

## Dairy Dispatch – Winter 2000

### **New education and research facility will enhance Davis' 93-year-old dairy program**

Dairying in California became a major industry in about 1890, after the state's first creamery was erected in 1889 near Ferndale in Humboldt County. The centrifugal cream separator was introduced about that time, increasing the availability of creamery-made butter in the state. Nearly 300 more creameries as well as several condensed milk factories were constructed in the 1890s. With this expansion came the need for dairy education.

By 1904, the California Livestock Breeders Association introduced a bill to the state Legislature calling for purchase of at least 250 acres of the best agricultural land in the state to build a "University Farm" that would operate under the jurisdiction of the Regents of the University of California. The next year, an appointed commission selected 786 acres near Davisville, now Davis, in Yolo County. By Sept. 1, 1906, the land was occupied by the University of California. Four buildings, including a creamery, were constructed in 1907 and the Department of Dairy Industry began its 51-year history at UC Davis.

In 1917 the state Legislature appropriated \$50,000 for a new dairy industry building, but construction of the project was postponed due to World War I. It wasn't until 1922 that the Dairy Industry Building was constructed at a cost of \$205,000, and manufacturing equipment costing \$25,000 was installed. In 1963, the building was renamed Roadhouse Hall in honor of Dr. C.L. Roadhouse, who was head of the UC Davis Department of Dairy Industry from 1917 until 1944, when he resigned as chairman due to illness but remained on the faculty until 1951.

The Department of Dairy Industry was merged with the UC Davis Division of Food Technology in the 1950s to form the present Department of Food Science and Technology in Cruess Hall. Roadhouse Hall and the dairy pilot plant were eventually demolished in the early 1970s because of structural instability, and the dairy equipment was moved into the fruit and vegetable pilot plant in Cruess Hall. Even though the California Dairy Research Foundation (CDRF) has funded numerous UC Davis dairy-related projects during recent years, the inadequacy of the current facilities and equipment is now hindering growth of this important research effort.

"Considering the importance of the dairy industry to California, it is ironic that the UC Davis Food Science and Technology department-the only such department in the UC system-has no dairy foods research and teaching facility," says John Krochta, a UC Davis professor of Food Science and Technology who holds the endowed Peter J. Shields Chair in Dairy Food Science.

Krochta was recently instrumental in securing funding for a UC Davis dairy foods research and education facility by submitting a proposal to the UC Davis College of Agricultural and Environmental Sciences (CAES) and the Division of Agriculture and Natural Resources (DANR). In his proposal, Krochta committed \$100,000 of Shields Endowment funds toward the facility, and was successful in obtaining \$150,000 from DANR, and \$100,000 from CAES, bringing the total funding to \$350,000.

The Dairy Foods Research and Education Facility will be constructed within the existing Food Science and Technology pilot plant in Cruess Hall, with walls and a ceiling that will separate it from other pilot plant activities. The existing pilot plant contains utilities that can be adapted and extended into the dairy foods facility, making shared use feasible and economical. The proposed dairy facility is intended to be flexible for research and teaching, and will include three separate areas in a space totaling about 1,500 square feet. One room will provide space and

equipment for receiving and handling raw milk, separating milk into cream and nonfat milk, and homogenizing and pasteurizing milk. The second room will be devoted to cheese research, but will also be flexible for other needs (e.g., ice cream and new concept development). The third room is intended for cheese culture and an analytical laboratory.

"This facility is an essential step toward enhancing the ability of UC Davis to provide the education and research required to improve the California dairy industry's position within the rapidly developing global economy," says Krochta.

An advisory committee composed of individuals from UC Davis, the dairy industry and CDRF will aid in the facility development process. The upgraded dairy facility is expected to become fully functional in about a year.

### **First California Marschall Seminar "Gateway to Success"**

In recognition of its emergence as a major factor in the United States cheese industry, California hosted the Marschall Cheese Seminar for the first time in 1999. Co-sponsored by the California Dairy Research Foundation (CDRF) and Rhodia Inc., the seminar, a 35-year-old institution traditionally held in Wisconsin, provided two days of presentations, workshops and trade show exhibits targeting the domestic cheese market.

The seminar was held September 9-10 at the Santa Clara Convention Center. With its theme, "Gateway to Success," the program brought together cheesemakers and cheese industry suppliers to share information and technology.

"Cheesemaking is an important part of California's thriving dairy industry," said Joseph O'Donnell, executive director of the CDRF. "By sponsoring educational opportunities like the Marschall seminar, we want to continue its growth and also foster a cooperative environment between cheesemakers in this state and others.

"The Wednesday prior to the two-day event, a group of attendees visited three California specialty cheesemaking plants: Marin French Cheese Co. in Petaluma, Sonoma Cheese Factory and Vella Cheese Co. Participants were able to tour the cheesemaking facilities of these three plants and visit one-on-one with the cheesemakers.

According to Kevin Thome of the Cheese Reporter, the plant tours, a new feature, were an informative addition to the Marschall program. "We welcomed the opportunity to view these cheesemaking operations up close," he said. "In all, the experience was very educational and complemented the goals of the Marschall Cheese Seminar."

Seminar activities kicked off Thursday, Sept. 9, with a morning of presentations by national and international researchers from organizations such as the International Dairy Foods Association (IDFA), University of Wisconsin, Ireland's University College, Cornell University and Canadian Inovatech Inc.

Speakers included IDFA's Clay Detlefsen, who described some of the environmental issues affecting the dairy processing industry, and John Lucey of the University of Wisconsin, discussing the implications of gels made by a combination of rennet and acid on cheesemaking.

Detlefsen identified the following as environmental issues important for dairy processors: the EPA's Risk Management Program (RMP), a companion regulation to OSHA's Process Safety Management Regulation affecting dairy processors with 10,000 pounds of anhydrous ammonia or various amounts of listed chemicals such as chlorine or propane; the Toxic Release Inventory (TRI) affecting producers using ammonia, nitric acid and phosphoric acid; the use of plasticizers, recently cited for health concerns; dairy processing wastewater issues; and the current environmental amnesty program.

Lucey, who recently joined the University of Wisconsin's Department of Food Science, talked about his work studying gels made by a combination of rennet and acid to provide a model to simulate and increase understanding of natural and fresh cheese manufacturing. According to Lucey, a better understanding of how gels work would allow for better control of the cheesemaking process including moisture content, textural development and tailoring the physical properties of cheeses such as shred, sliceability, machinability and melting behavior.

Afternoon activities on the first day included a trade show featuring more than 40 exhibits by suppliers to the cheese industry and a wine and cheese reception with award-winning cheeses from around the world, including California cheese varieties from manufacturers such as Sonoma Cheese Factory, Spring Hill Jersey Cheese and Vella Cheese Co.

Day two of the seminar featured workshop presentations from California State Polytechnic University researchers Nana Farkye, Rafael Jiménez-Flores and Phillip Tong, as well as Mary Anne Drake of Mississippi State University, and Mark Smith of Rhodia's Food division in England.

Cal Poly's Tong discussed research conducted at the Dairy Products Technology Center to improve the quality and yield of cheese, including investigating using adjunct cultures of selected lactobacilli (in addition to normal starter culture) to enhance Cheddar cheese quality. Farkye and Jiménez-Flores covered challenges in cheese analysis and manufacturing issues and potential solutions for specialty cheesemaking.

Additional presentation topics included evaluating sensory quality of cheese and manipulating cheese flavor using microbial enzymes.

More than 300 cheesemakers, suppliers and other industry representatives attended the Marschall Cheese Seminar, which will be held in California's dairy-rich Central Valley in 2000. The 37th annual event will be held at the Visalia Convention Center September 13 and 14, 2000.

"This is an important opportunity for cheesemakers, and we're happy to be a part of bringing it back to California in 2000," said O'Donnell. "The cheese market is constantly evolving. The Marschall Seminar, allows cheesemakers a unique opportunity to share ideas and stay on top of the latest trends to remain successful."

For cheesemakers unable to attend last year's seminar, a limited quantity of the program's proceedings with detailed abstracts can be obtained by contacting Corinne Esser at the CDRF, (530) 753-0681 or by e-mail at [esser@cdrf.org](mailto:esser@cdrf.org).

For more information on this year's Marschall Cheese Seminar, contact Jo Ann Sterenberg at (574) 264-2557 or visit the Marschall Cheese Seminar Web site at <http://www.rhodiadairy.com> for continuing updates.

## **New methods for delivering pharmaceuticals with whey protein**

by Moshe Rosenberg, D.Sc.

Microcapsules are widely used in controlled-and/or sustained-delivery of pharmaceuticals. Proteins are recognized as suitable wall materials in developing microcapsules for controlled release of drugs. Among the proteins that have been suggested as wall materials in developing such microcapsules were albumin, gelatin, collagen, legumin and vicilin. Bovine caseins and albumins are effective wall materials in microcapsules for controlled release of different drugs. In recent years, my colleagues and I at UC Davis have investigated the microencapsulating properties of whey proteins, and the suitability of these proteins as wall material for encapsulation of different volatile and non-volatile core materials has been reported and patented. Recently, we reported on the suitability of whey proteins as wall material in microcapsules for controlled and/or sustained core release (see accompanying article in this issue).

Developing microcapsules for controlled release of water-soluble drugs into aqueous environment (human body fluids) represents a challenge. Such microcapsules should be water-insoluble at physiological conditions and should allow release of the encapsulated drug at a pre-determined relatively slow rate. In a recently concluded research project, funded by Dairy Management Inc. through the California Dairy Research Foundation, we investigated and developed whey protein-based microcapsules for controlled delivery of a water-soluble model drug theophylline, which is used to treat asthma.

The microencapsulation process consisted of forming a suspension of the drug in whey protein solution, formation of wet, soft microcapsules in organic phase and then chemically cross-linking the wet protein matrices to yield water-insoluble microcapsules. Our research investigated the effect of composition variables, microencapsulation process conditions and cross-linking conditions on the formation of microcapsules, their structural features and on drug release from the capsules into simulated intestinal- and simulated gastric-fluid (SIF and SGF, respectively), at physiological temperature.

In all cases, spherical microcapsules ranging in diameter between 75 and 800 nm were obtained (Fig. 1A). Results allowed identifying cross-linking conditions that favored formation of microcapsules free of cracks. Outer topography of microcapsules was not affected by composition. Investigating the inner structure of microcapsules revealed (Fig. 1B) that drug crystals were embedded throughout the cross-linked whey protein-based matrix. Drug crystals were physically entrapped in the protein matrix and no indications for interactions between the encapsulated drug and the protein matrix could be identified. Drug retention during the microencapsulation process ranged from about 70 percent to about 95 percent and was affected by composition and cross-linking conditions. Drug content in microcapsules ranged from 51 to 59.5 percent (w/w).

In all cases, microcapsules were insoluble in both SIF and SGF. Drug release from microcapsules was diffusion-driven and did not involve destruction, solubilization or softening of the protein matrix. Rate of core release was inversely related to microcapsule diameter and was proportionally related to cross-linking density. In all cases, the rate of drug release into SIF was higher than that into SGF. This could be attributed to the difference in swelling of microcapsules in the two fluids. Incorporating lipids in the protein matrix significantly decreased the rate of drug release. We observed complete release of theophylline from microcapsules containing lipids into SGF and SIF was observed after about 5.5 hours and after 2.5 hours, respectively.

Results of our research clearly indicate the suitability of whey proteins for developing insoluble microcapsules for controlled delivery of water-soluble drugs. Our study suggests significant potential for whey proteins in pharmaceutical, value-added applications and may provide opportunities in developing new markets for whey proteins.

Moshe Rosenberg, D. Sc., is a dairy food engineering specialist in the UC Davis Department of Food Science and Technology.

### **Whey protein-based microcapsules for controlled core release**

by Moshe Rosenberg, D.Sc.

Efforts have been made for the past three decades to develop delivery systems such as microcapsules for controlled release of a broad array of different compounds for different applications in food products, agro-chemicals and pharmaceuticals. Microcapsules for controlled core release applications should be water-insoluble, should maintain their structure pending core release and should be designed to allow a gradual release of the encapsulated core at the desired rate and condition. Current approaches in developing such microcapsules call for utilization of natural biodegradable biopolymers rather than synthetic polymers.

Protein-based microcapsules or microspheres have attracted significant attention as a potential vehicle for controlled and sustained release of different drugs. Recently, our research group at UC Davis has developed and patented a process for using whey proteins as water-soluble microencapsulating agents. Reviewing the physico-chemical and functional properties of whey protein suggested to us that whey proteins possess chemical and functional properties that may allow their use as wall material in developing water-insoluble microcapsules for the aforementioned applications. In a three-year project, funded by Dairy Management Inc. through the California Dairy Research Foundation, our investigations resulted in developing a new concept that allows utilization of whey proteins as microencapsulating agents in preparing water-insoluble microcapsules.

We investigated two microencapsulation processes for developing the new model lipid-containing microcapsule prototypes. The first consisted of double emulsification and cross-linking by heat treatment (HGMC), and the second consisted of double emulsification and chemical cross-linking (CCMC). The first approach is suitable for preparing microcapsules for food applications, while the second approach is suitable for applications in which chemical cross-linking is permitted (agro-chemicals and pharmaceuticals).

Microcapsules prepared using the HGMC and the CCMC processes are depicted in Figs. 1A and 1B, respectively. In all cases we obtained spherical microcapsules ranging in diameter from 80 to about 150 nm. Results indicated that the model encapsulated lipid was organized in small droplets (0.3-0.5µm in diameter) embedded throughout the protein-based wall matrix. Structure analysis did not reveal pores or channels connecting core domains with the outer environment and thus suggested effective isolation of the encapsulated core. Lipid retention during microencapsulation was very high and ranged from 88 to 94 percent for microcapsules prepared using the CCMC process and from

94 to 99 percent in microcapsules prepared using the HGMC process. These results clearly indicate the high efficiency of the microencapsulation processes in achieving high core retention during the process. Critical to suitability of microcapsules for controlled core release application

in aqueous medium is their water-insolubility. We tested water solubility of the microcapsules for 14 days at 4-30°C and pH 4.5-7.0. Water solubility of microcapsules prepared using the CCMC process was lower than 1.5 percent and that of microcapsules prepared using HGMC process ranged from 0.1 to 5 percent. In all cases microcapsules were practically water-insoluble. Results of our study indicate suitability and very high efficiency of whey proteins as microencapsulating agent in developing apolar core-containing microcapsules for controlled and/or sustained core release applications. The results and the developed microcapsule prototypes represent new opportunities in developing value-added applications for whey proteins in food and non-food systems. Our results may open new market horizons for whey proteins.

### **Research Update: Latest developments in dairy foods research**

The latest developments in dairy foods research from the National Dairy Council are described in a new edition of Handbook of Dairy Foods and Nutrition, Second Edition, written by Gregory D. Miller, Judith K. Jarvis and Lois D. McBean of the National Dairy Council; and edited by Ira Wolinsky of the University of Houston, editor of the CRC Series in Modern Nutrition. The 423-page hardcover book, which serves as a resource for individuals interested in nutritional and clinical aspects of milk and milk products, examines the role of dairy products in cardiovascular health, reduction of risk for blood pressure and colon cancer, and enhancement of bone and oral health. The book examines findings related to the bone health of vegetarians and lactose-intolerant individuals, as well as the importance of milk and milk products in the diet throughout the lifecycle. The Handbook of Dairy Foods and Nutrition, Second Edition (ISBN: 0-8493-8731-0; \$89.95) can be ordered from CRC Press by calling (800) 272-7737 or by visiting the CRC Web site at <http://www.crcpress.com>.

### **Nutrition, taste and economics support California milk standards**

by Joseph A. O'Donnell, Ph.D., executive director, CDRF

Bovine milk varies in its composition depending on a myriad of factors, especially the breed. The dominant breed in the United States is the Holstein, and about 90 percent of the cows in California are Holstein. California leads the country in milk production per cow (approximately 9,000 kg/yr) and in total milk production (approximately 13.5 million metric tonnes/yr). Over time the standards for fluid milk composition in California evolved from the typical composition of Holstein milk, pricing and consumer preferences.

California maintains four fluid milk standards: whole, reduced fat, lowfat and nonfat milk. These standards, which operate under a state order not the federal order, are unique to California. Each of these milk products requires the addition of nonfat milk solids in order to reach the minimum standard. When the standards were first implemented, nonfat dry milk powder (NFDM) was used, since it was easily stored and required little additional equipment to handle. Today nearly all bottlers use condensed milk because it is readily available, less labor intensive and the additional equipment required is now in place.

But how did California arrive at this point? Prior to 1961 the only fluid milk standard was for whole milk, with a minimum butterfat content of 3.5 percent, and nonfat milk, with a maximum butterfat test of 0.25 percent. No provisions were in place for fluid milk marketed between 0.25 percent and 3.5 percent milkfat. Processors conducted extensive polling and learned that consumers preferred product containing 2 percent milkfat and 10 percent solids nonfat (SNF).

The processors responded by initiating legislation to authorize the sale of lowfat milk. Producers who were paid much more for the butterfat than the SNF reacted vigorously.

The compromise was that the 2 percent product could be marketed after a raw product pricing plan was modified to reflect the changing standard. The result was component pricing.

Dairymen were to be paid approximately equally for the butterfat and the SNF, plus another amount for the fluid carrier. Thus, as the fat content went down and the SNF content went up in the lowfat product, producers were still paid fairly and the processors weren't paying for extra solids in the incoming milk going to the lowfat formulation. The payment for the fluid carrier allowed for a premium for milk used as fluid milk compared to other dairy product; and allowed for transportation differentials. For example, milk received far from the market would command a lower price for the fluid carrier since it had to be trucked a greater distance by the bottler. Today three pricing regions exist in the State: Northern California, Southern California and South Valley.

Standards for milks have continued to evolve, and today fortification is required in all fluid milk formulations in California. The demand for lower fat milk products prompted the California Milk Advisory Board to conduct extensive tests of a 1 percent butterfat product. The formulation consumers preferred most contained 11 percent SNF, which was launched in 1987 amid great consumer interest. The standards for the four fluid milk formulations today in California are:

A tremendous growth in the testing laboratories resulted from these standards. Today most of the testing is done by the handler but that was not the case in the beginning. Fat and SNF were the only components tested with the fluid carrier being obtained by difference. New testing procedures are welcome and will become more critical as more components are tested.

Another notable effect of the higher solids milk was the nutritional value of milk marketed in California compared to federal standards milk. The federal standard maintains 8.25 percent SNF no matter what the butterfat content, but most milk is delivered at 8.7 percent SNF. Nevertheless, if you were to compare milk formulated according to California standards vs. federal standards, the results show a 21 percent California advantage for protein, calcium and all other solids in reduced fat milks; a 33 percent advantage in lowfat milk; and a 9 percent advantage in nonfat milks. Even using 8.7 percent as the actual SNF value for federal-order milk, a nutritional advantage of 15 percent and 26 percent respectively in California milk remains very significant in the reduced fat and lowfat formulations.

Consumer pressure created the higher solids milk formulations, and consumer pressure continues to fuel the product research effort. Product development work will encompass the availability of milk powders of variable composition, perhaps even containing non-dairy components. This thinking represents a radical departure from current practices. It also represents tremendous opportunities for new markets.

California represents about 39 percent of the milk powder production in the United States. The West Coast as a whole represents about two-thirds of the country's milk powder production. About 10 years ago a large surplus of milk powder in the United States contributed to the motivation to increase the funding of dairy product promotion across the country.

With the gradual deregulation of the dairy industry, competition can be expected to increase and the market will likely see less stability, not that it was ever really stable, in milk powder production. Diversification of the product line, either by the large manufacturers, joint ventures

or small entrepreneurs will grow to capture world markets demanding specific products. The development of the lowfat milk formulations clearly suggest that products designed to meet the needs of the consumers will succeed over products formulated in the least expensive way.

The key to the success of the California dairy industry is fairness in the pricing of the milk; the formulation of products consistent with consumer preferences; and standardization of those products. The downside is that fluid milk is being shipped all across the country, and milk produced outside of California follows a different payment scheme and is formulated to a different standard. Largely because of the latter, the potential for disruption of the California system is great. Additionally, California milk (and other Western U.S. milk) is usually less expensive than the upper Midwest markets. These issues continue to keep lobbyists employed.

The subject of standardization is of interest globally because more countries are increasing the availability of dairy products to their citizens, and more suppliers are trying to capture this market. This implies that milk production will continue to expand and with its well-developed infrastructure and favorable geography, California can participate in this growth. California has learned to cope with changing market conditions and to demonstrate leadership in developing solutions even though the process is not without risk. I hope the historical description above offers some relief from the price of experience as milk standardization becomes an increasingly global concern.

### **Cal Poly ranks high in dairy contests**

The Cal Poly Dairy Products Judging Team took top honors during the 78th Collegiate Dairy Products Evaluation Contest held Oct. 30 in conjunction with the Worldwide Food Expo in Chicago. The event was sponsored by the Foundation of the International Association of Food Industry Suppliers (IAFIS), the American Dairy Science Association, USDA and the Dairy Recognition and Education Foundation.

Teams of undergraduate and graduate students from 19 colleges and universities evaluated six categories of dairy foods, and Cal Poly finished second overall. Kyle Kaepernick, Mabelyn Silva, Sara Renner, Renee McLaughlin, Nancy Deutsch and David Ahlem made up the team. They were accompanied by their coaches Will Gillis and Gary Reif. The team placed first in yogurt, second in milk, fourth in butter and cheddar cheese, fifth in cottage cheese and sixth in ice cream. Individual award winners were Nancy Deutsch, who placed third in cheddar cheese and third overall; Mabelyn Silva took first in yogurt, second in milk and fourth overall. In the graduate student competition, David Ahlem placed first in butter, first in yogurt, third in ice cream and second overall.

On Oct. 16 the team traveled to Chicago to participate in the Kraft Inc. Research Laboratories contest. Cal Poly took third out of 13 teams. Kyle Kaepernick took first in cheddar, second in cottage cheese, third in butter and fourth overall. David Ahlem was awarded first overall in the graduate student competition.

### **Krochta invited to write key chapters for upcoming book**

John Krochta, UC Davis professor of Food Science and Technology and holder of the endowed Peter J. Shields Chair in Dairy Food Science, was invited to write three chapters for an upcoming book on Protein-based Films and Coatings. Specifically, he will be writing the introductory chapter on: "Proteins as Raw Materials for Films and Coatings: Definitions, Current Status and Opportunities" He and his students will also write chapters titled "Formation and

Properties of Whey Protein Films and Coatings," and "Application of Edible Protein-based Coatings on Nuts."

"This book has authors from all over the world. So I believe our invitation to write these three key chapters indicates the UC Davis leadership in this area," said Krochta. "And, of course, the fact that the book is being assembled and marketed reflects the importance of the edible film and coating concept to food science and the food industry."

The publisher of the book, titled Protein-based Films and Coatings, is Technomic Publishing Co. Inc., Lancaster, PA. The targeted publication date is late 2000 or early 2001.