

Manufacturing Reduced Fat Cheddar Cheese

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When many consumers think of reduced fat cheese they think of a bland cheese with either a firm, rubbery body or a soft, pasty one. More often than not, people describe reduced fat cheeses as having a very undesirable taste. Even quality reduced fat cheese deteriorates after only a few months of storage. Unfortunately, reduced fat cheese with such a short shelf-life may be purchased well after body and flavor defects have developed. Although sales of reduced fat cheese have not approached the level that many cheese makers had hoped, interest remains high. We started this research project to determine the manufacturing practices that could lead to desirable body and flavor. We did not start from "ground zero" since there is a considerable base of knowledge about defects in cheese body and flavor. Also, the principles of cheese manufacturing, chemistry and flavor development are constant regardless of the variety or name attached to the cheese.

Two factors determine the fat content of the cheese; milk composition and the cheese manufacturing process. While it is possible to use milk of different fat levels and manipulate the moisture content of cheese by altering the manufacturing process, the challenge to the cheese maker is to standardize the milk composition and precisely control the manufacturing process to produce a cheese of consistent quality. It is the composition of the milk in terms of the ratio of casein to fat (C/F) that determines the FDM of cheese. Both the milk composition and moisture content of the cheese determine the fat as a percent of the total cheese weight (Table 1).

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To make a reduced fat cheese, the cheese maker must first raise the C/F ratio of the milk. Most often, this is done by removing fat from the milk or by adding reconstituted nonfat dry milk. As the cheese maker increases the C/F ratio of the milk, the FDM of the cheese decreases (Table 1). It is the cheese making procedure that determines the moisture content of the cheese and thus the % fat of the cheese.

Cheese - a matrix of protein, fat and water

Cheese is made up of a network of interconnected strands of protein that surround globules of fat. Water, either bound or adsorbed, is a major component of all cheese. Fat and water help to break up the continuous network of protein and soften the cheese. As the fat content decreases the concentration of protein increases and the body of the cheese becomes firmer.

To compensate for the loss of the softening that fat imparts to cheese, we make reduced fat cheeses with higher moisture. It is also more economical for the cheese maker to produce cheese with a higher moisture content since the cheese yield will be greater (Table 1). Reduced fat cheese is much more expensive to make than a similar higher fat cheese because of the decrease in cheese yield, cost of standardization, and lower value of butterfat. In a reduced fat cheese the higher moisture does not compensate for the loss of fat since the protein content is higher. Generally, the body of reduced fat cheese will still be firmer than a higher fat cheese. Instead of increasing the moisture content alone, fat mimetics are sometimes used to soften the body of reduced fat cheese. They bind water and help to separate the protein matrix. Metzger and Mistry, 1994, reported that the body of reduced fat cheese was smoother when the fat portion of the cheese milk was homogenized prior to cheese making. Homogenization produced numerous small fat globules that broke up the integrity of the protein network.

The firmness of the cheese is not controlled solely by its composition. Both pH and bound calcium influence the ionic interactions between protein strands and play a major role in the firmness of the cheese. However, proteolysis is the most important contributing factor to the firmness of cheese. Cheese

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Inventing a New Niche Product, Part 4

Paul Scharfman, Specialty Cheese Company and Wisconsin Specialty Cheese Institute

Congratulations! You've come up with an exciting new product idea and you are confident your firm can make the product. Should you invest in new labels? New equipment?

Not yet. I believe the best quote to give to a person in the thrall of dazzling new product idea is, "Don't sell the bike shop, Orville." Before you invest in a new product it's best to follow a market research plan.

The Reenap Company

In previous articles we discussed how a hypothetical, four employee Cheddar plant could assemble a new product development team, conduct a company self-assessment and then develop ideas for feasible new products. This firm, the Reenap company, decided that they should consider developing a new product in one of five areas:

small sized packages of aged Cheddar
Cheshire
Stilton
Manchego
Jack with bacon and mushroom

Next, refine your ideas

The Reenap Company's new product development team started the next task; specifying the benefits their new products would bring to the market. To do so, they asked themselves why anyone would choose their new products over the alternatives. Answering this question is called "positioning" your product — and it is one of the most fundamental parts of marketing a new product.

The team started with their first idea, small packages of aged Cheddar. In order to answer the question of why anyone would want to buy their new product compared to the alternatives — their competition — they needed to do a "competitive review." While the team had looked at a few small size packages as part of their earlier idea generating sessions, they had not thoroughly reviewed the small size segment of the aged Cheddar market.

The Reenap team started by visiting local supermarkets and specialty cheese stores. They called their customers and their brokers. They posed the same question to store clerks and business associates alike, "We're thinking of coming out

with a small package of aged Cheddar. What is our competition? How can we get a sample?"

Over the following three weeks, the team was deluged by information. They learned about branded one ounce pieces of Cheddar, trial size "giveaway" pieces, airline packages, gift box sizes, and much more. They got a rough idea about pricing and, after one marathon tasting session, a sense for the range of quality that was already available in small sizes. And, they got discouraged. "The world does not need another small package of aged Cheddar," said one team member.

The team leader cautioned against discouragement and suggested that the team take all the competitive packages and place them on a large table asking, "What do you, as consumers, wish was here?"

The team looked at each other in confusion. Finally, one of them spoke up, "I wish there was a little package for my dad. He loves cheese but as he's gotten older he doesn't use it as much as he used to. Actually, I'm not sure why, but I think he'd be more likely to buy a smaller package."

Inventing Possible Niches

The team realized they had found a "hole" in the market. There were no small size packages of Cheddar that were targeted to the "senior" market. Perhaps the Reenap company could fill that market niche!

As the Team stood around the table laden with competitive packages they started to realize that there were many "holes" in



the market. Some sounded silly, some seemed technically difficult to produce, but there were more market niche possibilities than they imagined before they did their competitive review.

Here is the list of possible niches and issues that the Team developed over the next hour:

Small size packages of Cheddar that...

- are for seniors (what do they want?)
- are rich in vitamins and minerals (who would want this?)
- are calcium-enriched (are there labeling issues?)
- are high in iron (who would want this?)
- have active cheese cultures (maybe more than yogurt?)
- are fun colors for kids (do kids care?)
- are shaped like your state (would this only be a fad?)

What started out as one possible new product idea had blossomed into many. The team now had the opportunity to "position" many new product ideas. For each one they still had to answer the question of why anyone would buy their new product instead of the available alternatives.

Go ask the customer

Every successful new product is clearly "positioned" in the minds of its customers. That means, the customer can say "the reason I buy this product is because it gives me _____ benefit. I believe that benefit is there because of _____." For example, a consumer of a local dairy's milk might say, "The reason I buy the local milk is that it tastes fresher. I believe it tastes fresher because it is produced nearby."

In my next article, I will explore how a firm can use discussions with customers and consumers to develop clear positioning for their new product ideas. Once you know a new product's positioning, you can estimate its costs and potential. 

News from CDR

CDR hosts two visiting scientists

Dr. Muhammet Ak will work with Professor S. Gunasekaran of the Ag Engineering/Food Science Departments to develop a method to measure cheese melt/flow characteristics. Dr. Ak did his PhD thesis on Rheological Measurements on Mozzarella Cheese. He joins Gunasekaran and the cheese ingredient research group with valuable insights and experience in this area. Dr. Ak will be visiting CDR July 1 to September 7, 1995.

Dr. Hugo Garcia will join Professor Charles Hill of Chemical Engineering to continue his research using immobilized lipases for chemical modification of milkfat. Garcia has participated in CDR's milkfat research program for the past 3 years and continues to work on making a commercially viable technology for use of milkfat as a food ingredient. Dr. Garcia will be here from July 1 to September 1, 1995.

Now available — Producing Safe Dairy Foods Video

The Wisconsin Center for Dairy Research has produced a comprehensive safety training video for the dairy industry. In this 12 part video set, University of Wisconsin-Madison food safety experts address the critical dairy foods pathogens. The speakers address the behavior, control and incidence of industry outbreaks for the following topics; Staphylococcus, Clostridium botulinum, mycotoxins, E. coli, Campylobacteriosis, Yersiniosis, Listeria, Brucellosis, Tuberculosis, Streptococci, Salmonella, injured pathogens, animal drug residues, HACCP measures. All material is presented with industry applications in mind. Cost \$350.00, which includes a reference manual. To order this video set contact Sarah Quinones at 608/262-2217 or 608/265-2117. 

Developing Foreign Markets for Wisconsin Cheese

by Jennifer Thomas, Wisconsin Department of Agriculture

Has the growing global economy motivated you to consider expanding your sales abroad? Are you established in the domestic market — with the capacity to expand sales? Do you want to set up distribution channels in foreign markets, but don't know how to begin? Perhaps you want to do business with foreign clients, but are concerned about getting paid?

These are a few of the most common concerns that companies face when they explore the export market. Staff at the International Agri-Business Center (IABC) of the Wisconsin Department of Agriculture, Trade and Consumer Protection (DATCP), can help you answer these questions and prepare your firm for international sales. We provide an array of services to help companies enter foreign markets and we assist seasoned exporters to reach their export potential.

We also help dairy processors and marketers obtain international contacts through our international trade lead system. Food buyers place requests to the U.S. Department of Agriculture's Foreign Agricultural Service (USDA/FAS) staff based at over 70 American Embassies worldwide for U.S. suppliers of specific products. These inquiries are forwarded daily to the FAS staff in Washington, D. C., then electronically to DATCP. The Center subsequently transmits these foreign offers to buy to the respective companies listed on its export database.

International trade shows are another way that we help companies obtain foreign distributors and relevant market research. The IABC organizes a state of Wisconsin booth at key international trade shows where a large number of potential distributors are present. For example, we organized a Wisconsin pavilion of ten companies at the Food Marketing Institute's (FMI) U. S. Food Export Showcase held in Chicago in May. This show has worldwide recognition among the nearly 4,000 international food buyer attendees. We are also sponsoring a booth of up to five companies at ABRA'S 95 supermarket and food show, held September 17-20, 1995 in Rio de Janeiro, Brazil.

In addition, foreign buyers often contact us directly for assistance in locating Wisconsin suppliers of specific products. We list names of Wisconsin firms by product for foreign buyers. Throughout the year, foreign buyers travel to meet potential producers. IABC coordinates itineraries for foreign buyers and travels with them throughout the state to make the introductions between buyers and sellers.

Although cheese exports are small compared to domestic sales, they are growing at a pace of sixteen percent annually. Dairy product exports from Wisconsin were valued at \$190.5 million in 1993, while estimated cheese exports for are valued at \$4.76 million. In 1993, total U. S. dairy product exports were valued at more than \$857.4 million, while cheese exports account for only \$22 million, or about 2.5 percent.



IABC Marketing Specialists

Each IABC's marketing consultant specializes in geographic regions of the world to provide expert consultation to companies or individuals. We can help you: respond to foreign buyer requests, set prices for international markets, organize methods of payment, set up distribution channels, identify and qualify potential distributors, obtain foreign market information, shipping products internationally, export documentation, import requirements.

For more information about IABC's programs, or to talk to a marketing consultant about the potential for exporting your product, please contact us at the phone, fax, or address below:

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Table 1. Milk and cheese composition relating moisture content to % fat in cheese and cheese yield. (Calculated by the cheese yield formula.)

Milk Composition				Cheese Composition	
% Fat	%Casein	C/F	%FDM ³	% Fat (% Yield) at 37% H ₂ O	% Fat (% Yield) at 47% H ₂ O
¹ 3.60	2.40	0.667	52.7	33.2 (10.0)	27.9 (11.9)
² 1.90	2.44	1.285	38.1	24.0 (7.3)	20.2 (8.7)
² 1.20	2.46	2.050	28.4	17.9 (6.2)	15.1 (7.3)

¹ whole milk
² skim milk made by removing cream from whole milk
³ FDM = Fat in the Dry Matter

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becomes softer as the network of casein is destroyed or broken apart (hydrolyzed) by the action of proteases. It is extensive proteolysis that occurs as the cheese ages, coupled with high moisture content that is responsible for the soft, pasty body of reduced fat cheese. The sources of proteases in cheese include the chymosin used to coagulate the milk, naturally occurring milk enzymes and bacterial enzymes from both contaminating bacteria and bacteria deliberately added to the milk to produce acid or develop flavor. Products of proteolysis i.e., amino acids and peptides, and especially compounds derived from them, are known to contribute to flavor of cheese (both desirable and undesirable).

Manufacturing reduced fat Cheddar cheese

Most manufacturers of reduced fat Cheddar cheese in the United States actually use a slightly modified Colby make procedure. This procedure includes rinsing or soaking the curd in water after the whey is drained. The rinse increases the moisture content of the curd and removes lactic acid and lactose. Many cheese makers believe that the cheese will become excessively acid unless the lactose level in the curd is reduced. With reduced fat Cheddar cheese, cold water (ca. 22°C or 72°F) is used to lower the curd temperature. It slows syneresis (protein contraction which forces entrapped moisture out of the curd) and allows absorption of water by the curd. A warm water rinse (ca. 35°C or 94°F) may enhance syneresis but the curd does not absorb water. Thus, the temperature of the rinse water can influence the final moisture of the cheese.

Washing out flavor

This is not without precedent since Colby and similarly washed curd cheeses do not develop the strong flavor associated with Cheddar cheese, which is usually made without a curd wash treatment. Many cheese makers believe that the stirred curd process used to make Colby and some Cheddar cheese contributes to the lower flavor of Colby cheese compared to milled curd Cheddar cheese. However, this is not documented in the literature. We did not choose to use the stirred curd procedure but we believe our results still apply to cheeses made by the stirred curd process. Both are made with the same starter bacteria and follow the same basic principles of manufacture.

Make procedure

For our experiments, a conventional Cheddar manufacturing procedure (milled curd procedure) was followed using .5% to 1.0% starter inoculum (Chen, 1991). Curd and whey were heated to 38°C (100°F). The whey was then immediately drained from the curd and cheddared. At the proper pH, the curd was milled. When a wash treatment was used, the milled curd was soaked with occasional stirring in water (5 parts curd to 7 parts water) for twenty minutes. The curd/water mixture was held at ca. 22°C or 35°C (72°F or 94°F), depending on the experiment. The key to producing this cheese was to separate the whey from the curd at a relatively high pH (curd pH of 6.35) and mill (also salt) at a high pH, ca. pH 5.8-5.9. In order to achieve these parameters it was necessary to develop acid slowly (addition of starter to mill was ca. 3.5 hr). An average

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FDA Regulations

The Food and Drug Administration has established standards of identity for several cheeses. These standards prescribe the amount of fat in relation to the amount of other solids in the cheese i.e. fat in the dry matter (FDM) and the amount of moisture allowed. Reductions in fat content for a specific reduced fat cheese type, as now allowed by NLEA regulations, must be based on the legal minimum fat content of the reference cheese. For example, the legal minimum fat content for Cheddar cheese is 30.5%, calculated as the % of fat in the finished product. Thus the maximum fat content of 25% and 50% reduced fat cheese is 22.9% and 15.25%, respectively. The legal definitions of reduced fat cheeses are defined in terms of maximum fat rather than FDM. Unlike reference cheeses, reduced fat cheeses do not have a moisture standard so the moisture content of reduced fat cheeses can vary, except for specifications set by the buyer.

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Table 2. Average composition of reduced-fat Cheddar cheese.

Manufacturing Technique	Vats	% fat	% moisture	% salt
no-wash curd	19	17.7	43.60	1.67
22°C (72°F) wash	7	17.3	46.84	1.61
35°C (94°F) wash	3	17.8	43.67	1.60

Table 3. Lactic acid in washed and no-wash curd reduced-fat Cheddar cheese.

Manufacturing Technique	% Total lactic acid			
	1 day	45 days	3 month	6 month
no-wash curd	.97	1.69	1.72	1.73
22°C (72°F) wash	1.02	1.45	1.45	1.47
35°C (94°F) wash	.69	1.45	1.45	1.45

Table 4. pH of washed and no-washed curd reduced-fat Cheddar cheese.

Manufacturing Technique	pH			
	1 day	45 days	3 month	6 month
no-wash	5.33	5.09	5.13	5.17
22°C (72°F) wash	5.20	5.09	5.17	5.25
35°C (94°F) wash	5.28	5.13	5.20	5.23

Table 5. Three-month evaluation of reduced-fat Cheddar cheese, effect of culture.

Manufacturing Technique	A	Culture B	C
no-wash	mild	mild	mild, slightly sweet
22°C (72°F) wash	mild, slight meaty-brothy	mild, slight meaty-brothy	pronounced meaty-brothy
35°C (94°F) wash	bland	bland	pronounced meaty-brothy

composition of washed and no-washed cheeses is given in Table 2. As expected, curd washed at 22°C (72°F) produced cheese with the highest moisture. Although the no-wash curd cheese had a higher level of lactic acid (Table 3) the pH of the no-wash curd cheeses was only slightly lower than the washed curd cheeses (Table 4).

We also tested the influence that the starter has on the flavor of reduced fat cheese. We varied the starter, comparing cheeses made with a curd wash treatment to those made with the no-wash treatment (Table 5 and Table 6). The cultures were chosen on the basis of their slow acid production during cheese making and the fact that they had been used to make quality higher fat Cheddar cheese previously.

No-wash curd wins

A young, higher moisture, washed curd reduced fat Cheddar cheese has a softer, smoother body and is free of flavor defects other than blandness (body scores are not included in Tables). However, as they age, these cheeses quickly deteriorate into weak and pasty bodied cheeses that are highly unclean or have objectionable meaty-brothy flavors. Although the wash treatment has a greater impact, the intensity of the off-flavors appears to be related to the particular starter used. The lower moisture no-wash curd cheeses, although initially firm, curdy and slightly acidic in flavor, showed consistently higher quality at 3 and 6 months of age. The no-wash curd cheeses developed a stronger Cheddar flavor intensity than did the washed curd cheeses, even at similar moisture levels. It is apparent from this study that not all starter cultures are suitable for washed curd cheeses, even though

they produce quality no-wash curd cheeses. We do not know the characteristics of the starters that contribute to this discrepancy but we are investigating them.

Residual lactose was highest in the no-wash cheese at one day (Table 7). Thus, more lactose would be fermented during storage of the no-wash curd cheese than in the washed curd cheeses. This may explain the flavor differences noted between washed and no-washed curd cheeses. As the starter ferments lactose, oxygen within the cheese is converted to other compounds and the re-dox potential of the cheese becomes reduced. Kristoffersen, 1967, reported that a reduced re-dox potential was needed for desirable flavor development within cheese. We did not make controlled measurements of the re-dox potential of our cheeses but it is possible that the increased fermentation of lactose (lower pH and more lactic acid, Tables 3 and 4) in the no-washed curd cheeses resulted in lower re-dox potential and increased flavor development. In another trial the whey was diluted to remove lactose rather than use the rinse step. These cheeses also had less flavor than the no-wash curd cheeses.

Buffering and pH

How can a high acid cheese not be too acidic or too low in pH (i.e. pH less than 5.0)? Phosphates in milk (attached to proteins) are a natural buffering system.

Table 7. Effect of curd washing on residual lactose.

Culture	Wash Treatment	% lactose in cheese		
		1 day	1.5 months	3 months
A	no-wash	.59	.06	.05
	22°C wash	.51	.01	.04
B	no-wash	.98	.07	.03
	22° C wash	.62	.08	.01
	35° C wash	.63	.01	.00
C	no-wash	.70	.26	.12
	22° C wash	.48	.09	.05
	35° C wash	.43	.01	.00

Table 8. Unclean flavors from aromatic amino acids

Amino Acid	Flavor/ Chemical
Phenylalanine	Rosy Flavors Phenethanol
Tyrosine	Barny, Utensil p-cresol
Tryptophan	Lingering Unclean Skatole

However, as the pH drops during cheese manufacture the colloidal calcium phosphate becomes disassociated from the protein, dissolves in the whey, and is removed as the whey is drained or pressed from the curd. Rinsing probably enhances the removal of the dissolved calcium phosphate and may actually result in increased dissolution of the colloidal calcium phosphate. By draining the whey at a high pH and slowing the rate of acid development, more of the buffering capacity is retained. Thus, you can make a cheese with a high acid content and a high

buffering capacity with a pH greater than 5.0. Washed curd cheeses are higher in pH than no-wash curd cheeses because their lactic acid content is lower and they may actually have less buffering capacity than the no-washed curd cheeses. According to Lucey and Fox, 1993, lactic acid also can buffer the cheese at pH 5.0.

Developing flavor

During cheese making the main role of the starter bacteria is to ferment lactose to lactic acid in a predictable and dependable manner. Since milk does not contain sufficient amounts of free amino acids to sustain growth, the starter must also be able to breakdown casein. By hydrolyzing protein, starters increase the amount of free amino acids in the curd. If they are not used for growth, they can be enzymatically transformed into flavor compounds or be altered

“We believe that the rinsing or washing procedure contributes to the lack of flavor development in the reduced fat Cheddar cheese.”

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chemically during ripening. Traditionally, we haven't thought of amino acids or peptides as contributing directly to the development of cheese flavor. One exception is bitterness in cheese, resulting from metabolic activities (or lack thereof) of the starter. Small bitter peptides are not breaking down. There is still much to discover concerning flavor development – even the compound(s) that give Cheddar its distinctive flavor are not well documented.

Recent work by Guthrie, 1993, implicates non-starter lactobacilli when certain off-flavors in cheese develop from amino acids (Table 8). The meaty-brothy flavor defect comes from a group of flavor compounds via carbonyl-amino acid-type reactions, as well as self-condensation reactions. The compounds include pyrazines, furanones, and possibly lactones (Robert Lindsay, personal communication). The role of starter metabolism in off-flavor development is not known, but it is intriguing in light of what we observed using different starters (Table 5 and Table 6).

In order to increase the flavor intensity of reduced fat cheese, enzymes including mixtures of proteases or peptidases, have been added to milk used for cheese making or directly to the curd. Johnson, 1995, added spray dried whole cells of *Lactobacillus helveticus* CNRZ 32 to milk. The flavor of the reduced-fat cheese was intensified and the cheeses with the added cells received higher preference ratings.

Conclusion

It is apparent that curd washing produces a reduced-fat Cheddar cheese that can develop inferior flavor and body characteristics compared to a reduced fat Cheddar cheese made without a wash treatment. The advantages of using the wash treatment to produce a high moisture cheese are quickly outweighed by increased rate of deterioration of the body and flavor often characteristic of these cheeses.

It is also obvious that not all starter cultures that produce good full fat Cheddar are capable of producing good quality reduced-fat Cheddar. This is a puzzle we are still trying to solve.

Acknowledgement

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References

- Chen, C.M., 1991, Reduced-fat make schedules, Wisconsin Center for Dairy Research, Reduced-Fat Cheddar Seminar, Madison, Wisconsin.
- Food and Drug Administration, Department of Health and Human Services, 1992, Code of federal regulations, chapter 21, U.S. Government Printing Office, Washington, D.C.
- Guthrie, B. 1993, Influence of cheese-related microflora on the production of unclean-flavored aromatic amino acid metabolites in Cheddar cheese, Ph.D. Thesis, University of Wisconsin, Madison.
- Johnson, J.A.C., M. R. Etzel, C. M. Chen, and M. E. Johnson, 1995. Accelerated ripening of reduced-fat Cheddar cheese using four attenuated *Lactobacillus helveticus* adjuncts, J. Dairy Sci. 78:769-776
- Kristoffersen, T., 1967, Interrelationship of flavor and chemical changes in cheese, J. Dairy Sci. 50:279.
- Lucey, J.A., and Fox, P.F., 1993, Importance of calcium and phosphate in cheese manufacture: a review, J. Dairy Sci. 76:1714.
- Metzger, L.E., and Mistry, V.V., 1994, A new approach using homogenization of cream in the manufacture of reduced-fat Cheddar cheese. 1. manufacture, composition and yield, J. Dairy Sci. 77:3506-3515.



Increase Milk Production with Salty Whey

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Salty whey, the pressings and drippings from direct-salted cheeses, may be evolving from a disposal problem to a soil enriching bonus. Recent research at the University of Wales (1,2) suggests that fertilizing pastures with sodium chloride (salt) can increase both milk production and the milkfat levels in milk from cows on rotational grazing. Although researchers have not analyzed the effects of applying salty whey to pastures, it's likely that the salt effects would be similar and the added nutrients in whey would be a bonus.

In the Wales study, twenty-four cows grazed in six treatment areas with three fertilizer levels: 45, 22, and 0 lb. of salt per acre. After rotating the cows among six pastures every 3 weeks, the researchers analyzed the results. Milk production from cows grazing the pastures fertilized with 45 lb. of salt per acre was 5.1 lb. of milk per day greater (32.2 vs. 27.1) than cows on the unfertilized pastures (3). Cows grazing on the salted pasture produced milk with an increased milkfat concentration, from 4.02 to 4.34% with salt fertilization. Milk lactose content also increased with salt but protein content was not affected by any of the treatments. Salt application to pastures increased milk yield and liveweight gain but directly supplementing salt in the ration did not produce the same effect.

Pasture growth rate and dry matter digestibility increased with salt fertilization but salt did not affect modified acid digestible fiber. Salt increased the sodium, chloride and calcium content of the grass, but greatly reduced the potassium content.

Cows graze longer

Since grazing increased linearly with increasing levels of salt fertilization, the increased milk production with salt fertilization was most likely due to higher forage intake. Cows grazing pasture fertilized with salt spent about 8 percent more time grazing and 22 percent more time ruminating than those on unfertilized pasture. Drinking frequency increased in proportion to the sodium levels in the forage on pasture. The higher rumen pH and improved rate of fiber digestion (2) probably explain increases in milkfat percentage.

Salty whey typically contains about 6% whey solids and 6% salt (4). Approximately 85 gallons/acre of salty whey will provide the 45 lb. of salt/acre used in the British study. This quantity of salty whey would also provide 1.0 lb. of nitrogen, 0.34 lb. of phosphorus and 1.2 lb. of potash per acre in additional nutrients for pasture growth. Application rates for salty whey could be increased to 315 gallons/acre/yr. without exceeding the state

regulations* limit of 170 lb. of chlorides/acre/yr. You must exercise care when applying the whey. Do it at a rate that will permit it to soak into the soil. Also, do not apply salty whey where there is a high risk of ground water or surface water contamination. Avoid applying it next to stream banks or ponds, or when there is a risk of run-off into waterways.

It's possible that the increased conversion of dairy herds to rotational grazing may provide a ready market for cheesemaker's salty whey. By managing nutrients properly, producers should be able to use salty whey effectively in their pasture management programs and maximize milk output per acre while reducing their milk production cost.

*Chapter NR 214 Land treatment of Industrial Liquid Wastes, By-product Solids and Sludges.

References:

1. Berger, L.L. 1994. Salt fertilization boosted pasture milk yields. *Hoard's Dairyman* 139: 795.
2. Chiy, C.P., and C.J.C. Phillips. 1991. The effects of sodium chloride application to pasture, or its direct supplementation, on dairy cow production and grazing preference. *Grass and Forage Sci.* 46: 325-331.
3. Chiy, C.P., C.J.C. Phillips and R. Bello. 1993. Sodium fertilizer application to pasture. 2. Effects on dairy cow production and behavior. *Grass and Forage Sci.* 48: 203-212.
4. Wendorff, W.L. 1993. Revised guidelines for landspreading whey and whey permeate. *UW Dairy Alert*, June 1, 1993.

We would like to thank James E. Geyer, Foremost Farms USA, for alerting us of this research study. 

Curd Clinic

Q. It seems like more of my patrons are considering rotational grazing. I've heard that late-lactation milk may cause some problems, can I really make cheese with it?

A. The short answer is that rotational grazing will add some challenges to cheesemaking and, yes, you can make cheese with late-lactation milk, particularly if you dilute it with mid-lactation milk.

In Ireland, milk production is seasonal because dairy farmers take advantage of grass as a feed source. The composition of milk changes during the lactation cycle, reflecting lactation and nutritional influences. This is particularly true towards the end of the season, when the low volume and quality of late-lactation milk can cause problems for cheese makers. You may face some of the following problems.

Impaired rennet coagulation

The rennet coagulation properties of late-lactation milk are impaired. Slow clotting and weak gels are common. Although some reports claim that slow clotting milk is responsible for weak gels, the rennet coagulation time (RCT) is actually determined by pH and relationships between RCT and gel firmness, which should be determined at a constant milk pH (e.g., 6.6).

Low milk yield is associated with abnormal milk composition and rennet coagulation properties. Milk at pH values > 6.9 is difficult to coagulate by rennet due to low rennet activity at these pH values. Thus, the high pH of late-lactation milk is responsible for its slow rennet coagulation. The low firmness of gels made from late-lactation milk could be due to some change in the structure or composition of casein, but proteolysis of casein by plasmin enzyme is the probable cause.

Adding CaCl_2 to milk may aid rennet coagulation by reducing milk pH and increasing the concentration of soluble Ca^{2+} . (Essential for aggregation of rennet-altered micelles and increasing the firmness of a rennet-induced gel, irrespective of pH). However, I can't stress enough that adding CaCl_2 to a very abnormal milk will not solve all your problems, particularly if the product is subjected to a number of strict functional tests. Adding CaCl_2 or adjusting pH may not improve the weak gel firmness of rennet-induced gels made from very abnormal late-lactation milk.

Seasonal variations in protein and fat

Looking at all regions in the United States, the average seasonal variation in milk fat and protein is approximately 0.5 and 0.2%, respectively. Some seasonal variation in cheese yield occurs in every country; a much larger variation in cheese yield occurs in regions where milk production has a pronounced seasonal pattern. Standardizing milk for cheesemaking to a constant casein to fat ratio makes it easier to produce cheese with a consistent composition, but does not diminish variations in cheese yield. Ideally, standardization should produce milk with uniform protein and fat concentra-

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"Rotational grazing will add some challenges to cheesemaking."

tions and reduce seasonal variations in cheese composition and yield.

To optimize yields, you should use the highest feasible concentrations of casein and fat. You can add cream to increase the fat content and evaporated condensed milk or low concentration factor ultrafiltration retentate can be used to increase the protein content of milk.

High somatic cell counts

Somatic cell counts (SCC) are high in mastitic milk and they also tend to increase as lactation progresses. Previous research suggests that increased levels of SCC in milk are associated with increased proteolytic activity, specifically increased plasmin activity. Somatic cells contain a plasminogen activator that converts plasminogen to plasmin in the mammary gland. Furthermore, the pH of late-lactation milk increases, also resulting in elevated plasmin activity. High SCC milk may inhibit starter cultures and lead to slower acid production during cheesemaking.

Reduced lactose

Lactose is involved in milk synthesis and is positively correlated with milk yield. I'm not sure if low lactose is a problem, or if it indicates problem milk. In Ireland,

"Do not use abnormal milk if you want to produce a good quality, functional cheese."

lactose peaks at 4.8 - 5.0% (May) and decreases to a minimum of 3.6 - 4.0% in November-December, depending on how low milk yield falls. The reduction in lactose content in late-lactation milk causes an increase in the concentration of Na^+ and Cl^- .

Impaired cheese functionality

In a recent study we determined the effects of late-lactation milk on functional properties of Mozzarella cheese. We found that an increased concentration of plasmin in freshly manufactured Mozzarella cheese made from late-lactation milk lead to a rapid increase in proteolysis. We also saw an increase in water-soluble nitrogen (WSN) and a decrease in the stretchability of Mozzarella. It was obvious during the cooking/stretching stage that Mozzarella cheese made from abnormal late-lactation milk had very impaired functionality. The main problems encountered when trying to produce good quality Mozzarella from abnormal late-lactation milk include:

- slow rennet coagulation
- slow acidification rate
- poor syneresis
- high moisture
- high plasmin content (milk and cheese)
- weak and less elastic body
- poor melting and stretching properties
- high proteolysis rate

Elevated moisture content and body defects are signs of impaired functionality in Cheddar cheese.

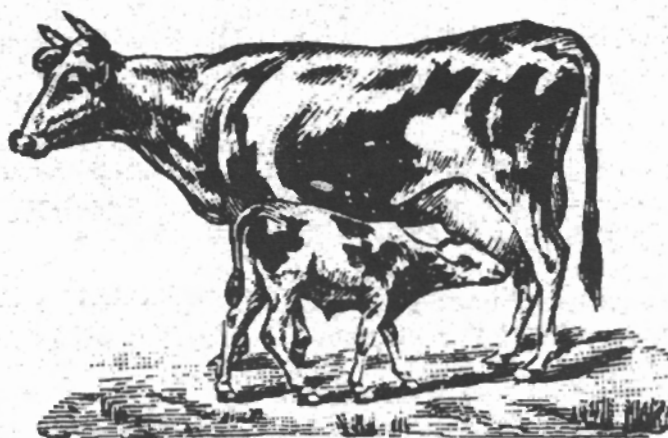
Conclusion

Rotational grazing can influence cheesemaking. A good working relationship with your patrons will help you prevent and solve the problems that you may encounter. You will also need to identify abnormal milk (late-lactation, mastitic or other abnormal types). Do not use abnormal milk if you want to produce a good quality, functional cheese.

You can identify abnormal milk based on altered milk composition or coagulation characteristics. A high milk pH (> 6.8), low lactose content ($< 4.3\%$) or high SCC ($> 500,000/\text{ml}$) are reasonable indicators of abnormal milk but the most reliable indicators for cheesemaking are the rennet coagulation properties of the milk.

Husbandry techniques essential for producing quality late-lactation milk for cheesemaking include:

- ◆ Maintain herds on a good nutritional plane, i.e., supplementary feeding when sufficient grass is unavailable



- ◆ Segregate very poor quality milk (LL, mastitic or other abnormal types)
- ◆ Dry-off cows before they attain very low milk yields (e.g., $< 5 \text{ kg/cow/d}$)
- ◆ Implement efficient mastitis/SCC control programs

Not all late-lactation milk is unsuitable for cheese manufacture; herds on a high nutritional plane and with improved milking practices produce milk which is very suitable for processing. Good quality cheese has been produced in Ireland even during the winter months with proper farm management practices.



Questions for the Curd Clinic?

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Calendar

June 25-28 American Dairy Science Association Annual Meeting, sponsored by American Dairy Science Assn. For more information call ADSA, (217) 356-3182.

July 19 Wisconsin Dairy Products Association Annual Butter and Cheese Grading Clinic. Wisconsin Dells, WI. For information call WDPA, (608) 836-3336.

Aug. 2-5 American Cheese Society Annual Conference and Cheese Judging, Green Bay, WI. For information call Dominique Delugeau, (414) 863-8791.

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

Aug. 29-30 Producing Safe Dairy Foods. Madison, WI. Call Sarah Quinones (608) 262-2217 for more details. Call CALS Conference Office to register, (608) 262-1672.

Sept. 28-29 Dairy, Food and Environmental Health Symposium. cosponsored by Wisconsin Association of Milk and Food Sanitarians, WI Association of Dairy Plant Field Reps, and WI Environmental Health Assn., Appleton, WI. For more information, call Bill Wendorff at (608) 263-2015.

Oct. 13-17 Wisconsin Cheese Technology Short Course. Madison, WI. Call Bill Wendorff at (608) 263-2015.

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