UW Dairy Pipeline

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Pipeline focus: Culture systems

Culture systems for reduced-fat Cheddar

by Dr. Roy Leach, Research Manager for Mesophilic Cultures;
Ken Von Ruden, Director of Technical Services;
Steven Lutzke, Marketing Manager;
Chr. Hansen's Laboratory, Inc.

Serious research on reduced-fat Cheddar cheese began about 12 years ago. Early attempts resulted in cheeses with a firm, rubbery body and a variety of off-flavors, most frequently bitter, brothy and meaty. Rank et al. (1) showed in the early 1980s that culture selection could influence many of these off-flavors. Recent work by Johnson et al. (2) has demonstrated that variations in make procedures, such as washing or not washing the curd during manufacture, have a strong impact on flavor development. We know that with a systems approach — a combination of the proper cultures and make procedures — an acceptable Cheddar with one-third less fat can be produced.

A successful reduced-fat system will not only produce cheese with good flavor and body and an adequate shelf life, but will also provide the

continued next page...

What's Inside:

Controlling phage: The foundation for successful cultures

by Terri Rexroat, Manager of Research & Development — Culture Products
Sanofi Bio-Industries, Inc.

Acid production at a controlled rate is the primary function of starter cultures in the cheesemaking process, and is absolutely essential for the production of a quality product. Bacteriophage attacking starter cultures and destroying their acid producing ability is among the most prevalent of starter problems. Controlling bacteriophage is therefore the foundation for a successful starter program.

Bacteriophage, also called phage, are viruses that invade and kill bacterial cells. To multiply, phage require living, growing cells to serve as a host. Cheese curd and whey contain high levels of active bacteria, and provide ample opportunity for phage to multiply in the cheese environment.

When a phage comes in contact with a susceptible bacterial cell, it attaches to specific receptor sites on the cell surface. This attachment (adsorption) generally requires free calcium ions. The phage then injects its own DNA into the cell. This foreign DNA takes control of cell metabolism to produce numerous copies of itself inside the cell. Finally, the cell will lyse, or burst, releasing dozens or even hundreds of new phage.

The period of time from phage attachment to lysis varies according to the type of phage, but averages about 35 minutes. The burst size, the number of replicas a phage makes inside each bacterial cell,

see phage, page 7...

...reduced-fat cultures, continued

flexibility for accommodating different make procedures, customer needs and consumer tastes. The ideal system accomplishes these goals by utilizing a variety of cultures and adjuncts that take into account all the variables in making a reduced-fat cheese: the use of fat substitutes, common defects and their causes, the desire to have a typical full-fat flavor, changes in composition and variations in make procedure.

Figure 1. HPLC chromatograms of six-month-old Colby-type cheeses made with low salt content and different starter cultures.

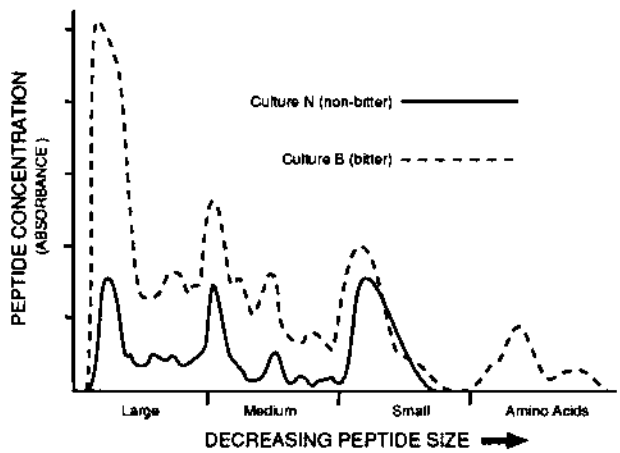
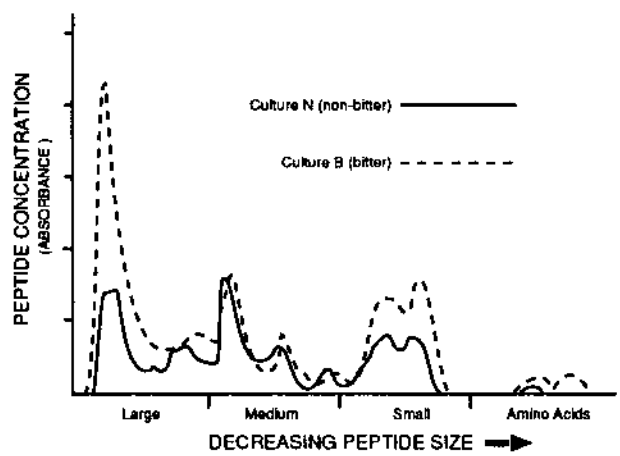


Figure 2. HPLC chromatograms of six-month-old Colby-type cheeses made with high salt content and different starter cultures.



Cultures

The basic elements of the ideal reduced-fat system are specially-selected starter cultures and adjuncts. Adjuncts are organisms, enzymes or compounds used in conjunction with a starter culture to influence specific cheese characteristics. Properly matching these special starters and adjuncts is essential. The starter cultures are selected on the basis of their phage resistance, rate of acid production, balanced enzyme profiles, and flavor production qualities. Starter adjuncts used for manufacturing natural reduced-fat Cheddar cheese include proteolytic, lipolytic and flavor-producing adjuncts.

Proteolysis and Culture Selection

Proteolysis, the breakdown of proteins and peptides through enzymatic action, is among the most critical factors in the development of Cheddar cheese flavor. Culture selection influences proteolysis more than any other factor, especially if pH and titratable acidity remain constant in a given cheese.

Proteolysis can be categorized as either primary or secondary. During primary proteolysis, protease enzymes break caseins down into peptides. During secondary proteolysis, peptidase and aminopeptidase enzymes attack the peptides, further degrading them into smaller peptides and amino acids. The relative rates of primary and secondary proteolysis produced by a culture are important in controlling flavor development in the cheese. If the culture's balance of enzymes results in rapid primary proteolysis and slow secondary proteolysis, the concentration of larger peptides builds up in the cheese. Current theory associates a high concentration of certain moderately large peptides with bitter off-flavors in the cheese. Selecting a culture with an efficient system of secondary proteolysis to degrade these bitter peptides will produce a less-bitter cheese.

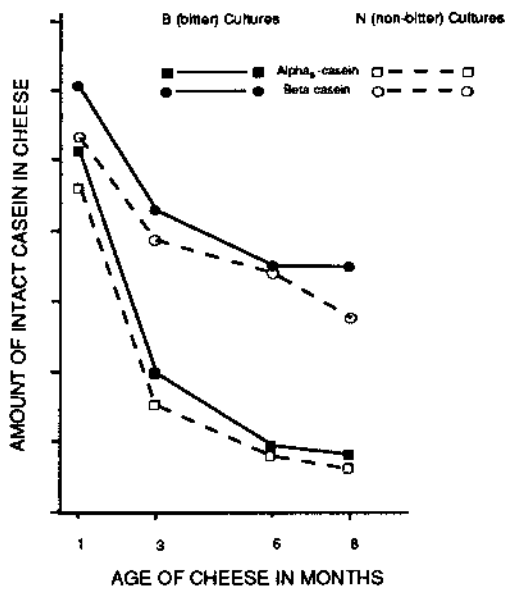
Figure 1 shows the proteolytic profiles of two different cultures when used to manufacture a low-salt cheese. One

culture produces a bitter cheese and the other produces a non-bitter cheese. The peaks on the left side of the graph represent the quantities of the larger peptides produced by each culture. Quantities of the smaller peptides and amino acids are represented by the peaks on the right. Note that the non-bitter culture produces much less of the large and moderately large peptides.

Figure 2 uses similar data to illustrate how cheese composition can affect culture selection. This figure shows the proteolytic profiles of the same two cultures when used in a high-salt cheese. Quantities of moderately large peptides produced by each of the cultures are nearly the same. Therefore, Culture B will produce a less-bitter cheese if the salt content is high.

Figure 3 shows the breakdown for two types of casein by the same two cultures. The data shown are typical of primary proteolysis. The two cultures behave similarly, indicating that the difference between the "bitter culture" and the "non-bitter culture" is in the strength of their secondary proteolytic enzymes.

Figure 3. Break-down of caseins over time in cheeses made with different starter cultures. Based on electrophoretic analysis of cheese composition.



The rate of acid production is an important point to consider in the selection of a culture. A fast acid producer has a high rate of primary proteolysis. Slower cultures have lower rates of primary proteolysis, which means that the rate of production of bitter peptides in the cheese will also be low. However, slow acid production also means that the cheese may take longer to manufacture and ripen. A culture system may utilize an adjunct designed to maintain a balance of primary and secondary enzyme activity even though the starter culture may be a relatively fast acid producer in the vat.

Proteolytic Adjuncts

Adjuncts for increasing flavor through proteolysis include protease enzymes, lactobacilli cultures and "cheese ripening" cultures. These products focus on secondary proteolysis and improve flavor quality through protein breakdown. They may also help body and texture development.

Lactobacilli: In recent trials at the University of Minnesota, the use of lactobacilli for reduced-fat Cheddar cheese was evaluated. *Lactobacillus casei* has been reported to be the most promising to date.

"Cheese ripening" cultures: Cheese ripening cultures are specifically high in aminopeptidases, the enzymes that break peptides down into amino acids. They are designed to increase the rate of secondary proteolysis, decrease bitterness and enhance flavor.

Lipolytic Adjuncts

Lipases are enzymes that break fat down into free fatty acids. While the role of fat in Cheddar flavor development is still largely unknown, many investigators feel that free fatty acids play an important role in typical flavor development. Some hypothesize that the surfaces of fat globule membranes are critical for flavor reactions. Research has indicated that, when used alone, starter cultures have little influence in this area. With reduced-fat products, certain flavor notes related to fat breakdown may be missing and need to be added through the use of lipases. The new broad-spectrum microbial lipases have shown promise.

...reduced-fat cultures, continued

Flavor-producing Adjuncts

Leuconostoc and *diacetylactis** are cultures currently used in many dairy products to produce flavor and aroma. These organisms provide butterfat/diacetyl flavors that could be beneficial for reduced-fat cheese. In early reduced-fat cheese trials it was observed that cheese made with a culture containing *Leuconostoc* was less bitter than cheese made with a culture without *Leuconostoc*. Both organisms have excellent flavor production qualities along with the low acid and gas production levels desired.

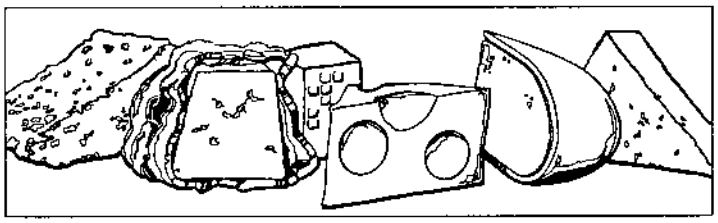
Conclusion

Experience and past research have shown that with proper cultures and make procedures an acceptable reduced-fat Cheddar cheese can be produced. However, many challenges remain in developing flexible, adaptable systems that both meet the needs of the cheesemaker and enhance the flavor of reduced-fat cheeses to the level of their full-fat counterparts. By taking a total systems approach, we hope to allow cheesemakers to select the necessary elements for customizing their cheeses to suit their particular markets, customers and procedural needs. ■

1. Rank, T.C. Proteolysis and flavor development in low-fat and whole milk Colby and Cheddar-type cheeses. Ph.D. Thesis, University of Wisconsin, 1985

2. Johnson, M.E. and C.M. Chen. Making quality reduced-fat cheese. *Center for Dairy Research Cheese Research and Technology Conference Proceedings*. March 6-7, 1991, Madison, WI

* *Lactococcus lactis* ssp. *lactis* biovar. *diacetylactis*



The Curd Clinic

Question: Recently, we've had problems with our reduced-fat Cheddar cheese developing cracks and inflating its package on the store shelf. So far, our full-fat Cheddar hasn't done this. What's wrong with the reduced-fat cheese?

Answer: Slits, cracks, holes, and blown packages are all common problems caused by gas-forming microorganisms in cheese. Non-starter bacteria and yeasts that contaminate the cheese can ferment sugars or other compounds to produce gas. The gas, usually carbon dioxide, builds up pressure inside the cheese and can split Cheddar open. In elastic cheeses, such as young Swiss, the gas forms round eyes rather than cracks.

Gas problems may begin soon after the cheese is made, or they can take several months to develop. Often gas formation goes unnoticed until the cheese is on the retail shelf. Cheese in the store may be kept at a high enough temperature to allow non-starter bacteria in the cheese to become active and produce more gas. Or gas already in the cheese may expand when the cheese is warmed. Either way, the result can be slits and blown-up packages.

Potential gas-producers in cheese include coliforms, yeasts, lactobacilli, clostridia, lactococci, propionibacteria, bacilli and *leuconostoc*. However, in our recent investigations we found the most common sources of gas in cheese to be non-starter strains of lactobacilli.

The lactobacilli used in starter cultures form lactic acid as a by-product of lactose fermentation. Because they produce only lactic acid, these strains are called homofermentative lactobacilli. *Lactobacillus helveticus* and *Lactobacillus bulgaricus* are examples of homofermentative strains used in starter cultures. But many wild lactobacilli ferment lactose heterofermentatively, i.e., they produce carbon dioxide gas in addition to lactic acid.

These heterofermentative lactobacilli were the gas-producers in 18 of 22 different cheeses sent to CDR for analysis. In two more of the cheeses, we were unable to identify the source of gas, but suspect lactobacilli or bacilli. In the remaining two samples, gassiness was caused by clostridia.

Whether or not these organisms actually produce gas in a given cheese depends on the characteristics of that particular cheese. Some cheeses provide a more hospitable environment for gas formation than others. Factors favoring the growth of contaminating organisms are slow acid development, residual sugar, high pH, high moisture and low salt. Insufficient acid development gives contaminating organisms an opportunity to grow. Gassiness is sometimes a symptom of using a culture slowed by phage attack or by antibiotic residue in the milk. Under these conditions, any non-starter organisms can multiply rapidly. Some non-starter lactobacilli, for example, can double every 45 minutes at 90°F.

Reduced-fat cheeses are more susceptible to gas problems than full-fat cheeses because they usually have higher moisture, higher pH, lower salt in the moisture and take longer for acid to develop. Reduced-fat cheeses are especially vulnerable to gassiness if made using a washed-curd make procedure, because washing increases the moisture content and removes acid.

Even if initial pH is low enough to inhibit non-starter activity, gas-formers can resume growth months later as the cheese ages and the pH rises. Gas formation has only been delayed. Likewise, lack of residual sugar discourages only those organisms that require sugar. Several gas-forming bacteria metabolize other available compounds, such as lactic, citric or acetic acid. The only sure way to prevent gas formation is to prevent contamination in the first place. The keys to preventing contamination are good raw milk quality, proper pasteurization and especially plant sanitation.

With the possible exception of milk with abnormally high counts of heat-tolerant strains, pasteurization will nearly eliminate all non-starter lactobacilli in the cheesemilk. In a recent CDR project on the heat-resistance of non-starter lactobacilli, we subjected 107 different strains of lactobacilli to pasteurization conditions of 161°F for 17 seconds. We found that, for most strains, this level of heat treatment produced a reduction of eight log cycles, or a reduction of from one billion cells per ml to fewer than 1 cell per ml of milk. Spore-formers can cause gas problems when as few as five per ml are present after pasteurization. We suspect the same may be true for non-starter lactobacilli.

Only two of the strains studied, *L. casei* and *L. plantarum* showed any potential to survive pasteurization. These two species showed a reduction of three log cycles. If present in abnormally large quantities — i.e., 10,000 cells per ml of milk — these species could survive pasteurization in sufficient numbers to affect the cheese. However, neither of these is heterofermentative. *L. casei* and *L. plantarum* are facultatively heterofermentative, which means they can produce carbon dioxide from the fermentation of citric acid or, when sufficient oxygen is present, lactic acid. Since they do not produce gas from lactose, they are less likely to be a problem than heterofermentative strains.

Coliforms with the potential to form gas are even more sensitive to heat than are the lactobacilli. They will also be eliminated during pasteurization. Since pasteurization is so effective against gas-forming organisms, gassy cheese is a good indication that you need to do a better job cleaning and sanitizing.

However, bacterial spores and yeasts can survive pasteurization. If gassiness is caused by a spore former, such as clostridia, you will want to check into the quality of your raw milk. Milk can be contaminated on the farm though dust and airborne organic matter. Spores in your cheesemilk may enter your cheesemilk through condensed milk, nonfat dry milk, skim milk or cream used for standardization.

Finally, pay attention to how the cheese is handled through ripening and distribution. Cool it rapidly and keep it below 45°F to slow the growth of non-starter bacteria. To prevent blown packages the cheese should ripen as little as possible in the consumer package, so hold off on final packaging.

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

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

This and that...

Dr. William Sandine, professor of microbiology at Oregon State University, will teach a two-week graduate-level course at UW-Madison this summer. The class "Starter Cultures," is a one-credit course offered by the Department of Food Science July 20-Aug. 2. Sandine will also participate in CDR's Mentor program during his visit. As a mentor, he will meet with UW microbiologists Mark Johnson, Jim Steele and John Luchansky to discuss aspects of their research.

Retired New Zealand Dairy Research Institute Director **Peter Robertson** arrived at CDR for a three-month visit in late March. While at CDR, Dr. Robertson will assist in planning new research with an emphasis on the development of commercial technologies. He will also assist in structuring the research relationship between CDR and the New Zealand institute, where he enjoyed a 35-year career before retiring in 1988.

Associate Professor of Food Science **Rich Hartel** will host a meeting with a trio of milkfat researchers from Canada and New Zealand on June 18-19. **Dr. Armand Boudreau**, professor of Food Science and Technology at Laval University in Canada, **David Illingworth**, senior researcher at the New Zealand Dairy Research Institute, and **Dr. Selwyn Jebson** of Massey University in New Zealand, will spend two days on campus discussing milkfat research with a number of UW scientists. Dr. Jebson is a co-principal investigator on Dr. Hartel's WMMB-sponsored project, "A new technology for milkfat."

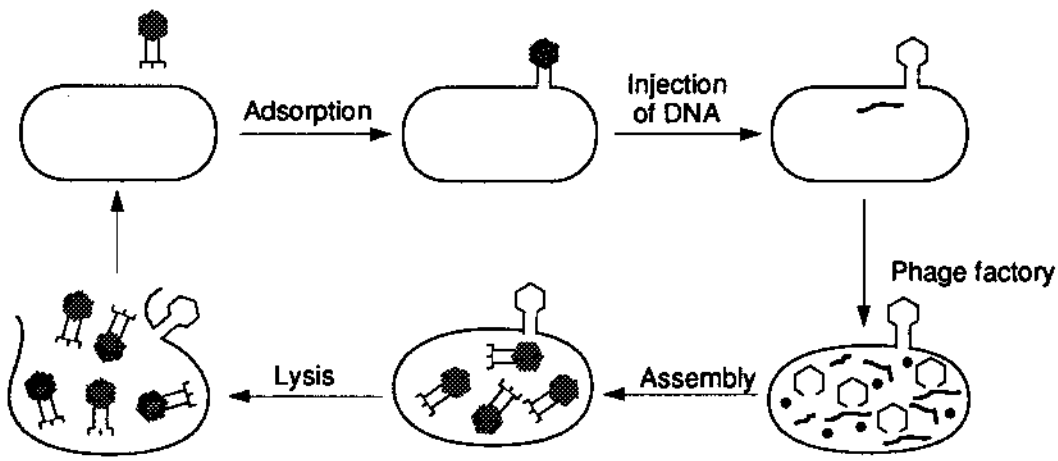
1992 Dairy Products Technical Conference

April 29-30, 1992
O'Hare Marriott, Chicago, IL

Co-sponsored by:
American Dairy Products Institute/Wisconsin Center for Dairy Research
Chicago, IL Madison, WI

April 29	**Session I**
8:30 a.m.	**Assaying Milk Quality;** Dr. Larry L. Claypool, Mid-American Dairymen, Inc.
9:15 a.m.	**Genetic Modification of Milk Composition for Dietary & Pharmaceutical Markets;** Dr. Robert D. Bremel, University of Wisconsin
10:00 a.m.	**Break**
10:30 a.m.	**Cleaning & Sanitizing UF Membranes Used in Whey Processing;** Dr. Robert L. Bradley, University of Wisconsin
11:15 a.m.	**Using a Total Quality Concept to Ensure Finished Product Quality;** Douglas R. Engebretson, Land O'Lakes, Inc.
12:15 p.m.	**Luncheon: Is Drinking Milk Really Good for You?** Dr. Joseph A. O'Donnell, Executive Director, California Dairy Foods Research Center
	Session II
2:00 p.m.	**Producing Alcohol Fuels from Whey & Co-products;** Dr. Khem M. Shahani, University of Nebraska
2:40 p.m.	**Developing Edible Films from Milk Proteins;** Dr. John M. Krochta, University of California-Davis
3:20 p.m.	**Break**
3:45 p.m.	**CMA Production from Whey Permeate;** Dr. Shang-Tian Yang, The Ohio State University
4:15 p.m.	**Production of Degradable Polymers from Food Waste Streams;** Dr. Shih-Perng Tsai, Argonne National Lab.
7:00 p.m.	**Western Comedy Dinner Show: The Dry Gulch**
April 30	**Session III**
8:30 a.m.	**Functional Properties of Milk Proteins Essential to Food Applications;** Dr. Michael E. Mangino, The Ohio State University
9:15 a.m.	**Control & Improvement of Whey Product Foaming Properties;** Dr. David M. Barbano, Cornell University
10:00 a.m.	**Break**
10:30 a.m.	**Potential for Milk Protein Use in Meat Products;** Dr. Curtis M. Amundson, Oscar Meyer, Inc.
11:15 a.m.	**Use of Probiotics in Veal Feeds;** Dr. William Aimutis, New Zealand Milk Products, Inc.
12:15 p.m.	**Luncheon: Development of the Whey Processing Industry — Domestically & Internationally;** Bernard S. Horton, Horton International, Inc.

Cost for the Conference, including two luncheons, is $150 with pre-registration or $175 for on-site registration. For information contact ADPI at (312) 782-4888.



The bacteriophage lytic cycle

(Adapted from Freifelder, 1983. Molecular Biology, Science Books International, Portola Valley, CA)

...phage control, from page 1

usually ranges from 25 to 250 phage per cell.

A typical starter culture bacteria divides every 30 minutes. At that rate, one starter culture cell will divide twice to make four cells in an hour. By contrast, a single phage with a burst size of 150 and a latent period of 30 minutes can produce 22,500 new phage in one hour. Each of these replicate phage are capable of infecting and killing other host cells they contact. It is therefore apparent that phage can quickly take over a starter culture.

Phage control begins with proper starter culture selection and management. In addition, starter culture media provide a component of phage protection. Bulk starter programs utilize culture media to economically grow the large volumes of starter culture required for the fermentation process. Phosphate salts in the media bind free calcium ions, making them unavailable for phage to use in attaching to starter cells. Media sterilization provides the heat needed for this reaction to occur.

Starter culture systems currently used for phage control can generally be categorized as either multiple-strain culture rotation programs or defined-strain culture programs. Multiple-strain cultures were the first widely utilized commercial culture programs, and have been used successfully for over 25 years. Using a number of slightly different multiple-strain cultures (usually 15-20) on a rotating basis provides phage protection based on the principle that different bacterial strains are susceptible to attack by different types of phage. One culture is used for one fill of the plant's vats, then another culture with different phage-resistant characteristics is used for the next fill, and so on through the rotation.

Multiple-strain cultures normally contain from three to five phage-unrelated bacterial strains mixed together. This combination of multiple strains provides some protection against phage attack. However, given time, phage can adapt to attack a bacterial strain that was previously resistant. Rotating the cultures gives each type of phage less access to the specific strains of bacteria in which it can multiply and less opportunity to adapt to a specific environment.

When using a multiple-strain rotation, all the cultures used in the rotation should be from the same supplier. Some cheesemakers include cultures from different suppliers in their rotations, assuming that the cultures are substantially different from one another in phage resistance. In reality, culture suppliers have designed their rotation programs to maximize the differences in phage tolerance between the strains in their own program. Using cultures from two different programs is likely to neutralize the careful planning both suppliers put into their products.

Because each multiple-strain culture has its own characteristics, the final pH and moisture of

the cheese will vary accordingly. A more recent development in culture technology, the defined-strain approach, makes it easier to produce consistent cheese because the number of cultures in the rotation is significantly smaller. This type of phage control currently dominates the industry for cheeses made with mesophilic starters.

In a defined-strain program, each strain has been extensively studied and characterized, so its cheesemaking and phage-resistance properties are well understood. These strains are more tolerant of phage, and the phage that do attack them are likely to be slow multipliers. Use of a limited rotation provides additional phage protection. As with multiple-strain cultures, several strains are normally used together for optimal cheesemaking properties and phage-resistance. But unlike multiple-strain cultures, the combinations contain known ratios of each strain.

How often defined-strain cultures are rotated varies from plant to plant, and is based on intensive monitoring of phage activity. Usually, a single culture can be used for an entire day. Use of fewer cultures in the rotation allows for better control of acid production for day-to-day cheese manufacture. This results in better final pH and moisture control and often a more uniform cheese flavor.

A disadvantage of using a defined strain program is that recovering from a serious phage attack may be more difficult and costly than if a multiple-strain rotation were being used. If phage knock out a defined strain, immediately replacing it with another strain may be difficult since more factors must be considered in choosing the replacement than in the multiple-strain rotational program. If phage prevent culture growth in the starter room, the plant may be forced to use costly direct vat inoculants for the day. Therefore the success of a defined-strain program depends on timely and accurate phage monitoring. Regular monitoring can detect phage and allow for culture substitution while phage levels are still low.

Monitoring can be done at the plant, or whey samples can be sent to the culture supplier for analysis. Suppliers may provide training for plant personnel or test kits for basic qualitative activity tests. Simple, qualitative tests are done by inoculating whey into vials containing bromcresol purple pH indicator and culture strains. Comparing acid production rates between vials with added whey and control vials allows for detection of inhibitory levels of phage. A more complex, but more accurate, quantitative plating method is used to determine actual phage numbers when decreased acid production is observed.

Phage can never be completely eliminated from the plant environment, so special care must be taken to keep infection to a minimum. Physical separation of all the processing areas is the ideal in plant layout. This is especially important for the starter room since no culture program will be viable with phage in the starter room. Since phage inhibitory media prevent replication but do not kill phage, phage in the starter will end up in the cheese vat. Starter room equipment must be well maintained and kept thoroughly clean and sanitized. A separate air supply with positive pressure for the starter room will also help.

Sanitation is also important outside of the starter room. Vats should be cleaned and sanitized between fills, and floors kept clean and dry to lessen the potential of phage transport on boots. Whey is a particularly fertile breeding ground for microorganisms, including phage. Phage problems are more prevalent in the cheese industry than in the cultured products industry primarily due to physical separation of curd and whey, and subsequent processing of large volumes of whey. Whey handling should be located as far as possible from the starter room, the pasteurizer surge tank and the cheese vats.

Personnel play a significant role in contamination control. Starter room personnel should avoid going into other areas of the plant, but since that is usually impractical, it is critical that they properly sanitize before entering the starter room. Personnel should be aware that they are carrying phage on their boots, hands and clothing. Chlorine foot baths and hand washing sinks must be provided for personal sanitation.

Culture suppliers and cheese/cultured products manufacturers must work together to minimize phage problems and maximize starter program potential. Quality cultures, proper use of starter programs, accurate monitoring and good plant sanitation are all necessary elements in building a foundation for effective phage control.

Sanitation

Beating *Listeria*: Tips from the WDATCP

by Mike Barnett, Technical Specialist (Food Division of the Wisconsin Department of Agriculture, Trade and Consumer Protection)

Following the California listeriosis outbreak in 1985, the U.S. Food and Drug Administration initiated a dairy plant survey program that includes plant inspection and product and environmental sampling. Still, *Listeria monocytogenes*, the organism responsible for listeriosis, is occasionally detected in finished dairy products, forcing the plant to halt operation for a period of time and/or recall and destroy finished product.

Proper pasteurization, vat or HTST, will inactivate *Listeria*, as well as all other pathogenic organisms other than spores. Pathogens in finished product are nearly always introduced through post-pasteurization contamination.

Protect your products from *Listeria* and other pathogens by paying special attention to sanitation of the processing equipment and the plant areas used between pasteurization and packaging. These areas and equipment need frequent and complete cleaning and sanitizing. This includes overhead shields, overhead supports, and conveyors. Keep floors, walls, and ceilings dry and free of condensate. Pooling of milk, water, or other processing wastes must be minimized.

In addition, you can reduce the risk of introducing potentially harmful microorganisms in sensitive areas by watching:

Plant Traffic

Minimize employee movement between plant areas. Those handling raw dairy ingredients (milk haulers, intake people) should not move into finished product areas or work with pasteurized, finished product. Employees must be trained to recognize the importance of cross contamination. Review and restrict the movement of pallets, forklifts, and equipment from the raw ingredients areas to the pasteurized products area. Brushes used in one area should be restricted to that area.

Equipment Design

Eliminate pitted, corroded, and threaded product-contact equipment. Threads, if needed for safety or other functional reasons, must be of a sanitary design. Inspect equipment blueprints and actual equipment to be sure there are no cross-connections that can cause co-mingling of pasteurized and unpasteurized product.

Product Reworking

Treat all reworked product as a raw ingredient.

Ice Cream Barrel Freezers

Make sure that clean, filtered air is available and used. Keep the areas around the air intake clean. Floors and drains must be constructed and maintained to insure drainage. Drains should not be located near the filling or packaging equipment.

Cleaning and Sanitizing Procedures

Clean all product contact surfaces after use and sanitize prior to use. Minimize or eliminate the use of high pressure hoses and unshielded pumps in order to minimize aerosol formation.

Eliminate the use of absorbent sponges or rags. These act as a "microbiological zoo" that can cause the spread of microorganisms. Separate brushes should be used for product and non-product contact surfaces.

Record Keeping

Maintain and review time/temperature records for holding tanks, pasteurization, storage rooms, and clean-in-place equipment which is not physically inspected. Take corrective actions when records indicate a problem is developing.

The items listed above will reduce the potential for problems with *Listeria* or other undesirable bacteria in your plant and products. For more information, contact Mike Barnett at (608) 266-1450.

UW dairy research projects: Cheese technology

Numerous dairy foods research projects are underway at UW-Madison. The following are only those involving cheese technology.

1. Construction of a gene bank of *Lactobacillus helveticus* CNRZ 32: Cloning and characterization of the aminopeptidase and threonine aldolase genes. Dr. James Steele, Dept. of Food Science. (NDPRB) 7/89-6/92

2. Physical and thermal properties of different cheeses. Dr. Sundaram Gunasekaran, Depts. of Agricultural Engineering /Food Science. (NDPRB) 5/90-4/93

3. Effect of post-processing on cell viability, cell permeability, and enzyme activity of *Lactobacillus helveticus* cheese starter culture adjunct. Dr. Mark Etzel, Dept. of Food Science. (NDPRB) 10/89-9/92

4. Development of a systematic approach for producing cheese as a food ingredient. Dr. Norm Olson, CDR/Dept. of Food Science. (WMMB) 1/90-12/93

5. Control of color formation in smoked cheese. Dr. William Wendorff, Dept. of Food Science. (NDPRB) 9/90-8/92

6. Effect of fat, moisture, and salt on the freezing qualities of Cheddar cheese. Dr. William Wendorff, Dept. of Food Science. (NDPRB) 7/90-6/92

7. Improving the flavor of enzyme-modified cheeses by control of lipase action in supercritical CO_2. Dr. Richard Hartel, Dept. of Food Science. (CRI) 7/89-6/92

8. Development of an economic engineering microcomputer model for analysis of cheese plant operation. Dr. Brian Gould, CDR/Dept. of Agricultural Economics. (WMMB)

9. Mechanisms of injury to *Lactococcus lactis* ssp. *lactis* during spray drying. Dr. Mark Etzel, Dept. of Food Science. (NDPRB) 1/91-6/92

10. Effect of starter culture produced glutathione on cheese flavor development. Dr. James Steele, Dept. of Food Science. (NDPRB) 1/91-6/92

continued next page...

Project Profile:

Effect of fat, moisture, and salt on the freezing qualities of Cheddar cheese, Dr. Bill Wendorff, Dept. of Food Science

Through this project, Dr. Wendorff and his research group are attempting to determine how changes in fat, moisture and salt content effect the freezing qualities of Cheddar-type cheese. They hope to predict what types of specialty cheeses could be successfully frozen, and to identify methods to improve the texture of thawed cheeses.

The ability to maintain high quality in frozen cheeses would provide the industry with increased flexibility in manufacturing and marketing. Processors would be able to increase production when milk prices are low, then hold the cheese for periods of lower production. By freezing at the proper stage of ripening, a quality supply of specialty cheeses could be easily managed to fit any number of marketing options.

During the first phase of this study, the researcher manufactured Cheddar cheeses with three different fat levels, three moisture levels and two salt levels. The cheeses were aged for 60 days and then flash frozen in a -30°C blast freezer. After storage at - 18°C for 90 days, the quality of frozen and thawed cheeses was evaluated using the Instron Universal Testing Machine and sensory evaluations by trained panelists. Testing and sampling was conducted immediately after thawing and again after two, four, and eight weeks to determine the effect of aging on texture and flavor. Data gathered during these tests are currently being analyzed and interpreted.

11. Genetically-modified bacteriocinogenic lactic starter cultures and associated bacteriocins for control of pathogenic bacteria in unpasteurized high-moisture cheese products. Dr. John Luchansky, Food Research Institute. (NDPRB) 7/91-6/93

12. Examination of thermoinducible bacteriophages from temperature-sensitive strains of *Lactococcus lactis* ssp. *cremoris*. Dr. James Steele, Dept. of Food Science. (Hatch Grant) 1989-1992

13. Characterization of the X-prolyl dipeptidyl aminopeptidase gene and its influence on milk protein degradation. Dr. James Steele, Dept. of Food Science. (NDPRB) 1/92-6/92

14. Development of new starter adjunct strategies for improved quality and intensity of flavors in Cheddar-type cheeses. Dr. Robert Lindsay, Dept. of Food Science. (NDPRB) 1/92-1/93

15. Enhancing flavor characteristics and maturation rate of cheese by selected enzymatic and microbial treatments. Dr. Norm Olson, CDR/Dept. of Food Science. (NDPRB) 6/90-6/93

Resource Center

New CDR Videotape

"Physical Chemistry of Milk and Dairy Products," a new videotape selection featuring Dr. Pieter Walstra, is now available through the CDR Video Library. The program was recorded during a two-week graduate-level course taught at UW-Madison July 22-Aug. 2, 1991. A 10-tape set, the complete package runs a total of 16 hours, 20 minutes, and includes written course materials.

Course instructor Dr. Walstra is a professor and chair of the Department of Food Science at Wageningen Agricultural University, The Netherlands. An internationally-known dairy scientist, his course covers the structural elements of milk, their changes during processing and how they affect milk and dairy product properties.

Tape 1: Structural elements of milk — physical and physicochemical aspects.
Tape 2: Milkfat globules — size distribution and fat globule membrane properties, cold agglutination and creaming.
Tape 3: Homogenization of milk and cream.
Tape 4: Fat crystallization.
Tape 5: Stability of fat globules.
Tape 6: Casein micelles — composition and structure.
Tape 7: Colloidal stability of casein micelles.
Tape 8: Renneting of milk — enzymatic and aggregation reactions.
Tape 9: Syneresis of acid and rennet milk gels.
Tape 10: Cheese structure and rheology.

Cost for the complete set is $175. To order, or for more information call CDR Videotapes at (608) 262-2217.

IDFA Labeling Manuals & Workshops

The International Dairy Foods Association plans to publish a series of manuals covering changes in dairy products labeling regulations by the end of the year. National Cheese Institute and American Butter Institute members will receive manuals on cheese and butter labeling respectively, while Milk Industries Foundation and International Ice Cream Association members will receive manuals focusing on their products. Prices for non-members, or for additional copies for members, have not yet been determined. The manuals will address all aspects of labeling, and will include an index, appendices and references. They will be available by January 1993, shortly after the new Food and Drug Administration labeling guidelines are finalized. They will also be featured at 10 IDFA Labeling Workshops, scheduled for January, February and March of 1993 in various cities around the nation. For more information on the manuals or the workshops, call IDFA at (202) 296-4250.

Milk Quality Improvement Report

The New York State Milk Quality Improvement Project at Cornell University recently published its 1991 Interim Annual Report. Projects summarized include the Fluid Milk Plant Quality Assurance Visitation and Shelf Life Program, a twice-per-year sampling of every fluid milk processing plant in New York, and the Total Quality Program-Cultured Dairy Products, a program monitoring the initial and keeping quality of cottage cheese. To receive a copy of the report contact Pat Curran of the Northeast Dairy Foods Research Center at (607) 255-2889.

Calendar of Events

April 21-24 ***Basic Cheesemaker's License Short Course.*** River Falls, WI. Call Ranee May at (715) 425-3150 for information.

April 29-30 ***Dairy Products Technical Conference,*** O'Hare Marriott, Chicago, IL. Sponsored by CDR and the American Dairy Products Institute. See program, page 6. For more information, call Dr. Warren Clark, Jr., at (312) 782-4888.

June 4-5 ***Wisconsin Cheese Grading Short Course.*** Madison, WI. For details call Bill Wendorff at (608) 263-2015. To register call the CALS Conference Office at (608) 263-1672.

July 15 ***Wisconsin Dairy Products Association Annual Cheese and Butter Evaluation Clinic.*** Wisconsin Rapids, WI. To register, or for more information call Brad Legreid at (608) 221-1035.

Aug. 17-21 ***Milk Pasteurization and Process Control School.*** Madison, WI. For information call Bob Bradley at (608) 263-2007. To register call the CALS Conference Office at (608) 263-1672.

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Sarah Hundt Quinones, Managing Editor
David Gaeuman, Editor

We welcome your questions and input. Send correspondence to:

The UW Dairy Pipeline
CDR, 1605 Linden Dr. , Madison, WI 53706
Phone: 608/262-8015 or 608/262-2217
FAX: 608/262-1578

Technical Reviewers:
Mark Johnson, Senior Scientist, CDR
Norman Olson, Director, CDR
Jim Path, Cheese Outreach Specialist, CDR
Tom Szalkucki, Administrative Officer, CDR
Bill Wendorff, Asst. Professor, Dept. of Food Science

Aug. 19-22 ***American Cheese Society 9th Annual Conference.*** Madison, WI. Includes the ACS annual American specialty cheese tasting and competition. For more information call ACS at (212) 727-7939.

Sept. 21-25 ***Wisconsin Cheese Technology Short Course.*** Madison, WI. For information call Bill Wendorff at (608) 263-2015.

CDR
CENTER FOR DAIRY RESEARCH
University of Wisconsin-Madison
1605 Linden Drive
Madison, Wisconsin 53706

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