Wisconsin Center for Dairy Research

DAIRY PIPELINE

A Technical Resource for Dairy Manufacturers
Volume 17 Number 3

Fortifying foods by adding protein—What's driving the trend?

Part I Health Benefits

by Galina Lubchesky, Valerie Kurka, Scott Rankin, and Karen Paulus

Consumers are interested in improving health, driving the demand for more fortified foods and beverages. For example, nearly nine out of ten consumers reported concerns about the nutritional content of food (10th annual survey, USB, 2003). In addition, there is growing public awareness of the health benefits associated with consuming specific proteins and/or with high-protein diets, which has boosted the protein fortification market.

Many protein ingredients available

Proteins are complex molecules. They are made of amino acids and they function as life process regulators as well as a primary structural material of animal tissue. Since humans cannot synthesize every amino acid, proteins are vital for health. However, not all proteins supply all essential amino acids. In particular, proteins from plant sources lack sufficient quantities of essential amino acids. Thus, cereals require protein fortification in order to increase a naturally low protein content and achieve a balanced essential amino acid composition.

Many protein ingredients are available to food product developers for formulating protein-fortified food products. For example, proteins are derived from animal sources such as meat, eggs, and milk. Collagen proteins are used in meat products to improve texture. Egg protein is often used in specialty protein supplements for athletes. Despite their excellent nutritional value, the costs of egg and meat proteins limit their use as a protein enhancer in food products.

Dairy proteins are another source of animal-derived proteins. In addition to outstanding nutritional value, associated health benefits and high functionality, dairy proteins are abundant and cost-effective. Native milk protein consists of 80% casein and 20% whey protein. Approximately 700,000 tons of whey proteins are available worldwide (de Wit, 1998). Concentrating and fractionating whey yields various whey protein products. For example, ultrafiltration produces whey protein concentrate (WPC), which contain 35-80% protein. When whey is concentrated to more than 90% protein, it is called whey protein isolate (WPI).

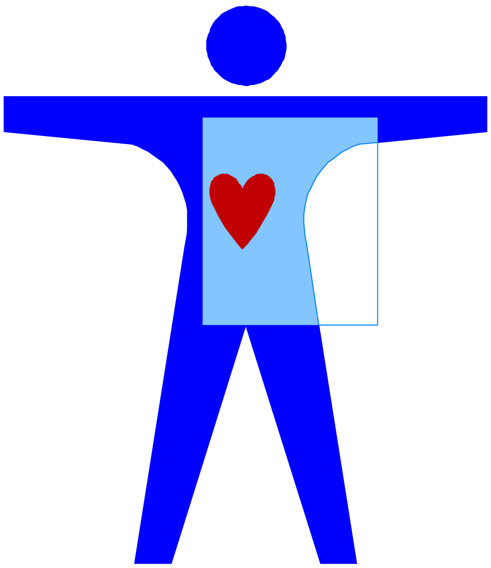
Plant-derived protein ingredients can be extracted from legumes, such as peas, fava beans, lentils, peanuts and soybeans, and from grains, such as wheat, oats and rice. Proteins from plant sources are significantly less expensive than animal derived proteins, however, most have limited nutritional value—with the exception of soy protein.

continued on page 2

What's Inside:

Protein

continued from page 1



"...emerging evidence suggests that soy and whey proteins may have beneficial effects for other health concerns, including cancer, kidney disease, osteoporosis, cognitive function, obesity, and possibly lowering the potential for insulin resistance in diabetics. "

Soy protein is available in many forms. One is soy flour, which contains 40-54% protein but it has a beany flavor that limits its application to strongly flavored or baked products. Extracting the soluble carbohydrates from soy flour yields soy protein concentrate (SPC) with 65-72% of protein. SPC has low solubility, but high water-holding capacity that allows using it in all-vegetable meat analogs. Soy protein isolate (SPI), the most concentrated commercially available form of soy protein, contains 90-92% protein. SPI's bland flavor makes it suitable for mildly flavored foods.

Both soy and whey proteins are used as functional and nutritional food ingredients in every food category available to consumers. Their availability, low-cost, health enhancing potential, and functional properties make them the most accepted commercially available proteins. Because of this, whey and soy proteins are the main examples used in this article to explore the nutritional, functional and economical aspects of ingredients used in protein fortification.

Nutritional attributes

A reduced risk for heart disease is the most recognized benefit offered by soy and whey proteins. However, emerging evidence suggests that soy and whey proteins may have beneficial effects for other health concerns, including cancer, kidney disease, osteoporosis, cognitive function, obesity, and possibly lowering the potential for insulin resistance in diabetics. In addition, soy and whey proteins play an important role in infant formula and in sports nutrition.

Cardiovascular disease

More than 25% of the U. S. population suffers from some form of cardiovascular disease (CVD). If you are one of them then you know that the two major risk factors contributing to CVD are hypertension and dyslipidemias. Dyslipidemias are disorders of lipoprotein metabolism, including lipoprotein overproduction or deficiency. Elevated serum total cholesterol, low-density lipoprotein (LDL) cholesterol and triglyceride concentrations, and a decrease in the high-density lipoprotein (HDL) cholesterol concentration are signs of dyslipidemia.

Including soy protein in your diet can significantly decrease blood cholesterol and low-density-lipoprotein (LDL) cholesterol concentration. In 1999, the Food and Drug Administration approved a soy protein health claim based on the relationship of soy protein and reduced risks of heart disease (DHHS, 1999).

Bioactive whey peptides can reduce both CVD risk factors. For example, whey peptides can inhibit the activity of angiotensin-I-converting enzyme (ACE) *in vitro* and *in vivo* studies. (Huth, P., Miller, G., Brown, P., 2003). Also, some bioactive whey peptides demonstrate opioid-like activity that has shown potential as a blood pressure regulator (Antila, et al. 1991). In addition, bioactive whey peptides have anti-clotting and cholesterol-reducing activity. Both whey and soy proteins have shown antioxidant activity that improves overall cardiovascular health.

Cancer

Diets that include soy and whey proteins have been associated with a reduced risk for certain cancers, especially breast and prostate cancers. Acid and protease inhibitors found in soy may contribute to the anticarcinogenic effects. (Messina and Messina, 1991). Soy isoflavones, genistein and daidzein, have also been associated with reduced risk of certain types of cancer. In men, soy isoflavones are believed to help prevent prostate cancer. Genistein has been shown to reduce prostate-specific antigen (PSA) levels in men with untreated cancer, which is important since PSA levels are elevated when the prostate gland is enlarged due to cancer. In addition, a study from the University of Missouri-Columbia suggests that soy protein may help reduce colon cancer in mice (Guo et al., 2004).

A number of animal and clinical studies investigating the effects of whey protein concentrate on cancer prevention and treatment showed significant inhibition of cancer cell growth. In 1995 study, McIntosh found that whey protein offered "considerable protection to the host" over that of other proteins, including soy. Whey protein anticarcinogenic activity has been attributed to production of the antioxidant, glutathione (GSH). Recent *in vitro* studies show that levels of glutathione rise over 60% when human prostate cells are treated with whey protein concentrate (Bomser, 2003). Glutathione provides protection against cancer-causing free radicals. On the other hand, whey protein concentrate selectively depletes glutathione in cancerous cells, which enhances the effect of chemotherapy and radiation.

Calorie control

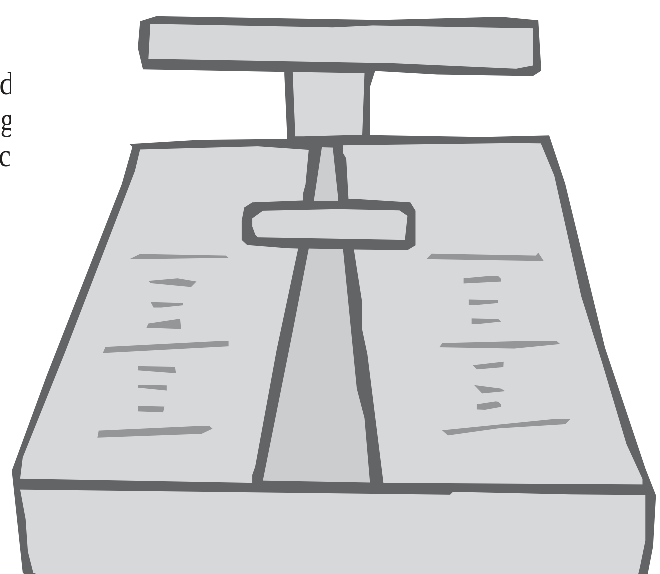
Obesity is a major public health concern in the United States. Growing numbers of consumers are modifying their diets by switching to high-protein diets. Evidenc suggests that restricting carbohydrate levels and increasing levels of protein may help people lose weight. However, dietitians still have concerns about high-protein diets. Long-term high consumption of animal fat may increase heart disease risk due to the high intake of saturated fat. High-protein intake also has been associated with urinary calcium loss. But the solution might be as simple as whey and soy protein fortification of food products since whey protein has an excellent capacity for carrying calcium, potentially improving the bioavailability of calcium. Soy protein, as a vegetable protein, does not cause calcium loss. High protein diets that include more in branched chain amino acids (BCAA) have been especially effective for controlling weight. Whey protein is an exceptionally rich source of the BCAA, leucine, isoleucine and valine. In addition, whey protein contains the bioactive peptide, glycomacropeptide (GMP), which stimulates the release of appetite-suppressing hormones (Hall et al., 2003).

Functional Aspects

Even though scientific evidence for the nutritional benefits of soy and whey proteins mounts every day, another consideration for fortifying with protein is their influence on functional characteristics. Virtually any property of a food product can be altered by adding an appropriate protein ingredient. The challenge is to choose the right ingredient out of the wide range of available protein products.

As mentioned earlier, proteins are complex macromolecules composed of one or more amino acid polypeptide chains. Protein functional properties are the result of both intrinsic factors such as protein size, structure, amino-acid composition and sequence, flexibility, net charge, and hydrophobicity and extrinsic factors including pH, ionic strength, temperature, and protein concentration (Hettiacachchy and Kalapathy, 1998).

continued on page 4

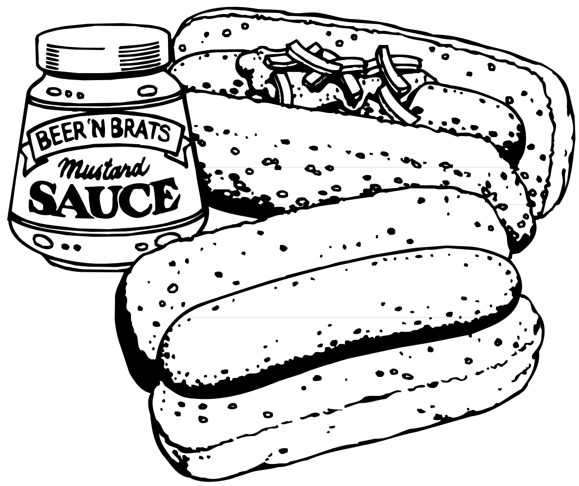


continued from page 3

The functional behavior of proteins in food products is complicated since they influence functionality by interacting with other components within the food system. In addition, protein functionality is affected by processing factors such as heating, freezing, homogenization and storage conditions (deWit, 1998).

Functional properties can be classified into three main groups: hydration properties, properties related to protein-protein interactions, and surface properties (Cheftal, Cuq and Lorient, 1985). Hydration properties include solubility, water absorption and retention, adhesion, dispersability, and viscosity. Precipitation, gelation, and the formation of dough and fibers are properties related to protein-protein interaction. The third group includes surface tension, emulsification, and foaming. However, many of these properties depend on more than one interaction. For instance, gelation, viscosity and solubility involve both protein-protein and protein-water interactions.

Functional properties can be classified into three main groups: hydration properties, properties related to protein-protein interactions, and surface properties (Cheftal, Cuq and Lorient, 1985). Hydration properties include solubility, water absorption and retention, adhesion, dispersability, and viscosity. Precipitation, gelation, and the formation of dough and fibers are properties related to protein-protein interaction. The third group includes surface

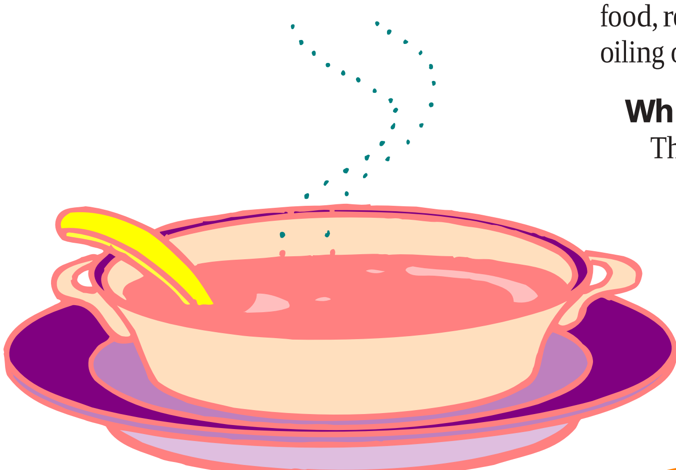


tension, emulsification, and foaming. However, many of these properties depend on more than one interaction. For instance, gelation, viscosity and solubility involve both protein-protein and protein-water interactions.

Emulsification

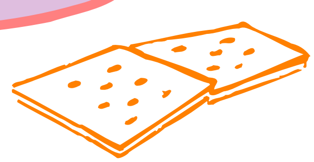
Hydrophobic and hydrophilic groups within the same polymer chain of proteins promote the formation of stable emulsions by influencing the association between water and oil. Most proteins can act at oil-water interfaces to form and stabilize emulsions. In an oil in water emulsion partially unfolded protein coats the lipid droplet, decreasing interfacial tension between water and oil and forming a physical barrier as well as an energy barrier to particle association and phase separation (Hettiacachchy and Kalapathy, 1998).

Protein ingredients are used in a variety of food applications for their emulsification properties. Common applications include salad dressings, soups, cakes, infant food formulations, vegetarian sausages, and processed meat products. Protein ingredients facilitate interaction between various components of food, resulting in products with little creaming, coalescence or oiling off and with enhanced moistness and mouthfeel.



Whipping/foaming

The process of foaming is similar to emulsification. During foaming, protein is rapidly diffused to the air-water interface. The protein partially unfolds with hydrophobic groups facing the air and hydrophilic amino acids remaining in the water. As a result, the surface tension between air and water is reduced, air bubbles are encapsulated and foam is stabilized.



The foaming properties of protein ingredients depend on the concentration and state of the protein and its solubility, ionic strength, pH, heat treatment and presence of other surfactants.

When properly processed and applied, protein ingredients are instrumental in forming and stabilizing foams in many food applications such as frozen desserts, mousses, meringues and whipped toppings.

Gelation

Under the appropriate conditions, protein molecules unfold, entrap water, and aggregate into an extended three-dimensional network, forming a gel. Moisture, fats, and solids are held by the gelation process, providing strong textural support to food products. A substantial amount of water is held by the gel matrix, which increases the water holding capacity and prevents moisture loss.

Appropriate supplementation with high-gelling protein ingredients can produce food products with enhanced sensory, hydration, textural and rheological properties as well as significant cost reduction. Both soy protein isolates and whey protein concentrates at 80% protein concentration are commonly used for gelation applications.

Water-binding

Water-binding is closely related to many functional properties of protein ingredients, including gelation, viscosity, swelling and solubility. Although water binding is a major determinate of texture of food products, it also affects other sensory attributes of food products.

During denaturation, protein molecules unfold exposing hydrophilic groups that are able to bind more water. Therefore, factors affecting denaturation of protein molecules and amino acid composition are critical factors in the water-holding capacity of a protein ingredient.

Viscosity

Viscosity describes the degree to which fluid resists flow. In practical terms, think of it as the variation in the flow of fluids, like the difference between water and molasses as you pour them out of a container. Protein ingredients can be customized to provide different degrees of viscosity to the finished food product. Therefore, protein ingredients can substitute for starches in food formulations potentially providing a cost savings, an improved ingredient statement and a healthier product.

Factors that affect protein based viscosity include pH, temperature, concentration, ionic strength, and gelation properties. Controlling specific processing parameters such as heat, enzyme modification, homogenization and pH, can produce protein ingredients with the desired viscosity. Generally, the process involves controlled denaturation of the protein molecules.

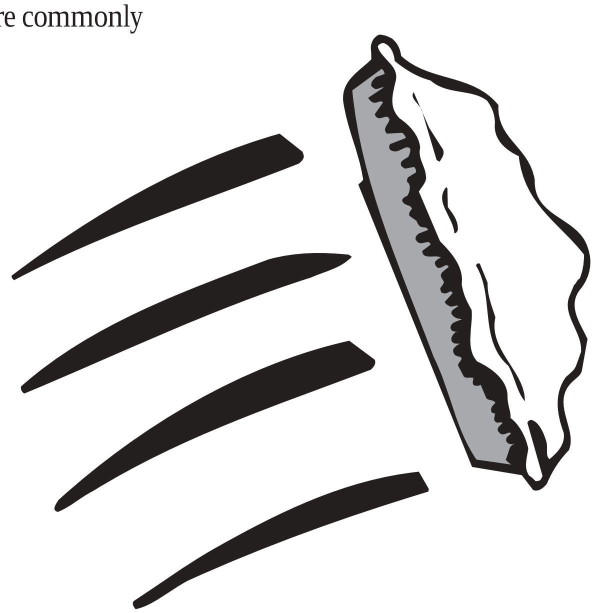
continued on next page

Gelation

Definition by Ziegler and Foegeding:
A gel is a continuous network of macroscopic dimensions immersed in a liquid medium exhibiting no steady-state flow.

Stages in heat induced gelation

- Protein unfolding
- Water binding
- Protein-protein interactions
- Water immobilization



"...protein ingredients are instrumental in forming and stabilizing foams in many food applications such as frozen desserts, mousses, meringues and whipped toppings."

continued from page 5

Solubility

Protein solubility in a solution defines many other functional properties of protein ingredients. The solubility characteristics depend on protein structure and amino-acid composition as well as on environmental factors such as pH, temperature and ionic strength. Adding salt initially increases protein solubility (salting-in) via electrostatic interactions between a charged protein molecule and its environment. However, when salt reaches maximum level, solubility decreases (salting-out). Whey proteins differ from other proteins because they are soluble over a wide pH range. Hence, whey protein ingredients can be successfully used in food products with extreme pH levels, such as acidic beverages. Heat-induced denaturation, however, decreases solubility due to the aggregation of molecules. This loss of solubility can be partly restored by partial hydrolysis. Similarly, limited enzymatic hydrolysis is used to improve the solubility properties of soy protein, rendering soy products soluble over a wide pH range. Generally, protein solubility is a desirable function in many food applications.

Continued in the next issue of the Dairy Pipeline, Part 2 Proteins in Food Systems

For more information about whey protein, go to the Dairy Management Inc. website:

http://www.dairyinfo.com/

or follow this link:

http://www.usdec.org/publications/monographs.cfm

References

Antila P., Paakkari I. et al. 1991. Opioid peptides derived from in-vitro proteolysis of bovine whey proteins. International Dairy J. 1:215-229.

Cheftal, J, Cuq, J and Lorient. 1985. Amino Acids, Peptides, and Proteins. In: Fennema, Owen, Editor. 1985. Food Chemistry. Second edition. New York, Basel: Marcel Dekker, Inc. p274, 291, 292, 282

De Wit, J.N. 1998. Nutritional and Functional Characteristics of Whey Proteins in Food Products. J. Dairy Sci. 81:597-608

Department of Health and Human Services, Food and Drug Administration, Food Labeling: Health claims; soy protein and coronary heart disease. Federal Register 1999; 64:57700-57733.

Guo J., Li X., et al. 2004. Dietary soy isoflavones and estrone protect ovariectomized and wild-type mice from carcinogen-induced colon cancer. J. Nutr. 134:179-182.

Hall WL, et al., 2003. Casein and whey exert different effects on plasma amino acid profiles, gastrointestinal hormone secretion and appetite. Brit. J. Nutr. 89:239-248.

Hettiarachchy, N. S. and Kalapathy, U. 1998. Functional Properties of Soy Proteins. In Marcel Dekker, Eds Srinivasan Damodaran and Alain Paraf "Food proteins and their applications", 1997, pp 80-95

Huth, P., Miller, G., Brown, P. 2003. Milk – a key to new products; unlocking the physiological benefits of milk proteins. Ingredient Technology. Dairy Foods.

McIntosh, G.H., et. al., 1995. Journal of Nutrition.

Messina, M., and Messina, V. (1991) J. Am, Diet. Assoc. 91, 836.

Research Update: Adding Flavors to Cheese

What if you were looking for a healthy dairy snack to put in your child's lunch box—your child that won't touch cheese? Perhaps cheese flavored to please children might be the way to go. With this scenario in mind, CDR developed a project, funded by Dairy Management, Inc. (DMI), focusing on incorporating sweeteners and flavors into cheese. Led by John Jaeggi, the Cheese Applications group first worked with string cheese and then made processed cheese with flavors that kids go for, like bubble gum, watermelon and green apple.

The group started by producing a strawberry-flavored string cheese. Given the pH range of string cheese, they were concerned about the pH ranges needed to produce a full strawberry flavor. Another concern was the chance that the thermophilic starter culture would ferment the sweeteners, possibly causing late gas formation in the cheese package. Incorporation points as well as the issue of retaining strawberry flavors in the cheese matrix were other variables the researchers considered.

Strawberry string cheese

To answer these questions, the group ran four strawberry-flavored string cheese trials that used different methodologies to incorporate sweeteners and strawberry flavoring. They were aiming for a cheese that tasted like strawberry yogurt but acted like string cheese. The first trials showed that the string cheese texture was better when standardizing milk to a casein:fat ratio matching regular string cheese. Thermophilic cultures did not seem to produce more gas in the packages than did the mesophilic cultures. Also, the researchers found that adding all ingredients to the stirred curd—at the time of salting and ingredient addition and before the molding step—was the best way to incorporate them into the cheese matrix. They were able to gauge the level of sweetener needed, (sucrose) as well as artificial sweetener (sucralose), to bring out flavor and sweetness in the string cheese. In addition, they were also able to verify that adding an emulsifying salt in addition to sodium chloride helped to incorporate the sweetener and flavor into the string cheese as opposed to adding sodium chloride only.

Although many questions were answered by trials, the researchers learned that the pH range of string cheese (~5.10-5.30) limited the expression of strawberry flavor. When malic or citric acid was added, more strawberry flavor was noted as well as a nice aroma. However, due to the lower pH, these acids had a detrimental effect on the final string cheese texture; it was pasty and had little or no string. When no acid was added, the texture of the string cheese was good with nice string, but very little strawberry flavor.

Looking for interested companies

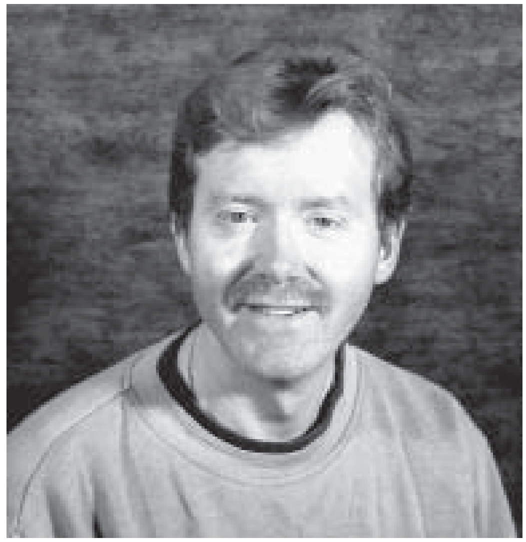
The group switched to trials using flavors detectable at pH ranges similar to those of the string cheese. The manufacturing parameters developed for the strawberry flavored cheese were used to made cotton candy, bubble gum, green apple, and banana flavored cheese. Colors were added to the cheese milk to give vibrant colors. Although they had no effect on the cheese manufacturing process, the colors, as expected, had an effect on the color of the whey. Adding color directly to the cheese after mixing might be worth a try. Informal tasters easily identified all the cheese flavors, particularly the cotton candy and the bubble gum. Although this project is finished, Jaeggi's group is willing to work with companies interested in looking at other flavors and cheese manufacturing combinations.

Processed cheese with flavors that kids go for, like bubble gum, watermelon and green apple.

News from CDR

Introducing...

CDR has recently hired three new people and we want you to meet them. Joe Jaeggi is a third generation cheesemaker, originally from Monroe, Wisconsin. However, Joe has been a Michigan resident for the last 14 years, working with his Dad at Jaeggi Hillsdale Country Cheese. The cheese plant was sold to a Hispanic family who plan to make Latino cheeses at the plant. And, luckily for us, Joe returned to Wisconsin. His title is Research Cheesemaker and he will be working in the pilot plant, once again alongside his cousin, John Jaeggi.



Joe Jaeggi

Gina Mode spent 9 years running the QA Lab in the Babcock Hall Dairy Plant. Gina now has an office upstairs but she will still be spending some time in the plant. Gina grew up on a dairy farm near Ft. Atkinson but once she earned a degree in Food Science at UW-Madison she stayed in Madison. She is an Assistant Coordinator in the Industry and Cheese Applications program.

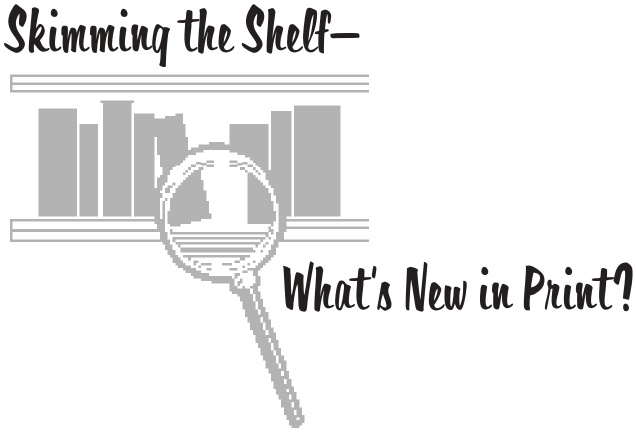
Gina Mode

Bilal Dosti has also been hired as an Assistant Coordinator in the Industry and Cheese Applications program, but his background is a little different. Bilal grew up in a big city, Ankara, Turkey. After earning a Bachelors degree in Ankara he came to the United States in 1995 to study at Clemson University in South Carolina. (Bilal says his first impression of the U.S. was "Why aren't they speaking English?") Dosti came to Madison to work on his Ph.D. in Molecular Biology under Jim Steele. Although his thesis is still a work in progress, it will summarize his work constructing a derivative of *Lactobacillus casei*.

Bilal Dosti

Pipeline available in Spanish

By the end of the year a Spanish translation of the Dairy Pipeline will be available on our website. The translations will start with Vol. 17 #2.



American Farmstead Cheese
The Complete Guide to Making and Selling Artisan Cheese

By Paul Kindstedt with the Vermont Cheese Council
Chelsea Green Publishing/White River Junction, Vermont
May 2005

Congratulations to Paul Kindstedt and his collaborators for writing an accessible and affordable reference for cheesemakers. This book covers it all, from chemistry to safety to the business of artisan cheesemaking. The photos, flow charts and diagrams are well placed and helpful and references for further reading are provided.

The science behind cheesemaking isn't new to me, and perhaps that is why I enjoyed reading the first several chapters the most. Focusing on the historical development of cheese adds an interesting narrative to the story. And that is what this book does in Chapter One, The Rhyme and Reason of Cheese Diversity: The Old World Origins, which simplifies the hundreds of cheeses by suggesting there are really "20 or so distinct types of cheese." Describing and comparing the origin of the Alpine family of cheeses to soft cheeses is an effective method to get artisans thinking about the big picture of cheesemaking. Cheesemaking in England, cheesemaking in the colonies narrows this focus while bringing us up to date.

Cheese on Wheels

The Dairy Business Innovation Center recently honored both the Edelweiss Creamery and the Darlington Dairy Supply (DDS) for their innovation and pioneering spirit. The awards were presented during the World Dairy Expo, in front of the modular dairy plant built by DDS. Dubbed the COW, or Cheese on Wheels, this dairy plant sits on a 53' trailer. You can use it to bottle milk, maker butter, yogurt, ice cream and—of course—cheese! This nifty little plant has everything, a boiler, chiller, air compressor, vat, brine tank and a even a cooler. You just need to supply water, sewer and electrical connections, and the milk!

Torry Thuli and Lee North of Darlinton Dairy Supply

Darlington's unit has attracted interest from South Africa to Alabama, particularly among organic farmers, grazers, and people looking to add value by processing their own products.

For more information check out www.ddsco.com

Curd Clinic

Curd clinic doctor for this issue is Carol Chen, CDR researcher

Q. What ever happened to the "pizza cheese" that CDR developed several years back?

A. CDR's non pasta filata mozzarella cheese protocol, developed back in 1997, offered several advantages for pizza makers. Some of the big advantages affected the look of the baked cheese. For example, the cheese we developed has no residual sugar which means it doesn't brown during baking. In addition, the cheese was more opaque and whiter in color, leading some tasters to comment that those pizzas looked like that they had more cheese. Also, pizza's topped with CDR's cheese had 50% fewer blisters and 50% less oiling off, which means the cheese is less likely to have liquid fat pool during pizza baking.

As we worked out our protocol, we produced the CDR cheese in the University of Wisconsin dairy pilot plant. In retrospect, that may have influenced our perspective on the project. For example, wastewater wasn't a big concern for us due to the small size of the experimental pilot plant cheese vats. That is not true for large cheese plants. We also

continued on the next page

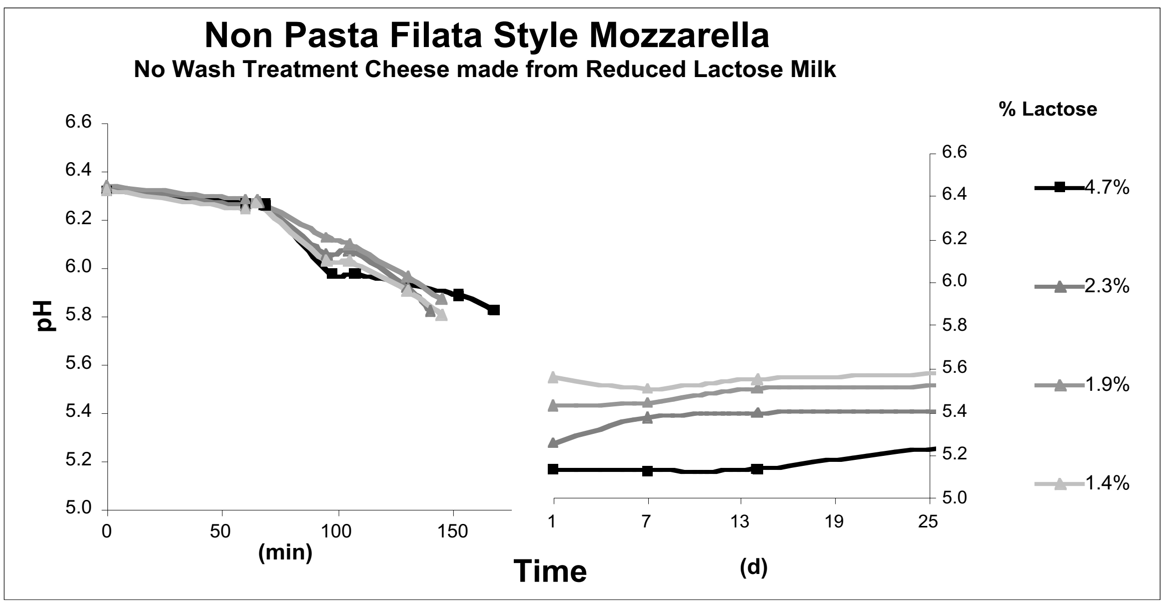


Figure 1.

The data above represent duplicate cheesemaking trials. Our control milk, 0.44 lactose to serum solid ratio, was standardized by skimming to a casein:fat ratio of 1.01. We made the low moisture part skim non-pasta filata mozzarella using a curd rinsing step prior to hooping to control the final pH of the cheese.

For the experimental treatments, milk sugars were removed from the milk prior to cheesemaking to control the final pH of the cheese without a curd rinsing step. In a two-step process consisting of ultrafilatration then diafilatration, initial lactose levels were reduced to 0.23, 0.19 and 0.15 lactose to serum solids.

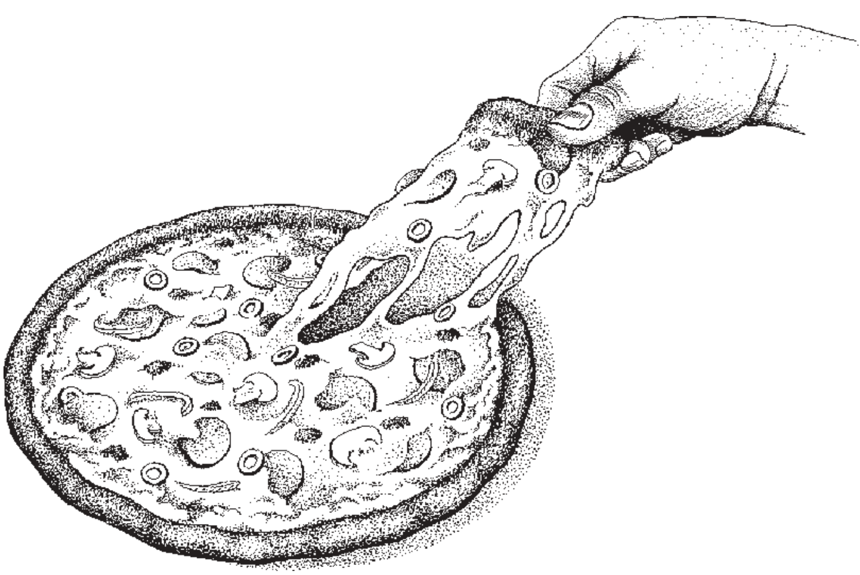
We standardized this milk for casein:fat and total milk solids and made cheese without a curd rinsing step. Removing lactose from the milk by UF/DF did not affect the rate of acid production during cheesemaking but did influence the amount of residual sugars in the curd and thus the final pH of the cheese. In fact, for the desired functionality of this LMPS mozzarella cheese lactose removal to 0.19 and 0.15 was too much. The experimental cheeses made from a lactose to serum solids ratio of 0.23 resulted in a cheese with a pH of 5.3 at 1 day and 5.4 at 4 weeks. This cheese pH profile is ideal for maintaining a firm textured cheese that shreds easily.

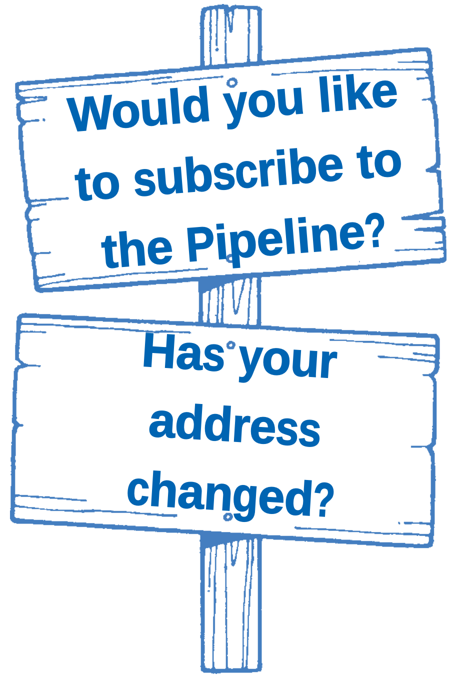
have the luxury of time and the limit of making a series of small vats of cheese. In the real world, scaling up the process increased the waste water, and lengthened the time it took to make a vat of the cheese.

We knew how our process worked, and the science behind the concept. Essentially, we were controlling the pH development in our pizza cheese by removing residual sugar. So, we went back to the drawing board and came up with another method to accomplish this goal. Unfortunately for smaller plants, it does involve a rather large capital investment for ultrafiltration equipment. We turned to ultrafiltration and diafiltration (UF and DF) of the cheese milk, which removes most of the sugar and some soluble minerals, for our improved method. (See Figure 1.)

Removing lactose from the milk does not affect the rate of acid production during cheesemaking but it does influence the final pH of the cheese. In the vat, there is an excess of lactose, so even when the percentage of lactose is reduced by 70%, the rate of acid production during cheesemaking is not affected. However, the initial milk lactose level did influence the final pH of the cheese. The lower the initial milk lactose content, the higher the final pH of the cheese. The pH profile of the cheese is one of the most important factors influencing cheese functionality. The experimental cheeses were made using UF/DF milk with a milk lactose content of 2.3%. The pH of this cheese ranged from 5.3 to 5.4 over time – an ideal pH profile for good functional mozzarella cheese.

This altered method of producing non pasta filata mozzarella does influence some of the functional charaterstics, depending on the age and moisture of the cheese.





Please help us keep our mailing list current! Simply phone, fax or e-mail the information requested below to:

The Dairy Pipeline
Center for Dairy Research
1605 Linden Dr.
Madison, WI 53706
phone: 608/262-8015
fax: 608/262-1578

You can also choose to forgo a mailed copy and get on our e-mail subscription list which will remind you to read the Pipeline on the web. Sign up for this option on our website: www.cdr.wisc.edu

Name ______________________

Company ______________________

Street Address ______________________

____

City ______________________

State ______________________

Zip ______________________

Country ______________________
(and mailing code)

____

☐ CHANGE ☐ ADD ☐ REMOVE

DAIRY PIPELINE

The Dairy Pipeline
Center for Dairy Research
1605 Linden Dr.
Madison, WI 53706-1565
phone: 608/262-5970
fax: 608/262-1578

Karen Paulus, Editor

Technical Reviewers:
Mark Johnson, CDR
Norm Olson, Dept. of Food Science
Jim Path, CDR
Marianne Smukowski, CDR
Tom Szalkucki, CDR
Karen Smith, CDR
Bill Wendorff, Dept. of Food Science

The *Dairy Pipeline* is published by the Center for Dairy Research and funded by the Wisconsin Milk Marketing Board.

To subscribe to the Pipeline simply phone, fax, or e-mail your request to CDR. (Form on page 11) We welcome your questions and comments. Send them to:

Karen Paulus, Editor
e-mail: Paulus@cdr.wisc.edu
phone: 608/262-8015

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

Calendar

Jan. 10-11 Milk Pasteurization and Process Control School, Madison, WI. Call Scott Rankin at (608) 263-2008 for information.

Jan. 19-20 Producing Safe Dairy Products, River Falls, WI. Call Ranee May at (715) 425-3704 for information.

Feb. 7-8 Quality Milk Conference (WI Dairy Field Reps), Madison, WI. Call Scott Rankin at (608) 263-2008.

Feb. 28-Mar. 1 Wisconsin Process Cheese Short Course, Madison, WI. Call Bill Wendorff at (608) 263-2015 or John Jaeggi at (608) 262-2264 for more details.

Mar. 27-31 Wisconsin Cheese Technology Short Course, Madison, WI Call Bill Wendorff at (608) 263-2015.

Apr. 25-27 International Cheese Technology Exposition, Madison, WI. For information, call Judy Keller at (608) 828-4550.

May 9 Wisconsin CIP Workshop, Madison, WI. Call Bill Wendorff at (608) 263-2015.

May 10 Dairy HACCP Workshop, Madison, WI. Call Marianne Smukowski at (608) 265-6346.

May 16-17 Applied Dairy Chemistry Short Course, Madison, WI. Call Scott Rankin at (608) 263-2008.

***Wisconsin* Center for Dairy Research**
University of Wisconsin-Madison
1605 Linden Drive
Madison, Wisconsin 53706-1565

ADDRESS SERVICE REQUESTED

Nonprofit Org.
U.S. Postage
PAID
Madison, WI
Permit No. 658