes, shown in Table 1. The TMR cheese was slightly higher in whey and milkfat aroma. There was a higher level of diacetyl in the TMR and G+G cheeses. The GBC and G+G treatments had slightly higher sulfur and brothy notes. Across all cheese ages, the GBC and G+G treatments had a significant grassy note; this attribute was higher in the GBC samples.

Textural differences

Textural differences were observed between GBC, G+G and TMR treatments. In short, the GBC were consistently softer in texture

	TMR	GBC	G+G
Cooked	3.1a	3.0a	2.9a
Whey	**2.5a**	**2.1b**	**2.3ab**
Diacetyl	**0.5a**	**0.0b**	**0.5a**
Milkfat	**3.4a**	**3.2b**	**3.2b**
Fruity	0.0a	0.0a	0.0a
Sulfur	**0.65b**	**1.0a**	**1.0a**
Free fatty acid	0.0a	0.0a	0.0a
Brothy	**0.80b**	**1.3a**	**1.2a**
Nutty	0.0a	0.0a	0.0a
Catty	0.0a	0.0a	0.0a
Cowy/barny	0.0a	0.0a	0.0a
Grass aroma	**0.0**	**1.7a**	**1.3b**
Sour	3.1a	3.1a	3.1a
Salty	3.8a	3.9a	3.9a
Bitter	0.0a	0.0a	0.0a
Sweet	2.2a	2.1a	2.2a
Umami	1.8a	1.7a	1.8a

Table 1. Scores of Cheddar cheeses evaluated by a trained sensory panel. Higher values represent higher attribute perception. Letters next to values represent significant differences at the 95% confidence level.

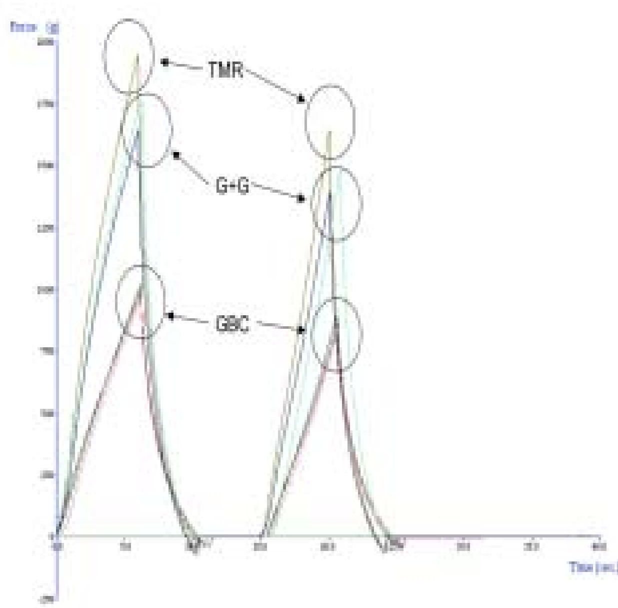


Figure 1. Texture analysis of GBC as compared to TMR and G+G samples. Lower peak force values relate to softer cheese texture.

than the other two treatments. The reasons for this are unclear, but they may relate to the GBC product having more unsaturated fatty acids (as reported in the literature), thus being softer (altered solid fat index) at a given temperature. The softer texture may also relate to some change in the casein micelle structure, yielding a curd with reduced firmness.

Identifying the grassy flavor

The researchers are still trying to identify the grassy flavor compounds. So far, multiple solvent-assisted flavor extracts have been completed. In addition, they have run approximately thirty chromatography runs (both with mass spectrometer and the olfactory port), and have been able to identify numerous potent odorants. However, a single, identifiable compound that is the root cause of the grassy note has not been identified yet. The grassy note may be due to a combination of several compounds and work to identify the chemical cause of the grassy note continues. The grassy note is definitely volatile, appears somewhat heat labile, and is clearly identifiable by sensory inspection in the GBC extracts.

Consider coliform counts on raw milk

R.L. Bradley and S. A. Rankin, Center for Dairy Research and Dept. of Food Science, UW–Madison

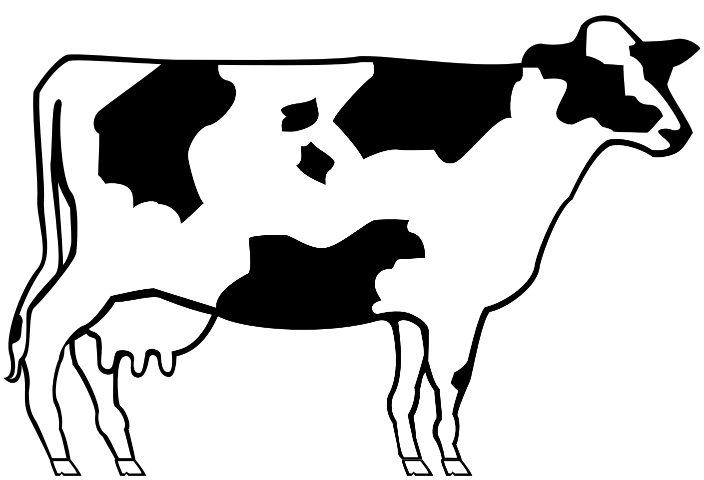
We all know that coliform organisms are indicators of post-pasteurized milk quality. And finding even one coliform would send most of us on a hunt for the source of contamination. In light of this, have you considered adding a test for raw milk coliforms to the usual Standard Plate Counts (SPC) and pre-incubation assays on your incoming milk? It might be useful as you attempt to gain better control of incoming milk supplies, particularly the milk coming directly from your patrons. If you did check raw milk what would you expect to find for coliform numbers? Here's my suggestion:

Less than 25 cfu/ml	**excellent quality milk**
25-50 cfu /ml	**good quality milk**
50-100 cfu/ml	**could be better**
100 cfu and higher/ml	**fieldman get busy**

In a review of published articles on this subject, there is good support for this assay. Soler et al. stated that statistical correlations between levels of the main microbial groups were significant at $p<.001$ level. Hutchison et al. acknowledged that total bacteria counts are not always a true indicator of on-farm hygiene but they failed to find a true marker organism that showed consistent higher correlations. In addition, Costello et al. showed a high correlation between (SPC) and coliform counts in 200 raw milk samples that were evaluated.

Cleaning and coliforms

Bramley and McKinnon stated that the causative sources of high coliform counts in raw milk are unclean equipment and low temperatures during cleaning. In the evaluation of raw milk from 70 Irish farms over 13 months, researchers found that coliform bacteria were present in all milk samples, but 65-71% had <100 CFU/ml. Murphy and Boor supported the evidence of Bramley and McKinnon relative to unclean equipment and low temperature cleaning. Further, these authors indicated milking cows that have not been properly cleaned before milking will lead to high coliform populations among other populations of bacteria in the milk. Pre-milking udder hygiene is extremely important for obtaining low count



milk. Lastly, the effective use of a sanitizer is important but the equipment, and the cow's udders, must be clean first. Another potent source for high coliform counts is coliform mastitis. These populations would usually be much greater than 100cfu/ml, depending on the amount of dilution in the bulk tank.

"...the effective use of a sanitizer is important but the equipment, and the cow's udders, must be clean first."

What can you gain by doing a coliform count on raw milk?

♦ Results in 18-24 hours. Your field staff has quicker and more focused information to assist the patron in producing better quality milk

♦ The cost to the plant is minimal. The equipment and supplies needed are already in the plant laboratory. If not, they should be!

♦ This assay is on raw product where the principle amount of focus should be and less on finished product. (That is too late.)

♦ Consider using a coliform count as a basis for premium payment, again directed at milk quality. Some dairy plants already do this. Coupled with SPC you will have a solid handle on equipment cleanliness, sanitation and milking practices on each farm

You will have to do some initial background coliform checks to establish the levels that you feel are appropriate. This is another good "tool" to use in your quest for the best quality raw milk.

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Bramley and McKinnon (Microbiology of Raw Milk, in Dairy Microbiology, vol. 1, 2nd edition, R. K. Robinson ed, Elsevier, London 1990)

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Hutchison et al., J. Food Protection 68:764-772, 2005

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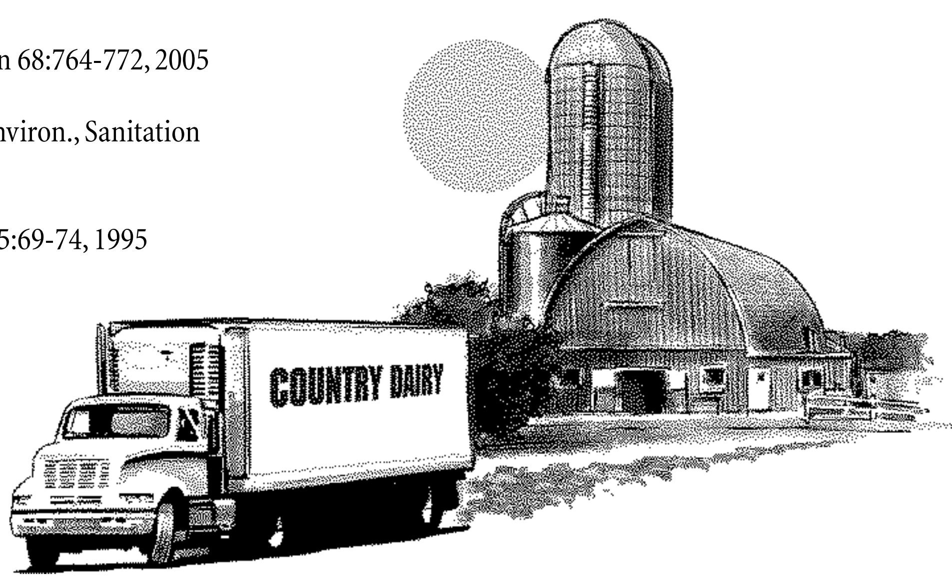

News from CDR

CDR staff on the go

Summer is the season of professional meetings that bring food science professionals together for lectures, presentations and trade shows. This year is no different, and several people here at CDR will be participating.

Institute of Food Technologists, IFT

Karen Smith, Ph.D., CDR Whey Separations Technologist, works with the dairy ingredients, and cheese research and applications programs at CDR. Karen will present "Ultrafiltered milk and ultrafiltered milk ingredients: What's in store for the future?" at the annual IFT meeting. New Orleans, LA is the site of the annual IFT meeting, July 16 to 20, 2005. Additional information can be found at: http://www.ift.org/

You can also visit with CDR folks at the Dairy Management Inc. IFT booth, where Kathy Nelson will be serving up some high protein cheese crackers. (See photo below and more photos on page 3.) KJ Burrington will be sampling a high protein beverage.

American Dairy Science Association, ADSA

Rani Govindasamy-Lucey, CDR scientist, presented findings of work recently completed at the Center at the 2005 ADSA annual meeting. Rani will discuss the "Use of Cold Microfiltration Rententates for Standardization of Milks for Pizza Cheese: Impact on Yield and Functionality". Cincinnati, Ohio was the site of the annual ADSA meeting, July 24 to 28, 2005. Additional information: http://www.adsa.org

Kyungwha (Kate) Lim, CDR sensory coordinator, also traveled to Ohio to present a summary of work recently completed at the Center during the 2005 ADSA annual meeting. Kate presented "The effect of cheese temperature on the texture and shredding of mozzarella."

International Dairy Federation

You still have time to register for the International Dairy Federation mtg., September 17-22nd in Vancouver. Over 500 people have already registered for this international meeting. For more details, including registration info and the entiire program check out: www.idf2005.com

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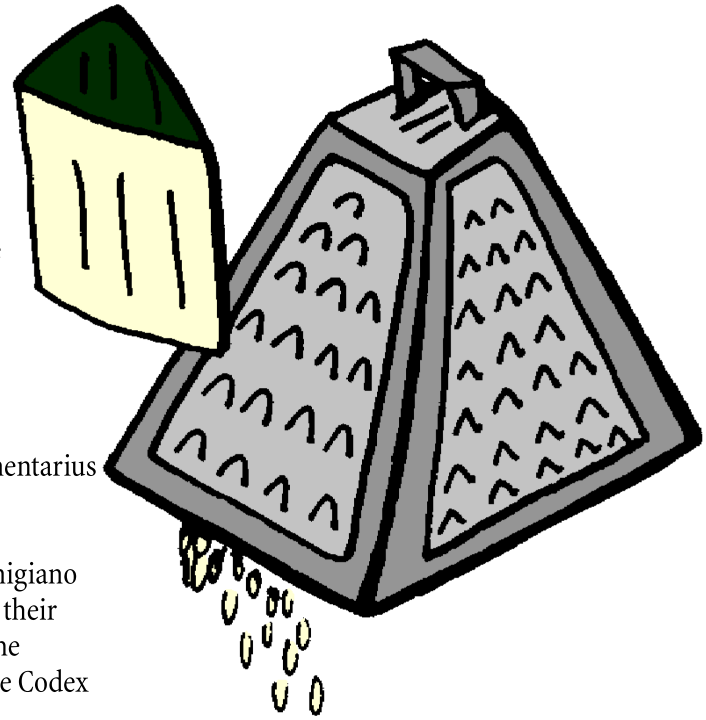
Moving on

It is always gratifying to see people move onwards and upwards to further their careers but when they leave CDR to do it we always miss them. Recently, Cindy Martinelli, Bill Hoesly, and Brian Lietzke left CDR for greener pastures—and we are missing them.

Master Cheesemaker program

Now that Jim Path has retired, Marianne Smukowski will be coordinating the Wisconsin Master Cheesemaker® Program. Joanne Gauthier continues her administrative role; call her with general questions and get in touch with Marianne to schedule cheese sampling or plant visits.

parmesan vs Parmesan



Is parmesan a generic name for a hard cheese that is often grated, or is it the English translation of Parmigiano Reggiano, a protected hard cheese made in Italy? If you are an Italian cheesemaker, chances are you back the latter interpretation and you are very protective of the name parmesan. If you are a Wisconsin cheesemaker who has been making parmesan for decades, you might also be feeling very protective of the name and identity of your parmesan cheese.

Thus, we have the polarization that stops the Codex Alimentarius Commission from developing a worldwide standard for parmesan cheese. European Union regulations support geographic indications that limit the production of Parmigiano Reggiano cheese to the area around Parma, Italy. And, in their interpretation, the same goes for parmesan. Outside of the European members, most of the165 member states of the Codex Commission disagree.

Although progress was blocked at the recent Codex meeting in Italy, creativity was not. Below is the unofficial report of the28th session of the Codex Alimentarius Commission.

The Ballad of Parmesan Cheese -
(Another Codex Moment)

In an age long ago when men had ten-fold
The strength and endurance today
A battle did rage in the chamber of delegates
In Rome on two hot muggy days.

The siege of Troy lasted ten years
And the Greeks gave no quarter it's true,
But the battle of Rome with the Italians at home
Aged us like cheese as it grew.

The war of the cheeses divided the world
Between parmesan, big "P" and small.
Were we crazy to fight and lash out with words
When a little "p" had gotten too tall?

The war of the cheeses began with a bang
With Canada's man in the Chair.
The EC began by planting its flag.
"Defend Parmesan cheese!" they declared.

The U.S. intervened with a Homeric retort
And challenged the EC in its views.
The hard grating cheeses are hardly so great.
Could this truly be groundbreaking news?

For one hundred years all nations have made
A product called parmesan cheese.
What manner of magic will vanquish the rights
Of companies to do as they please.

Must the Americas give up the right to their name
If Amerigo Vespucci returns?
Good sense is not common when passions are hot
And GI's are an issue that burns.

The light of the day was fading so fast
We thought that the end must be near.
Then Singapore called for a vote of the members
And the nuclear option was here.

Volcanoes erupted and spit forth their fire
And it appeared the world might end.
A long night of talking produced no results
For our principles we had to defend.

On day two of this epic in the annals of man
Our labors produced no rewards.
The EC betrayed our efforts for peace
And the multitude fell on their swords.

While hope yet remains that in future fair trade
Will protect us all if we pray.
For now, the consumer must weep as we
acknowledge defeat
For there's no parmesan standard today.

Curd Clinic

Q. While grading cheese recently my co-workers and I got into a discussion regarding cheese composition sampling. What led to the current technique for sampling barrels and large blocks of cheese?

A. Current sampling techniques originate from a 1982 research project, funded by the National Cheese Institute (NCI) and carried out right here in Madison. Members of NCI had consistently experienced solid cheese losses and they suspected inaccurate moisture measurements as the cause.

Back then, 500 lbs of cheese in corrugated, steel or fiber barrels were sampled by inserting a trier through the bung hole in the barrel cover and aiming toward the center of the barrel. The amount of moisture in that plug of cheese was used to determine the moisture content of the entire vat. But was this the most accurate method?

Tom Blatttner, Norm Olson, and Dean Wichern at the University of Wisconsin–Madison took on the task of developing a sampling procedure that would accurately measure the moisture content of barrel cheese. They started by sampling 54 steel and 18 fiber barrels of cheese using the conventional method. Then they sliced the cheese vertically through the center and used a grid to select 72 two-inch plugs. Finally, the remaining cheese from each barrel was ground, blended and five samples were taken. Duplicate samples were tested for moisture and the average of the ten samples defined the true moisture value. Knowing the true moisture and developing a "map" of the moisture throughout the barrel allowed the researchers to investigate alternative sampling locations. Once the site was selected, they followed up with a verification study which confirmed they had indeed developed a more accurate method for sampling barrel cheese for moisture.

By mapping the distribution of moisture in a barrel of cheese the researchers were able to describe a general pattern. They concluded that "Although the pattern varies from barrel to barrel, this study indicates that the area near the top center of the barrel contains cheese that is significantly lower in moisture than cheese located around the sides of the barrel. Sampling error is reduced by changing the angle of the trier when the sample is taken." See Figure 1. for a visual comparison of before and after sampling techniques.

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Blattner, T.M., Olson, N.F., Wichern, D.W., Sampling barrel cheese for moisture analysis: comparison of methods. J. Assoc. Off. Anal. Chem. 68:718 July/August 1985

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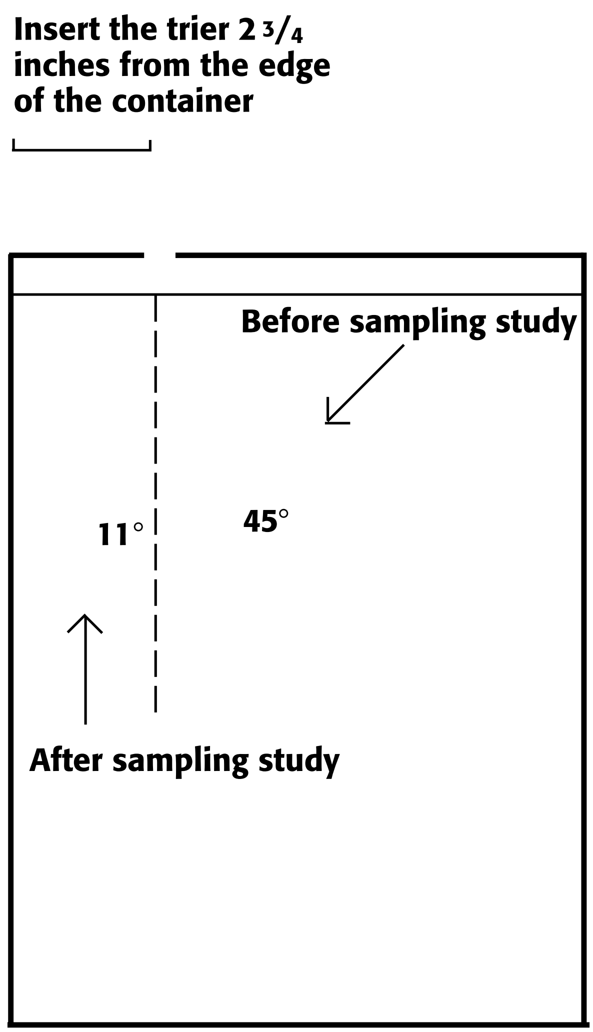
Figure 1.



Sampling technique described in the AOAC manual

33.1.06
AOAC Official Method 970.30
Sampling of Cheese
Final Action

C. Sampling technique for Barrels
—First Action 1986
—Final Action 1993

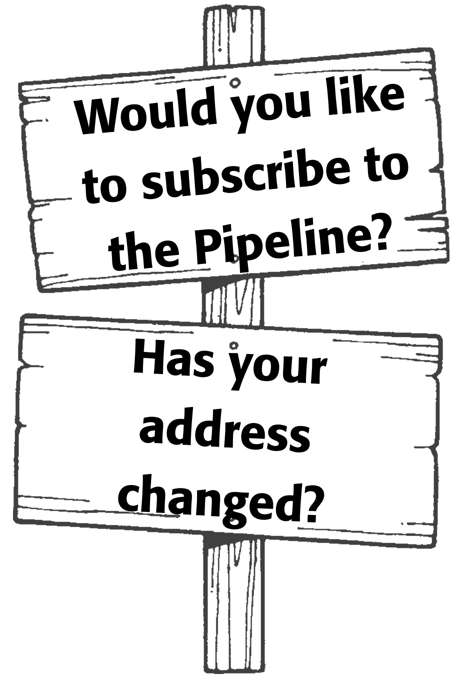
Sampling by means of trier.—Insert 30.5 cm (12 inch) blade length trier 7 cm (2.75 inch) from the edge of the cheese and toward nearest outside edge of barrel at 11° from the vertical. Center of the plug hole shall be 7 cm from the edge of the cheese. Trier guide fixed at 11° may be used as aid.

If cheese barrel is full, i.e., not >2-3 cm headspace, it is possible to draw reliable sample through bung or sample port in cover which permits insertion of trier at 7 cm point. If headspace is >3 cm, remove cover; other wise point of trier insertion will be distorted. In no instance should barrel containing cheese from more than 1 vat be selected as sample for moisture analysis.

For reliable sample, insert trier to draw full 27.9-30.5 cm. (11-12 inch) plug from full container. If plug breaks short of 25.4 cm (10 inch), draw another plug from a different location 7 cm from the edge. For plug between 25.5 and 30.5 cm, remove the top 11.4 cm (4.5 inch) for sealing the plug hole. Transfer the next 10.2 cm (4 inch) portion to sample container. Discard remaining bottom portion of plug.

For more information about measuring cheese moisture

The Journal of the AOAC International, Vol. 84, No. 2, 2001 published a special report on the variation and measurement of moisture in cheese. Guest editor was Bob Bradley, emerita professor of Food Science at the University of Wisconsin–Madison. We have several dozen reprints available, call 608 262-8015 if you would like a copy.



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Calendar

Aug. 30-31 Customizing Cheese Flavor Short Course, Madison, WI. (A Master Cheesemaker Short Course and an Artisan course) Call Bill Wendorff at (608) 263-2015 or John Jaeggi at (608) 262-2264 for information.

Sept. 21-22 Dairy, Food and Environmental Health Symposium. cosponsored by Wisconsin Association of Food Protection, WI Association of Dairy Plant Field Reps, and WI Environmental Health Assn., Mosinee, WI. For more information, contact David St. Jules, DATCP, at (608) 224-4713 or e-mail at: david.stjules@datcp.state.wi.us.

Oct. 5 Cheese & Butter Evaluation Clinic. World Dairy Expo, Madison, WI. Sponsored by Wis. Dairy Products Assn. For information, call WDPA at (608) 836-3336.

Oct. 10-14 Wisconsin Cheese Technology Short Course. Madison, WI. Call Bill Wendorff at (608) 263-2015.

Oct. 12-13 North Central Cheese Industries Assn. Annual Convention. St. Cloud, MN. For information, call Dr. David Henning at (605) 688-5477.

Oct. 18-19 Dairy Ingredient Utilization Workshop. Madison, WI. Program Coordinators: Bill Wendorff (608) 263-2015 and K.J. Burrington (608) 265-9297.

Nov. 3-5 Great Lakes Dairy Sheep Symposium. Burlington, VT. For information, contact Carol Delaney at the University of Vermont at (715) 635-3735 or e-mail at: carol.delaney@uvm.edu.

Nov. 15-16 Cheese Grading and Evaluation Short Course. Madison, WI. Call Scott Rankin at (608) 263-2008.

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