Wisconsin Center for Dairy Research

DAIRY PIPELINE

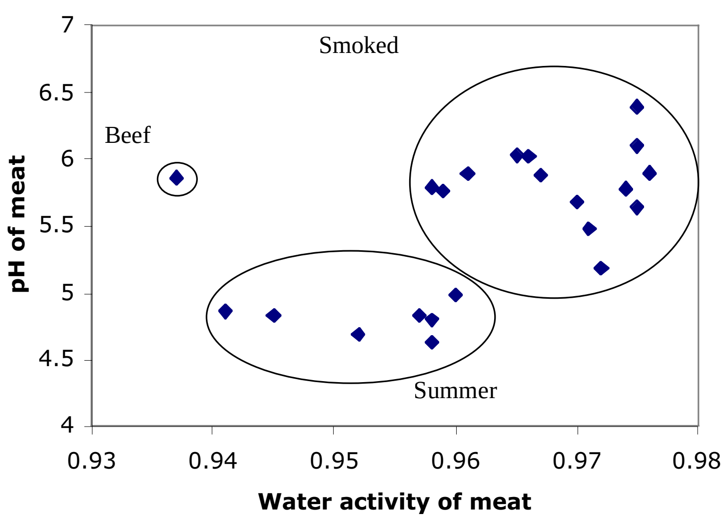
A Technical Resource for Dairy Manufacturers
Volume 18 Number 2 2006

Controlling moisture migration between cheese and sausage

By K. Mandl, R.W. Hartel and W.L. Wendorff, Dept. of Food Science

Specialty sausage manufacturers have encountered a few problems when adding cheese to their product. In fact, during the 2002 Wisconsin State Meats Contest, over 75% of the specialty sausages with added cheese were downgraded due to soft, mushy cheese pieces in the product. Sometimes called "cold melt," the cheese texture changes during refrigerated storage. Cold melt is the result of moisture moving from processed meats, like beef sticks, cooked summer sausage, salami, and smoked sausages to the natural cheese pieces. Some meat processors use highly stabilized pasteurized process cheese pieces to minimize the moisture migration problem. However, the process cheese pieces lack characteristic natural cheese flavor and are limited to American and Swiss types of process cheese.

Figure 1.



We examined the causes of moisture migration with the goal of developing methods to prevent it. By doing so, we hope to increase the use of uniquely flavored natural cheese in specialty sausage products. To begin, we sampled 24 commercial cheese-in-sausage products and evaluated them for moisture migration and cheese softening problems. The initial water activities and pH values of the sausages are shown in Figure 1.

When we measured the water activity of both the meat and cheese components we found that, over time, the water activities of the two components came to equilibrium. The softness of the cheese was subjectively placed into one of three categories: firm, soft, or fluid. Of the 24 samples, five fit into the fluid category, 12 fit into the soft category, and seven fit into the firm category. All of the products in the firm category were fermented summer sausage products. All of the products in the fluid category contained natural cheese. All processed cheese products fit into the soft category along with the other summer sausage and natural cheese products that did not fit in the extreme categories. The products with the highest equilibrium water activities fell into the fluid category and the products with the lowest equilibrium water activities fell into the firm category. Our initial sampling led us to conclude that free moisture plays an important role in the cold melt defect.

Controlled study

We then conducted a 2 X 2 X 2 full factorial study using a beef/pork salami-type formulation with 55 or 65% moisture, 1.5 or 2.5% salt, and a fat-to-protein ratio of 1.15 or 2.15. Once the sausages were processed and

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What's Inside:

Applications Update

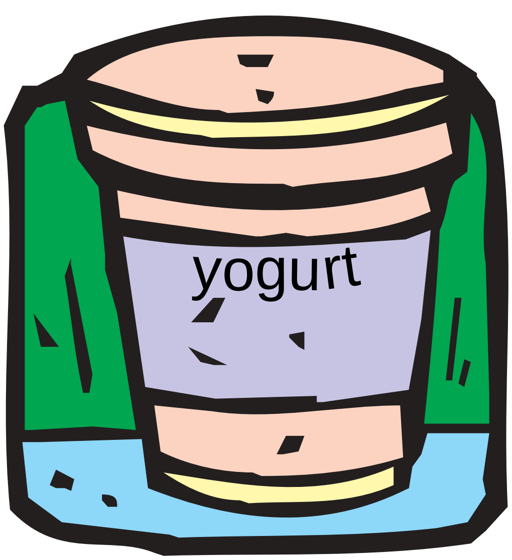
Yogurt—it's a food ingredient, too!

by Kathy Nelson, Wisconsin Center for Dairy Research

People in the Middle East have eaten yogurt for thousands of years, and now this fermented milk product is popular around the world. In fact, yogurt is in demand both as a food and a food ingredient. Perhaps yogurt appeals to so many because it offers a variety of benefits. Not only does it preserve the nutrients of milk, but it also makes milk more digestible, and it contains seven sought after nutrients; calcium, potassium, fiber, magnesium, and Vitamins A, C, and E.

Although most of the commercial production of yogurt uses cow's milk, milk for yogurt can come from many sources. Whole milk, partially skim milk, skim milk, or cream are all used to make yogurt. What's important is that the milk has a low bacteria count, is free from antibiotics, microbial growth inhibiting chemicals and virusesor phage.

The first step in yogurt production is standardizing the milk to a solids level between 12 and 16%. You can do this by evaporating water from the milk or by adding dairy powders like nonfat dry milk or whey protein concentrate. Then, the milk is heat-treated at a temperature of 185˚ F for 30 min, or 203˚F for 10 minutes, a treatment more stringent than pasteurization. This heat-treatment alters the casein micelles, which promotes casein/β-lactoglobulin binding. In addition, it denatures the whey proteins to enhance the thickness of yogurt and it leaves the milk relatively sterile, which allows the growth of added cultures. Next, the milk is homogenized, lactic acid bacterial cultures are added, and the mixture is held at elevated temperatures (approximately 108˚F) for several hours.



Starter cultures are one of the biggest influences on yogurt texture and flavor. Yogurt producers in North America legally must use a blend of *Streptococcus salivarius ssp thermophilus* (ST) and *Lactobacillus delbrueckii spp bulgaricus* (LB). These living organisms respond to many things, including temperature, nutrients, pH, and inhibitory chemicals. ST and LB are both thermophilic organisms; they grow best at higher temperatures. However, the temperature optimum is different for each of the organisms (104˚ F for ST, and 116˚ F for LB). These bacteria convert the milk sugar, lactose, into lactic acid, which gives yogurt its tart taste and provides an environment unfavorable for pathogen growth. Acetaldehyde, which is the characteristic flavor in yogurt, is one of the metabolic products derived from the amino acid threonine, primarily by LB, not ST. Other flavor components which are produced during the fermentation include diacetyl and acetoin.

ST and LB can grow independently, but when used together in a ratio of 1:1, they produce acid at a much higher rate. ST grows faster, produces acid and carbon dioxide, and is responsible for the initial drop to pH 5.0. Metabolic products from ST stimulate the growth of LB , which in turn is responsible for a further drop to pH 4.0. Gels will generally not form until the pH is at least 5.3. As lactic acid accumulates, casein is de-stabilized allowing binding to occur between the casein micelles, and β-lactoglobulin, the major whey protein. Eventually a large network of interacting proteins is formed, trapping water inside to produce a semi-solid product that is high in water content. As the pH decreases to 4, the cultures tend to lose activity, although some strains are more acid-tolerant than others. Fermentation times vary with different strains, and could take anywhere from 1 to 8 hours, depending on the incubation temperature, and the amount and type of sugar present. Yogurt is generally fermented to a final pH of 4.6 to 4.7, and then chilled to minimize further acid production.

The texture and viscosity of yogurt are influenced by the formation of the protein network with its entrapped water. One of the most common defects in yogurt is called "syneresis." You can see it when water, lost from the protein network, appears as a

Table 1. Typical composition of yogurt and dehydrated yogurt

	Fat free plain yogurt	Fat free dehydrated yogurt
Water, (%)	87.3	4.0
Fat, (%)	<1.0	Trace
Protein, (%)	5.2	34.0
Lactose, (%)	6.8	52.0
Ash, (%)	0.7	9.0
Calcium, (mg/100 g)	193.0	1250.0

" Yogurt enhances flavor, nutrition and moisture ..."

slightly cloudy free liquid on top of gelled yogurt. Many factors affect the protein network formation, its strength, and its tendency to lose water. They include heat treatment of the initial milk, bacterial strains, incubation temperature, amount of solids, and the processing conditions.

Dehydrated yogurt is used as an ingredient in many snack-type products, particularly coatings or frostings. Once the yogurt is cultured, it is taken through a spray-drying process that removes most of the water. The result is a dry powder with a tart dairy flavor, similar to yogurt, but milder. Many of the starter bacteria do not survive the spray-drying process, and their associated health benefits are lost. However, encapsulation has been used successfully to "protect" bacteria during drying. The calcium contribution it adds to a product is the major nutritional benefit of using dehydrated yogurt as an ingredient. Dehydrated yogurt also contributes protein, lactose and an assortment of other minerals besides calcium.

Many people eat yogurt right out of the carton, primarily for breakfast, or as a snack or dessert. You can find it plain or sweetened, with or without fruit, grains, nuts, or other ingredients. However, yogurt also offers benefits when used as an ingredient in entrees, desserts, baked goods, beverages, coatings, and snacks. For example, yogurt enhances flavor, nutrition and moisture in muffins, quick breads or yeast breads. Marinating meats or poultry in yogurt improves tenderness and eating quality. You can find yogurt in sauces or dips, sandwich fillings or desserts, and, sometimes, as a low calorie substitute for sour cream, cream cheese or mayonnaise. Using yogurt in heated sauces requires some precautions, since high heat will curdle it. You can minimize problems by bringing the yogurt to room temperature before adding it to a hot sauce, or mixing a tablespoon of cornstarch for every cup of yogurt.

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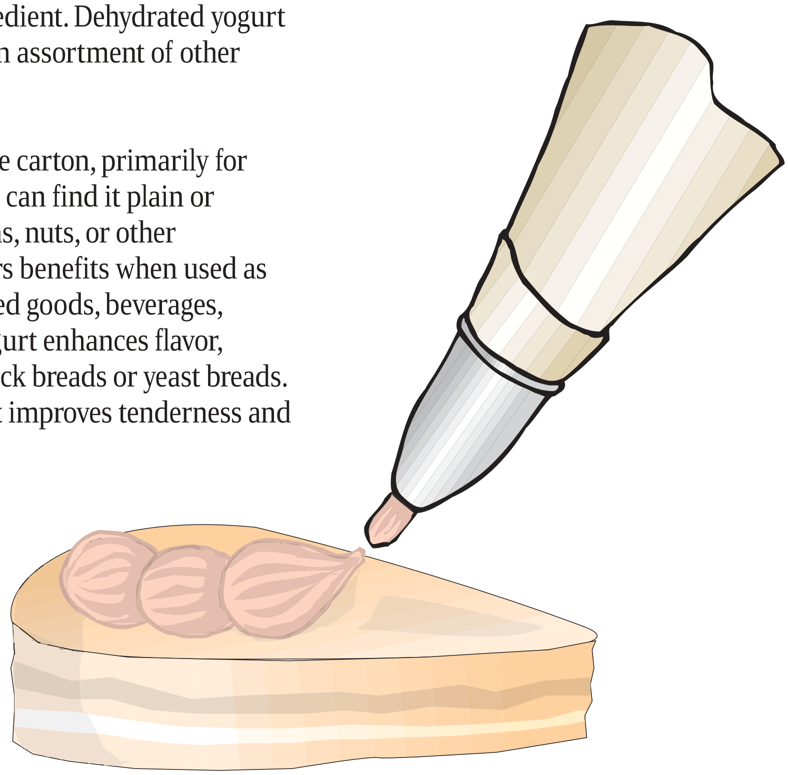

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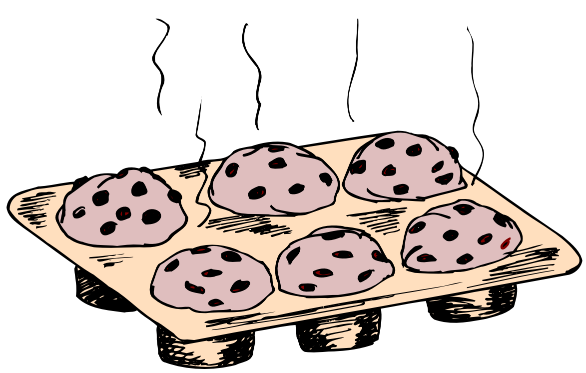
Yogurt provides the nutritional benefits of protein, vitamins, and minerals with relatively low calories. In addition, yogurt may aid digestion, boost immunity, fight infection and protect against cancer, which accounts for its reputation as a "health" food. Many of these health benefits are due to "probiotic" cultures, such as Bifidobacteria, that are routinely added to yogurt. The "healthy" image of yogurt has led to its widespread use in snack foods for kids, particularly in the powdered form. Powdered yogurt can be used in coatings for dried fruit, energy bars, pretzels, or other snacks, although in some of these products, high fat and sugar levels, as well as processing and baking, may diminish the health benefits by destroying the live microflora of yogurt. Below are several formulations highlighting the use of yogurt or yogurt powder as an ingredient.

Lemon Yogurt Muffins

Ingredients	Percent(%)
Flour, all-purpose	31.75
Plain yogurt	30.75
Sugar	15.79
Eggs	12.50
Butter, melted	4.88
Lemon juice	3.12
Baking powder	0.54
Baking soda	0.44
Salt	0.23
Lemon zest	-
TOTAL	100.00 %

Procedure:
Pre-heat oven to 400˚ F.
Combine flour, sugar, baking powder, baking soda, and salt, and set aside.
Mix together eggs, yogurt, melted butter, lemon juice and zest (if using). Add the wet mixture to the dry ingredients, and stir just until moistened. Do not overmix, or muffins will be tough.

Spray muffins cups with cooking spray. Add approximately 1/3 cup batter per muffin cup. Bake at 400˚ F for 15 minutes.



Light'N Fluffy Pancakes

Ingredients	Percent(%)
Plain yogurt	40.87
Flour, all-purpose	26.96
Water	12.17
Egg, fresh	9.56
Vegetable Oil	6.95
Sugar	2.09
Baking Powder	0.70
Baking Soda	0.35
Salt	0.35
TOTAL	100.00 %

Procedure:
Combine all dry ingredients in a bowl.
Mix yogurt, egg, water and oil together in a separate bowl.
Add wet ingredients all at once to dry ones and mix just until combined.

Pour about 1/3 cup batter on a hot griddle, and fry until bubbles appear on the surface and underside is browned. Turn the pancake over and brown on the other side. Serve immediately.

Strawberry-flavored Yogurt Frosting

Ingredients	Percent(%)
Confectioners' powdered sugar	59.29
Shortening	22.70
Water	6.20
WPC-34	6.00
Powdered yogurt	3.50
Milk calcium	1.00
Salt	0.65
Strawberry flavor	0.50
Sorbic acid	0.15
Red #40 (5% solution)	0.01
TOTAL	100.00 %

Procedure:
Mix together all dry ingredients in a bowl. In another bowl, cream shortening until light and fluffy. Gradually add sugar mixture to the shortening, alternating with additions of water. Add color to mixture and beat well, until completely incorporated. Continue to beat until a smooth, creamy consistency is reached.

continued from page 1

Moisture migration

cooled completely, a 16 cm section of the sausage was cut in half length-wise to give a long flat surface. We cut our sample blocks of cheese to the same length and width of the sausage interface, as shown in Figure 2.

The flat surface of the sausage was placed on the cheese block, sealed in a moisture/air impermeable plastic bag and stored in a cooler at 4ºC. At 7-day intervals, a 4 cm section of the sausage/cheese block was cut. From this section, the first 3 mm layer of sausage closest to the cheese and the first four 3 mm layers of cheese closest to the sausage were cut. On each layer, we measured moisture, salt, and water activity. Firmness test were run on each of the cheese layers. The sampling continued until 28 days of storage.

Figure 3. shows the water activity of the sausage and each cheese layer changing over time for the sausage produced with 55% moisture. Sausages with 65% moisture produced a fluid layer of cheddar cheese at the cheese-sausage interface after 28 days of storage. The graph shows that the water activity of the cheese rose over time and the water activity of the sausage decreased. If the samples had been stored long enough, we expect that the water activities of the cheese and sausage would be identical. There were no significant differences in fluid-layer development between samples with either high or low salt contents or high or low fat-to-protein ratios. Figure 4 shows how the moisture content of the sausage and each cheese layer changed during storage.

Like the trend we saw for water activity, the moisture content of the cheese rose over time, depending on the initial water content. The shape of the curves tended to show a larger change during the first weeks and then tapered off towards the fourth week as the driving forces for moisture migration diminished. The trends and shapes of the curves were similar for both cheddar and swiss cheeses.

Increasing the water content of the sausage caused an increase in the rate of softening, whereas increasing the salt content slowed the rate of softening. The

continued on page 6

Figure 1.

Sample Preparation

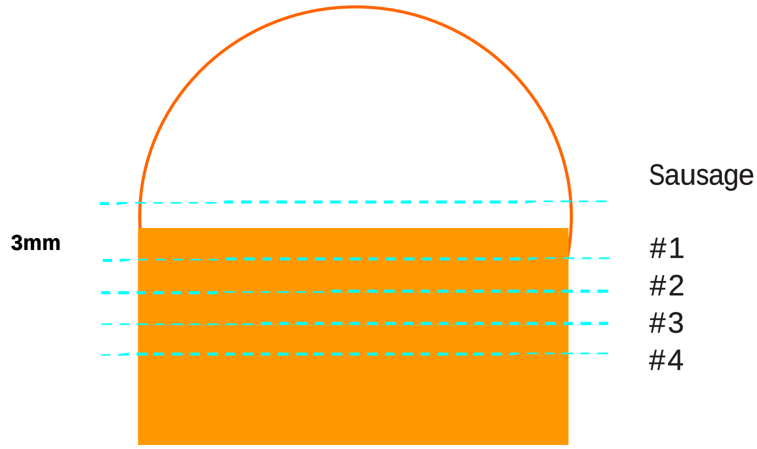


Figure 2.

Figure 3.

Water activity vs. time

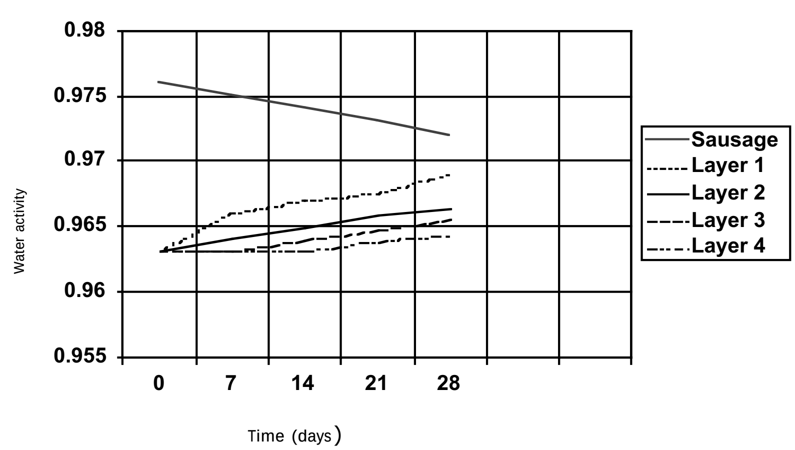
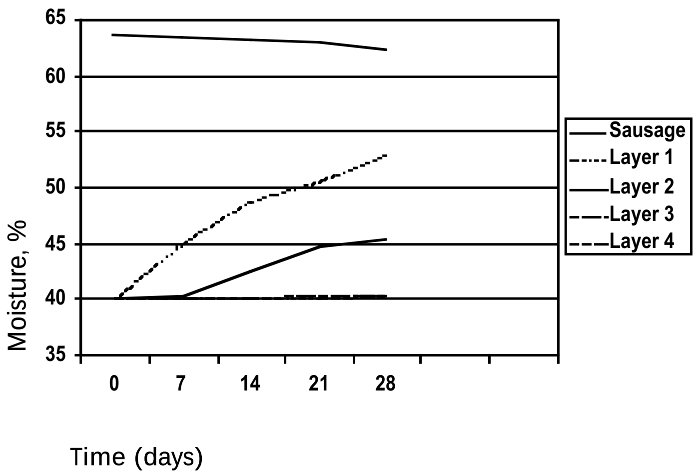


Figure 4.

Moisture vs. time



fact that the rate of softening was slowed with an increase in salt content shows that salt can have a positive effect on prohibiting cheese softening. However, even with high levels of salt, water still migrated and the cheese still softened after extended storage.

Migration of water is significantly affected by water content, salt content, and fat-to-protein ratio of the sausage. Each of these factors affects the amount of water that is not associated or interacting with proteins or solutes; therefore, they affect the driving force for diffusion. High water contents and fat-to-protein ratios each contribute to greater amounts of available water (water that is not associated or interacting with proteins or solutes) and larger effective diffusivities of water. High salt contents result in less available water and smaller effective diffusion.

Approaches to reduce cheese softening

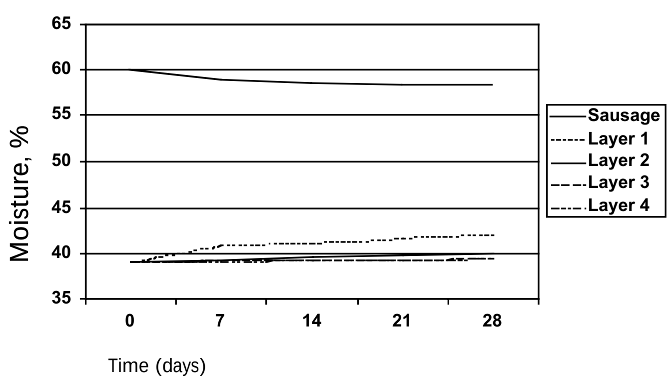
Based on data from the model systems, we determined that prohibiting moisture migration into the cheese would also retard cheese softening. Two possible approaches were evaluated: kinetic (lipid barriers) and thermodynamic (sausage reformulation). Sausages were made in the same way as the previous study and were stored under the same 4°C conditions.

Lipid barriers

A sausage with the 60% moisture, 2.0% salt and 1.65 fat-to-protein ratio composition was made and stored in contact with cheddar cheese that was covered with a layer of carnauba wax. Carnauba wax is a lipid that is used for coating confectionery products. In addition, it has a high melting point suggesting that it would not melt under smokehouse conditions. As shown in Figure 5, the lipid film provided a kinetic barrier for moisture migration, but migration was not stopped completely; it was merely slowed. The amount of water that migrated from the sausage to the cheese was decreased by over half and the effective diffusion of water was reduced by about two-thirds. Cheese protected with the lipid film showed a decrease in firmness, but to a lesser extent. Less water migration resulted in less cheese softening over the storage period.

Figure 5.

Moisture vs. time



Sausage reformulation

To prevent moisture migration, the water activity and salt content of a sausage was reduced to that of the cheese through careful sausage formulation. Moisture migration patterns are shown in Figure 6. Due to the thermodynamic balance between the cheese and sausage, there was no salt migration and very little moisture migration.

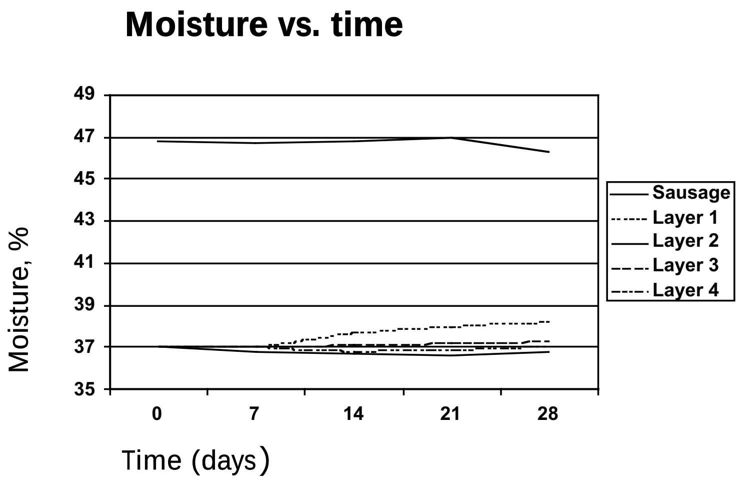


Figure 6.

After 28 days, the cheese firmness had declined to 91% of it initial firmness. This shows that preventing moisture migration into the cheese can also prevent cheese softening. The total change in water content of the cheese was significantly different between the lipid barrier protected cheeses and the thermodynamically balanced samples, but the effective diffusion was not. The water content of the sausage was lowered in the process of lowering the water activity to meet that of the cheese, making the initial difference in water content smaller.

Pairing of cheeses and sausage

You can also minimize moisture migration by selecting a variety of cheese that has a water activity or moisture content close to that of the sausage product. This would limit your selection to higher moisture cheeses used with lower moisture sausages, like fermented summer sausage or beef snack sticks. This is why we usually did not see cold melt problems in summer sausage with pepper jack cheese. Typical moistures for cheese and sausage products used in specialty sausages are shown in Figure 7.

Process cheese products allow for the slight addition of water and stabilizers to the cheese to bind some free moisture and increase viscosity to help retard moisture migration. This creates a product that maintains acceptable texture in sausage products but does not carry the unique flavors of a natural cheese.

By examining commercial specialty sausage product with cheese, we determined that the water activity of the sausage had the greatest effect on the cheese firmness, with higher water activities resulting in softer cheeses. Model system studies also confirmed that water was the most important factor on cheese softening in specialty sausage products. The differences in softening among the formulations could largely be explained by the available water, that is water not interacting with proteins or other dissolved solutes in the sausage. Sausage formulations with a higher amount of water added in addition to the moisture already associated with the muscle tissue, with a higher fat-to-protein ratio, caused more cheese softening to occur. Attempts to slow moisture migration from the sausage to the cheese kinetically with a lipid film and thermodynamically by balancing the activities of the migrating species both showed improvement over the control sausages.

Recommendations

Essentially, to prevent the cold melt defect in specialty sausages containing cheese you need to prevent moisture migration from the sausage into the cheese. You can eliminate the driving force for migration by formulating your product so there is an initial equilibrium between the cheese and sausage. Consider altering the formulation of the cheese, the sausage, or both to reach this equilibrium.

Since the standard of identities and processing parameters are more flexible in sausage than in cheeses, the sausage is a more likely candidate for a formulation change. The first step is to reduce the amount of moisture during production. Using cuts of meat that have low moisture contents inherently creates a lower-moisture product. Adding cuts high in fat also lowers the amount of water in the product, but too much fat disrupts the ability of the protein to form a stable emulsion to entrap water unless emulsifiers are added. Another method of lowering the water activity of the sausage is to add fillers, such as sugars, nonfat dry milk, whey protein concentrate, wheat gluten, tapioca dextrin, soy flour, soy protein concentrate, or polysaccharide gums. These ingredients not

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Figure 7. Moisture in Products

Cheddar = 38%
Pepper Jack = 43%
Swiss = 40%
Process American = 40%
Process Swiss = 43%
Process cheese food = 44%
Bologna = 62%
Weiners = 64%
Polish = 56%
Beef stick = 49%
Cooked salami = 46%
Smoked sausage = 46%
Fermented summer = 34%

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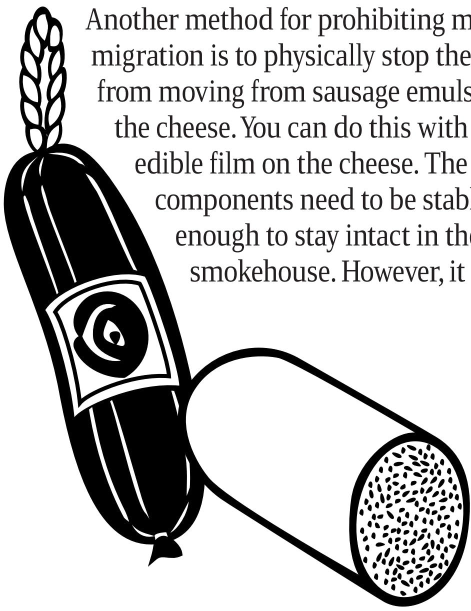
only add nonaqueous bulk to the sausage, but they also interact with the water, making it less available to migrate and lowering the water activity. Adding fillers or ingredients means you have to list them in the ingredient listing on the label of the product.



Another method for prohibiting moisture migration is to physically stop the water from moving from sausage emulsion to the cheese. You can do this with a lipid edible film on the cheese. The film's components need to be stable enough to stay intact in the smokehouse. However, it is difficult to apply to the cheese because it is in a solid state up through temperatures as high as found in the smokehouse and will solidify quickly if melted for application. An edible film also needs to completely coat the cheese in order to be effective. Consumers may not want to buy products with an edible lipid on the ingredient list of the product, further limiting the use of an edible lipid film.

References

Mandl, K. 2005. Effect of moisture and salt migration on cheese firmness in sausage products. M.S. thesis, University of Wisconsin-Madison.

Wendorff, W.L. 2005. Develop innovative solutions for the "cold melt" of cheese when partnered with another food ingredient (i.e., meat). Project progress report to CDR Cheese Industry Team, Dec. 6, 2005, Madison, WI.

Acknowledgements
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News from CDR

American Dairy Science Association

Carol Chen, researcher at the Wisconsin Center for Dairy Research, will present results of a recent project at the American Dairy Science Association (ADSA) mtg in Mpls in July. The title of her talk is, "Impact of milk lactose reduction on the chemical, textural and shredded cheese quality of mozzarella."

Also presenting at the ADSA mtg is Kerry Kaylegian, who headed CDR's milkfat research program in the 90's. Kerry recently earned her Ph.D. at Cornell University—congratulations Kerry!

Mary Thompson at the 2006 International Cheese Technology Expo

Farewell to Mary

Anyone who worked alongside the unflappable and ever gracious Mary Thompson, CDR's communications coordinator, will miss her as much as we do. Mary retires this summer after 9 years at CDR. We are grateful for her many contributions, and, well, a bit jealous too!

Great Milks, Great Markets

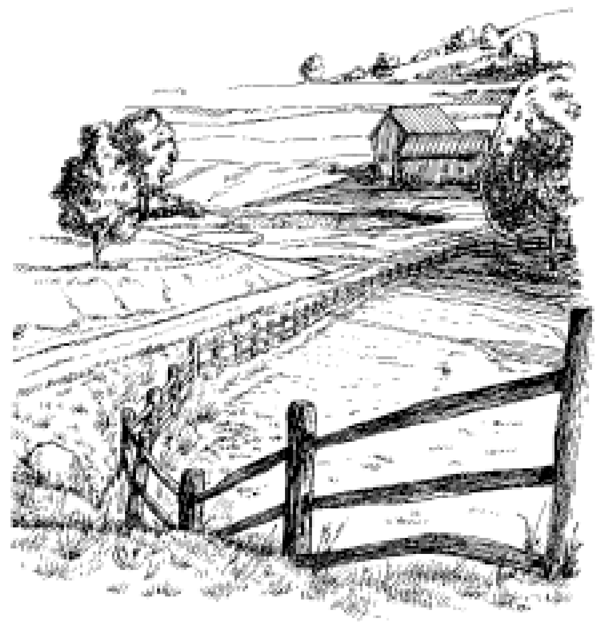
September 11-12, 2006
Radisson Hotel, La Crosse, Wisconsin

Sponsored by: DATCP, Food Science Department at the University of Wisconsin-Madison, Babcock Institute for International Dairy Research and Development.

Audience: This conference is for midwestern dairy producers and processors of cow, goat and sheep who make high-quality milk and want to create value-added products.

Goal: To discuss innovative product and packaging ideas, possible markets for new products and how to identify over/ under developed markets.

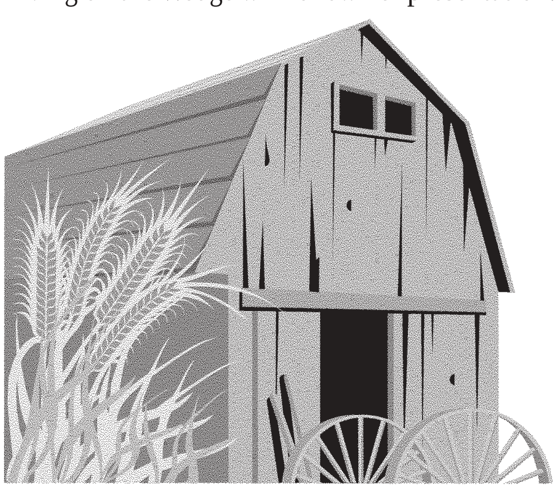
Overview: Domestic and international industry leaders will present ideas as part of moderated panel discussions and as keynote speakers. We will focus on innovative ideas producers can use to benefit from high-quality production.



Morning
Bil Luth of Tilamook Cheese and Norm Olsen from the UW-Madison Food Science Department will open our first day. Bil will tell the Tilamook story and Norm will talk about producing great raw milk as the first step.

Afternoon
Session 1: Great products from grazing dairy cows moderated by Paul Ditman
Session 2: Turning value-added products into profit by Dan Strongin
Session 3: Vermont Artisanal Cheese Center, Bringing quality to the consumer by Paul Kindstedt

Donna Berry, an expert on packaging, will be the evening speaker. A wine and cheese reception and a showing of the movie Living on the Wedge will follow her presentation.



Second day
Panel discussion of different world dairy markets led by Scott Rankin. Featuring Ed Jesse, Professor, Agricultural Economics, and Babcock Institute, Program Director of International Dairy Marketing and Trade: The dairy industry in India (invited), Karen Nielsen, Associate Director, The Babcock Institute: The dairy industry in China, Gerardo Ortiz Gonzalez, Professor, Monterrey Tec University-Queretaro Campus, Mexico: Cheese flavors for the Mexican market

For registration call 608-263-1672 or e-mail conference@cals.wisc.edu
For general questions call Laura Van Toll at : 608-265-0673 or e-mail babcock@cals.wisc.edu

Curd Clinic

Curd Clinic for this issue is Stevens J. Funk, Cargill BioActives LLC
steve_funk@cargill.com

Q:

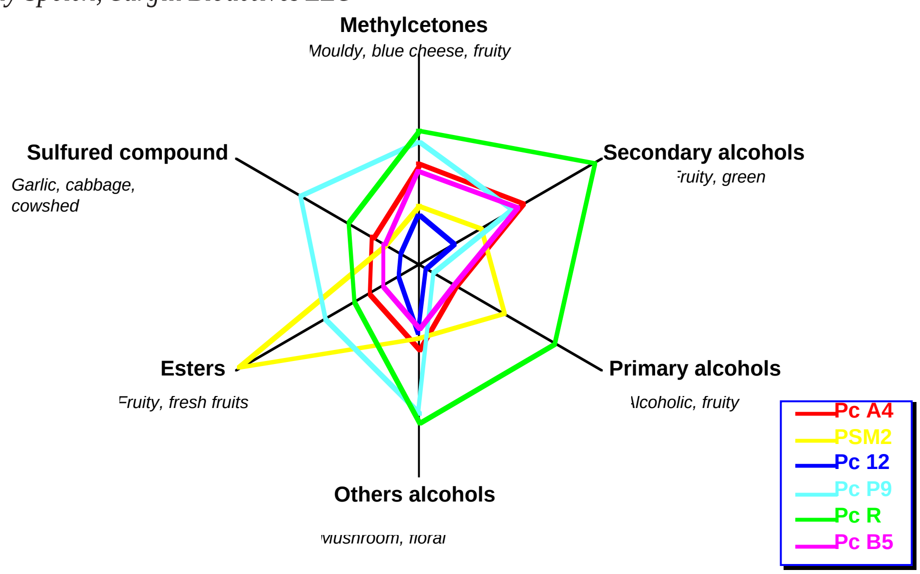
I keep hearing about using selected yeasts and molds to produce unique flavors in cheese. Can they really be used in traditional cheeses without the negative connotations usually associated with these organisms?

A:

Well, you are right; in the U.S. yeasts and molds in cheese are often viewed with suspicion. To some people they are undesirable and even suggest contamination due to poor sanitation. However, in other parts of the world, selected yeasts and molds are used to produce desirable flavors, aromas, and other attributes in cheeses. Raclette cheese is one example of a cheese that contains yeasts and molds and it is one that you can find, and taste, here in the U.S.

Yeast and molds require oxygen to reproduce, and when they do start growing you face the possibility of inducing some detrimental traits. However, putting yeasts and molds in an environment with limited oxygen allows you to derive some flavor benefit and avoid problems. For example, cheddar,

This star chart describes a flavor profile influenced by specific yeasts and molds. Supplied by Sandy Speich, Cargill Bioactives LLC



> "Cheesemakers can add yeasts and molds to cheese to create a unique, and consistent, flavor profile that will make their cheeses a bit more special."

parmesan, romano, and other cheeses that are ripened in a more enclosed environment can improve when added yeasts and molds release favorable cheese ripening enzymes and byproducts.

Yeasts and molds release these enzymes and by-products through lysis, or the actual breaking apart of the cell, that occurs naturally when a cell dies. These liberated enzymes can help to break down both protein and fat in the curd matrix, producing peptides and fatty acids that enhance flavor development. This development not only accelerates and accentuates desired cheese flavors but it can also help to prevent bitterness and other off-flavors. Thus, cheesemakers can add yeasts and molds to cheese to create a unique, and consistent, flavor profile that will make their cheeses a bit more special.

Contamination isn't an issue since the number of the organisms used is too low to contribute any detectable yeast or mold in the finished cheese. Cheesemakers can indeed get the desired positive contributions from these organisms.

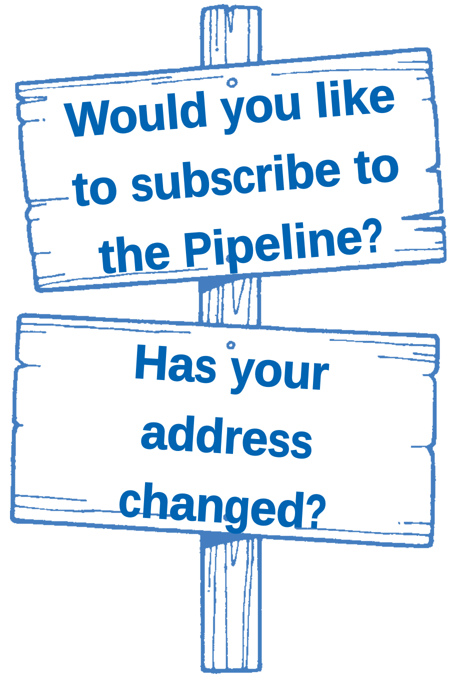
Many cheese culture suppliers with international expertise have identified and selected a variety of desirable yeasts and molds. They know which ones will contribute the traits you are interested in. They have used these internationally for many years and have introduced and expanded the use of these in the U.S. in the last decade.

Please contact your supplier or the Center for Dairy Research for more information.

Calender, continued

Oct. 18-19 North Central Cheese Industries Assn. Annual Convention. Brookings, SD. For information, call Dr. David Henning at (605) 688-5477.

Oct. 31-Nov. 1 Membrane Processing of Dairy Ingredients Short Course, Madison, WI. Call Bill Wendorff at (608) 263-2015 or Karen Smith at (608) 265-9605.



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

Calendar

Aug. 8-9 Milk Pasteurization and Process Control School. Madison, WI. Call Scott Rankin at (608) 263-2008 for information, or the CALS Outreach Services (608) 263-1672 to register.

Aug. 13-16 International Association for Food Protection Annual Meeting, Calgary, Alberta, Canada. Visit the website at: www.foodprotection.org for further information.

Sept 11-12 Great Milks, Great Markets, Radisson Hotel, La Crosse, Wisconsin. For info call Laura Van Toll at (608) 265-0673 or e-mail babcock@cals.wisc.edu

Sept. 12-13 The World of Hispanic Cheeses, Madison, WI. (A Master Cheesemaker Short Course) Call Dean Sommer at (608) 265-6469 or John Jaeggi at (608) 262-2264 for information.

Sept. 20-21 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., La Crosse, WI. For more information, contact Marianne Smukowski at (608) 265-6346 or e-mail at: msmuk@cdr.wisc.edu.

Oct. 3 Cheese & Butter Evaluation Clinic. World Dairy Expo, Madison, WI. Sponsored by Wis. Dairy Products Assn. For information, call WDPA at (608) 836-3336.

Oct. 3-8 World Dairy Expo, Madison, WI. For information see www.world-dairy-expo.com.

Oct. 9-13 Cheese Technology Short Course, Madison, WI. Call Bill Wendorff at (608) 263-2015.

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