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Dairy Cooperative Growth Challenges:

Technology, Ingredients (Proteins) and Equity Financing

Abstract

Filtration separates milk components for use as ingredients in new products or new manufacturing processes. Technology developments in filtration and new manufacturing processes are certain to shape the future of the dairy industry. Some ingredients, such as milk protein concentrate (MPC), casein and caseinate, are almost all imported due to lower prices in foreign markets. When domestic production becomes economically feasible, cooperatives are potential producers of milk protein ingredients, especially in the West region. Research and development, product development and marketing, acquiring manufacturing and processing technology and equity financing are cooperatives' major challenges. A brief historical review of tomatoes shows how technology has caused profound changes to an industry that strikingly resembles milk.

Key Words: Filtration, process technology, dairy ingredients, milk protein concentrate, cooperatives, equity, tomatoes.

Dairy Cooperative Growth Challenges: Technology, Ingredients (Proteins) and Equity Financing

K. Charles Ling
Agricultural Economist

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Preface

This report is intended to provide member-producers of dairy cooperatives information on recent technology developments and technology on the horizon. These developments will create new uses for milk, new dairy ingredients, new products, and new manufacturing processes and will open up new opportunities for the growth of the dairy industry. Along with the new opportunities come challenges.

This report identifies four major challenges: research and development, product development and marketing, acquiring manufacturing and processing technology and equity financing. Each of the four challenges is discussed at some length, with equity financing occupying a separate section.

In this report, an italic name in parentheses denotes the literature that is referred to by the text. All statistics cited were up-to-date as of Jan. 14, 2005. Milk-equivalent was calculated on a milk-protein basis. Mention of company and brand names does not signify endorsement over other companies' products and services.

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Highlights

Two aspects of modern technology are going to be very important for the future of the dairy industry. One is the filtration technology of fractionizing milk components. The other is the process technology of making dairy products using dairy-based ingredients with small amount of fresh milk. Wider adoption of these technologies will cause further restructuring of the milk industry. This presents dairy cooperatives with many challenges and potentially rewarding opportunities.

Filtration is the use of semi-permeable membranes to separate and "harvest" milk components for uses as ingredients in various foods, beverages and nutritional and pharmaceutical applications. Milk protein concentrate (MPC) is one such ingredient. In the future, further technological advances may turn milk plants into milk "refineries" that could fractionate milk components into all kinds of desired dairy ingredients.

On the other hand, advances in new manufacturing process technology may allow the use of dairy ingredients with small amount of fresh milk in the manufacture of dairy products. An example is a patented "wheyless process" for production of mozzarella cheese. This process enables the manufacture of cheese from nonperishable or shelf-stable dried dairy ingredients. This allows flexibility in the location of cheese manufacturing facilities as handling and/or transporting large quantities of fresh milk is not required. Also, the need for refrigerated storage of the fresh milk would be minimal. Several other wheyless-process patents also have been recently granted for making various other dairy products from dry ingredients.

Among dairy ingredients that are of particular current interest to dairy producers are MPC, MPC/casein, casein and caseinates. Until recently, there was no domestic production of MPC, casein and caseinates in the United States. Milk prices are such that domestic production of these products can not compete with imports. (Other protein products, such as whey protein concentrate (WPC) and other whey products, compete very well with foreign production because whey price is not regulated.)

Other than price, domestic milk-protein production may have some advantages over imports, such as fresher protein products at a lower transportation cost to customers, better customer services due to proximity to end-users, and ability to supply protein products in wet form or caseinates made from fresh milk.

Based on the profitability of milk production, the West is the region that is most certain to see continued growth in milk production and could support new plant capacity. This is the region where new milk-protein plants should be located, if they were to be built. In fact, the first plants in the United States for MPC production are located in Tempe, A.Z. and Portales, N.M.

One of the important functions of dairy cooperatives is supply- balancing and last-resort processing of surplus milk. Making milk protein ingredients would be an alternative outlet for such milk. Dairy cooperatives are certainly going to play a prominent role in a milk-protein ingredient sector if it becomes economically feasible to produce such products domestically.

Cooperatives also are end-users of dairy ingredients. Some cooperatives have been making nontraditional dairy or related products to satisfy consumers' shifting demand or to have a complete line of products to offer customers. In most cases, the nontraditional products are dairy-based, and dairy ingredients constitute the major share of the manufacturing inputs.

Highlights

In a future that is driven by technology, dairy cooperatives face many challenges. Chief among them are: (1) research and development, (2) product development and marketing, (3) acquiring manufacturing and process technology, and (4) equity financing.

Research and development is the foundation of manufacturing and processing technology, product development and marketing. Through check-off dollars, dairy farmers have funded many research projects that provide information pertaining to the development of process technology and new product development. However, only through a cooperative's own proprietary research and development efforts can it identify and have a full grasp of its market niches and bring the new products to the market.

New products may be developed by modifying the flavors, taste, colors, forms, packaging or shelf-life of existing products, or by fortifying them for desired functionality. Product development also refers to using dairy ingredients (or dairy products as ingredients) to develop or improve foods and beverages.

Marketing new consumer products requires market research, test marketing, advertising and promotion, consumer education, shelf-space acquisition, merchandising, and servicing the products. In marketing new dairy ingredients, the challenge is to provide end-users (processors) with information on the attributes, the functionality, and the application of the ingredients.

Machinery and equipment are the embodiment of manufacturing technology. Cooperatives usually acquire new manufacturing technology through buying new machinery and equipment. However, as the scale of dairy plants grows larger, the cost of building a new plant with new machinery and equipment is substantial. The plant also requires a large milk volume to sustain the operations.

To differentiate value-added products and gain competitive advantages, cooperatives also must devote adequate resources to develop or acquire the process technology and adopt new ways to manufacture or package them or enhance the particular attributes of the products. The other aspect of processing technology development is finding new ways to make existing products, such as the wheyless process for making mozzarella cheese.

To meet all these challenges requires adequate financing—the ultimate challenge. A dairy cooperative's debt financing may work much the same way as any business. Its equity financing, however, is unique and may have one or more of these features: (1) common stock held by cooperative members (usually of nominal value), (2) retained patronage as net savings allocated to members based on patronage but retained for operations, (3) capital retains that are milk payments but are withheld at a certain rate per hundredweight of milk, and (4) retained earnings that are earned on non-member business. Members must treat retained patronage and capital retains as income for tax purposes. They are revolved back to members after a certain period of time.

In lieu of retained patronage and capital retains, a cooperative may have a base capital plan. Under the plan, a target base-capital level is established at a rate per hundredweight of milk marketed during a representative period. This should provide an adequate level of equity capital.

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The challenge of managing a cooperative's unique way of equity financing comes from three directions. Members want as little retains and as short a revolving period as possible, while the cooperative needs an adequate amount of capital for operations and the lending institutions require the cooperative to maintain a certain level of equity.

The base capital plan may be viewed as a compromise among the three conflicting interests. Under the plan, once the prescribed base capital level is attained, a member can expect to receive all allocated patronage earnings in cash. The cooperative would have an adequate level of capital to operate with, and the base capital would have a certain degree of permanency that helps relieve lending institutions' concern about risk.

From 1997 to 2002, average cooperative equity increased by 3 cents per hundredweight, while assets increased by 97 cents and liabilities increased by 95 cents per hundredweight. Contributions by cooperative member-producers to the increased capital needs were minimal and cooperative growth was mostly financed by debts.

Various alternative equity financing methods have been used to reduce cooperative members' fiscal burden and investment risks: public stock corporations, limited liability companies (LLC), joint ventures, and new-generation cooperatives.

It is difficult to operate a public stock corporation or LLC on a cooperative basis because of one or more of the following: (1) Investors have problems with one-person, one-vote democratic control of cooperatives; (2) Producers support the cooperative's business by patronizing it; investors do not; (3) With investor capital, the cooperative is likely to lose Capper-Volstead status; (4) In a dairy cooperative, the distinction between milk pay prices and premiums, on one hand, and profits on the other, is not clear-cut, and the conflicts between producers and investors may be very difficult to reconcile; and (5) There are fundamental conflicts between benefits for member-producers and investors' focus on returns on investment.

The new-generation cooperative model has its strengths, but its characteristics also have created a host of problems. Only the joint-venture model seems to have worked. Many recent joint ventures formed by cooperatives with other cooperatives or firms are organized as LLCs. On the marketing side, a joint-venture LLC may be used by a cooperative and its partner to develop and market certain dairy products. The cooperative supplies milk to the LLC while the partner supplies technical and marketing know-how. The joint-venture partners share the financing and the risk of the business activities of the LLC. This organizational model reduces the financing burden and risk exposure of cooperative members, while a market outlet for milk is secured.

The promising rewards of adapting to new technology can be exciting, but the necessary industry adjustment can be challenging for dairy farmers and their cooperatives. Success will depend on adequate member equity capital, well thought-out strategic plans, and research and development.

Highlights

The evolution of the milk industry has a striking resemblance to the developments in the tomato industry. Like milk, tomatoes have two use categories. Tomatoes for fresh market are produced in every State in the Nation, while production of tomatoes for processing is highly concentrated, mostly in California. Improvements in bulk storage and transportation technology have created the situation in which Midwest and Eastern processors serve as final fabricators of processing tomatoes grown and partially processed in California. In essence, the tomato industry has developed into two separate sectors—fresh market and the processing sector—each with its specific varieties of tomatoes and distinctive characteristics. While the milk industry has not been differentiated to such extremes, the evolution of the tomato industry provides some food for thought as milk producers ponder the future.

Dairy Cooperative Growth Challenges:

Technology, Ingredients (Proteins) and Equity Financing

Introduction

The growth and the future of dairy farming depend on expanding the market for milk and milk-based products. The market for traditional dairy products, of course, remains very important. Uses of milk components as ingredients in new products that meet the needs and the lifestyles of active and aging population sectors would further open up new outlets for milk. Technology will likely drive this growth.

There are two aspects of modern technology that are going to be very important for the future of the dairy industry. One is the filtration technology of fractionizing milk components for use as ingredients in various foods, beverages and nutritional and pharmaceutical applications. The other is the processing technology of making dairy products using mostly dairy-based ingredients with small amount of fresh milk.

Advances in the technology of producing and processing milk have resulted in major milk production growth in the western United States. Wider adoption of the filtration technology and the new processing technology will cause further restructuring of the milk industry. This presents dairy cooperatives with many challenges and potentially rewarding opportunities.

Filtration Technology

Milk is a complex mixture of water, carbohydrates (lactose), fat, protein, minerals and vitamins (table 1). Advances in filtration technology allow milk to be fractionized into its basic components. Based on the characteristics and functionality of the components, they may then be used as ingredients in formulas to create final products.

What is filtration? Filtration is the use of semi-permeable membranes to separate milk components based on their molecular sizes. Depending on the pore size of the membrane, ranging from the smallest to the largest, the filtration process may be: reverse osmosis, nanofiltration, ultrafiltration, or microfiltration (box 1). Ultrafiltration is most useful in fractionalizing proteins in milk.

Advent of ultrafiltration. Ultrafiltration was originally developed to separate protein from whey. One of the first commercial-scale ultrafiltration facilities in the United States was a plant to treat whey, which was reported to have begun operation at LaFargeville, N.Y., in 1971 (*Kosikowski*, p. 456). Growing awareness of the nutritional value of various

Filtrations processes (simplified definition)

Reverse osmosis:	Removes water only.
Nanofiltration:	Removes monovalent ions and retains other solids.
Ultrafiltration:	Removes minerals, nonprotein nitrogenous compounds and lactose and retains proteins and fats.
Microfiltration:	Removes lactose, minerals and small proteins and retains fat, very large proteins and particles.

Source: *Smith* for details.

Table 1—**Composition of milk**

	Percent
Water	87.4
Carbohydrates	4.8
• Lactose (principal proportion)	
• Glucose, galactose, oligosaccharides and others (minor quantities)	
Milk fat	3.7
• The most complex of lipids—More than 400 different fatty acids and fatty acid derivatives, including CLA (conjugated linoleic acid)	
• Fat-soluble vitamins A, D, E and K.	
Protein	3.4
• Casein (2.8 percent):	
Alpha-casein	
Beta-casein	
Gamma-casein	
Kappa-casein	
• Whey protein (0.6 percent):	
Beta-lactoglobulin	
Alpha-lactalbumin	
Serum albumin	
Immunoglobulins (IgA, IgG, IgM)	
Protease peptones,	
Lactoferrin	
Transferrin	
• Nonprotein nitrogenous compounds (traces)	
Minerals, trace elements and salts	0.7
Total	100.0

Sources: National Dairy Council and Chandan.

whey proteins led to further advancement of the filtration technology. An example is a recently reported setup incorporating five filtering-process steps to fractionize whey within a closed loop membrane ultrafiltration system for harvesting valuable whey proteins (beta-lactoglobulin, serum albumin, IgG, alpha-lactalbumin…., etc.). Whey concentrates are now used in a variety of commercial products, including body-building complexes, bakery goods, and frozen food additives. In recent years, whey proteins have also become valuable in nutraceutical and biopharmaceutical applications *(Koph)*.

Two French scientists in 1969 originated the concept that enabled ultrafiltration of milk to become a continuous tool for cheesemaking (*Kosikowski*, p. 510). The ultrafiltration process for milk was developed in the 1970s (*United States General Accounting Office (GAO)*). In the United States, ultrafiltration of milk is an acceptable in-plant procedure during the manufacture of standardized cheeses— cheeses that are covered by the standards of identity regulations. (A list of the cheeses can be found in *GAO*, Appendix I. The regulations may be found at the *United States Food and Drug Administration (FDA)* Web site).

In 1996, FDA allowed an exception to its standard for Cheddar cheese in a pilot project to make cheese from ultra-filtered milk. Milk was ultra-filtered on a farm in New Mexico, then shipped to Bongards

Creamery in Minnesota for making Cheddar cheese. The process was permitted as long as the cheese produced met the criterion that it was nutritionally, physically, and chemically the same as cheese produced traditionally (*GAO*, pp. 1 and 12; also *Cessna*, APPENDIX B, for standard cheeses with alternate make procedures). In December 2004, FDA issued a temporary permit to Wells' Dairy, Inc., for market testing cottage cheese made using fluid ultra-filtered skim milk *(FDA, 2004).*

Milk protein concentrate. Ultra-filtered milk from the in-plant or on-farm process is in wet form. Up to two-thirds of the liquid components of the milk (mainly water) is removed to greatly reduce the cost of transporting the ultra-filtered milk to market or reduce the amount of whey in cheesemaking (*GAO*, p.13). When the ultra-filtered milk (usually skim milk) is dried into powder, it is known as milk protein concentrate (MPC). MPC contains unaltered forms of milk protein (both casein and whey protein).

In the first half of the 1980s, Hungary commercialized the first MPC *(Dairy Australia, p. 23)*. The technology continued to evolve and commercial applications of MPC took off as its functionality became better understood. (See, e.g. *Smith*; also *Hendrickx*, sheets 7-10, for a description of functionality and applications. For applications, see *Dairy Australia,* Appendix F.)

In dairy applications, MPC is preferred to nonfat dry milk for standardizing the protein level in the milk for making cheese products. MPC has a higher protein content (ranging from 42 percent to greater than 80 percent) than nonfat dry milk (which averages about 35 percent protein) and a correspondingly lower lactose level. Less lactose generates less whey and, as a result, cheese production is more efficient *(Jesse)*. In 2002, 62 percent of all MPC imports were used in making cheese products *(United States International Commerce Commission, USITC Publication 3692*, p 7-3).

MPC can also be used in a wide variety of nondairy applications, such as in sports drinks and bars, nutritional food products, nutraceutical foods, etc. (See, e.g. *Dairy Australia*, pp. 15, 25 and 71; *Childs; Frierott;* and *GAO*, Appendix IV). "Specialty nutrition" applications used 24 percent of all MPC imports in 2002 (*USITC Publication 3692*, p.7-3).

MPC can be custom-formulated according to the required protein content level of the end-users. While MPC is made through the ultrafiltration process, lower protein content MPC can also be formulated by blending casein and nonfat dry milk.

MPC co-precipitates and other milk protein products. Other than by filtration, some MPC may be made by the precipitation process, where calcium chloride or dilute acid is added to skim milk and the solution is then heated to precipitate both casein and whey protein. The co-precipitates contain 89 to 94 percent protein (*Smith*). (The USITC Harmonized Tariff Schedule classifies these MPC co-precipitates under the same heading as casein and caseinates, HTS 3501.)

Other concentrated milk protein products of interest include casein and caseinates. Casein contains around 90 percent protein and is made by adding either acid or rennet to skim milk. Addition of acid or rennet to milk causes casein (but not whey protein) to join together and separate from other components. Caseinate is produced by neutralizing acid/rennet casein with alkali and then drying the resulting product. The alkali treatment makes caseinate more soluble than casein (*Smith*). Production of casein dates back to at least early 1900s, primarily for nonfood uses. During the post-World War II era, developments in food technology changed the uses of casein and caseinates from almost entirely nonfood to mostly food (*Manchester*, p. 238).

Process Technology

Advances in new manufacturing process technology may allow the use of mostly dairy ingredients and small amounts of fresh milk in the manufacture of dairy products. An example is a patent (No. 6,372,268) recently issued by the United States Patent and Trademark Office, "Wheyless process for production of natural mozzarella cheese." The patent abstract states:

> "The present invention provides a wheyless process for preparing natural mozzarella cheese using dry dairy ingredients. This process enables the manufacture of cheese from non-perishable or shelf-stable ingredients such as dried milk protein concentrate and anhydrous milkfat. This enables greater flexibility in the location of cheese manufacturing facilities as handling and/or transporting large quantities of fresh milk is not required. Also, in utilizing such a process, the need for refrigerated storage of the fresh milk would be minimal. The dry dairy ingredients used in the present invention comprise milk protein concentrates and blends of milk protein concentrates with up to about 50 percent of a second dry dairy ingredient selected from the group consisting of whey protein concentrate, whey protein isolate, calcium caseinate, sodium caseinate, rennet casein, acid casein, nonfat dry milk, and mixtures thereof."

(Author's note: Whether the resulting product can be marketed as "mozzarella cheese" is subject to regulation by FDA's standards of identity.)

Several other wheyless process patents also have been granted for making various dairy products from dry ingredients. The proliferation of this type of manufacturing process technology using dry ingredients is going to alter the dairy landscape in a profound way. A plant making "cheese" (or other dairy products) from mostly dry ingredients can then be located anywhere, with no need to be close to dairy farms. The plant would no longer need to deal with producer payrolls, milk hauling, weather-induced intake variability, seasonality of milk production and composition, seasonal inventories of cheese, etc. This development will have great implications for milk producers and their cooperatives, especially in regard to cooperatives' roles in the supply chain.

Dairy Ingredients—Milk Proteins

Filtration technology is very useful in "harvesting" the components in milk. It is conceivable that further technological advances may someday turn milk plants into milk "refineries" that could fractionate milk components into all kinds of desired dairy ingredients (*Dairy Management, Inc., 2002*). The filtration technology that incorporates five filtering-process steps to fractionize whey within a closed loop membrane ultrafiltration system for harvesting valuable whey proteins (*Koph,* cited earlier) could be a precursor of more complete systems for fractionalizing milk components.

Milk proteins. The list of dairy ingredients could be very long (ingredients included in *American Dairy Products Institute* and *Chandan* are just the more familiar ones). Of particular interest to dairy farmers (and the focus of this section) are protein products such as milk protein concentrate (MPC), casein, and caseinates. The United States has relied on imports to satisfy demand for these products. However, growing import volumes of milk protein products over the past decade have heightened milk producers' concerns that they are displacing commercial uses of U.S.-produced nonfat dry milk.

Other protein products, such as whey protein concentrate (WPC), are produced with a technology similar to that used in producing MPC. However, unlike skim milk that is used to produce MPC and casein and is subject to administered prices, whey is a byproduct of cheese production and is not subject to price regulation. Without price being regulated, domestically produced whey products compete very well with foreign production and are not currently a pressing concern for milk producers. During the past 10 years, substantial amounts of dried whey, whey protein concentrate, and modified whey have been exported (table 2). According to the Food and Agricultural Organization of the United Nations, the U.S. share of world whey exports grew from 8 percent in 1994 to nearly 15 percent in 2002, before dropping back to 13 percent in 2003 (table 3).

Milk proteins are mostly imported. Until recently, there was no domestic production of MPC, casein, and caseinates in the United States. Milk prices are such that domestic production of these products can not compete with imports, which—besides being lower-priced—pay very low import duties or no tariffs at all.

There have been some recent efforts at starting the domestic production of the concentrated milk protein products. A facility with an annual production capacity of 16,000 metric tons of MPC-70 (the number following MPC denotes protein content, 70 percent protein in this case) equivalent product was completed in Portales, N.M., by DairiConcepts, a joint venture between two cooperatives, Dairy Farmers of America and Fonterra (of New Zealand) (*Kozak, et al*). Commercial operations started in July 2003 (*Parsons*). This followed on the start-up of MPC production (ranging from MPC-40 to PMC-70) by United Dairymen of Arizona,Tempe, A.Z., about 6 months earlier.

Beginning in June 2002, USDA has operated a program for the sale, at a discount, of Government-owned nonfat dry milk that has been in storage for more than 24 months to processors for casein or caseinate production. By the end of 2004, the activity in this program totaled nearly 42.7 million pounds of nonfat dry milk (*AMS*). (A similar program in 1986 and 1987 totaled only about one-half million pounds.) However, some claimed that protein products not made from fresh milk are less desirable in their sensory quality (e.g. *Frierott*).

Magnitude of milk protein imports. Following one set of conversion factors used by USITC, MPC on average may contain 65 percent protein; milk protein concentrate/casein (MPC imports in the same classification with casein and caseinates) may contain 90 percent protein; casein may contain 87 percent protein; and caseinates may contain 91 percent protein (*USITC Publication 3692,* p. 3-33). These conversion factors were used to calculate the volumes of protein contained in the imports of MPC, casein and caseinates as shown in table 4.

Table 2—U.S. whey products production and exports

Year	U.S. Production			Exports			Portion of production exported		
	Dried whey	Dried whey concentrate	Modified whey[1]	Dried whey[2]	Whey protein concentrate[3]	Modified whey[4]	Dried whey	Whey protein concentrate	Modified whey
	Metric tons						Percent		
1994	549,657	82,469	43,463	61,704	363	281	11.2	0.4	0.6
1995	520,391	133,518	49,243	93,991	5,681	727	18.1	4.3	1.5
1996	506,442	113,478	45,941	109,391	4,286	1,368	21.6	3.8	3.0
1997	515,655	119,767	40,619	103,961	10,234	1,805	20.2	8.5	4.4
1998	534,450	138,880	47,693	98,997	18,377	1,084	18.5	13.2	2.3
1999	520,446	162,589	54,575	120,172	14,344	1,384	23.1	8.8	2.5
2000	538,824	151,562	51,711	166,003	15,626	1,976	30.8	10.3	3.8
2001	474,301	152,507	58,625	142,979	21,721	3,118	30.1	14.2	5.3
2002	505,901	142,083	56,549	150,676	22,951	4,245	29.8	16.2	7.5
2003	492,757	153,751	38,152	138,984	20,976	3,565	28.2	13.6	9.3

1 Reduced lactose and reduced minerals.
2 HTS heading 0404104000.
3 HTS heading 0404100500.
4 HTS heading 0404100850.

Sources: U.S. production from Dairy Products, annual summaries, by USDA/NASS.
Exports from U.S. Trade Intenet System, http://www.fas.usda.gov/ustrade/, by USDA/FAS.

Table 3—**U.S. share of world whey[1] exports**

Year	U.S. exports	World exports	U.S. share
	Metric tons		*Percent*
1994	63,104	808,097	7.8
1995	100,971	820,490	12.3
1996	115,339	907,633	12.7
1997	116,942	956,687	12.2
1998	120,512	955,725	12.6
1999	136,125	993,908	13.7
2000	198,992	1,213,397	16.4
2001	168,717	1,190,409	14.2
2002	178,240	1,225,622	14.5
2003	164,954	1,310,592	12.6

[1] Whey and modified whey, whether or not concentrated or containing added sugar or other sweetening matter

Source: Food and Agricultural Organization of the United Nations, FAO Statistical Databases.

Between 1989 and 2003, MPC protein imports increased 22-fold, and MPC/casein protein imports increased fourfold. While casein imports (excluding casein glues) were rather flat (increased only 6 percent) over the time period, imports of protein contained in caseinates more than doubled (table 4). The volume of protein contained in imported MPC, casein, and caseinates, increased from 165 million pounds in 1989 to 279 million pounds in 2003, an increase of 69 percent.

One way to look at the magnitude of milk protein imports is to compare it to the protein level contained in U.S. nonfat dry milk production. Again, following the conversion factor used by USITC, nonfat dry milk averages around 36 percent milk protein (*USITC Publication 3692*, p. 3-33). Protein contained in the U.S. nonfat dry milk production increased 82 percent, from 315 million pounds in 1989 to 572 million pounds in 2003.

During the 15-year period, total protein imports were equivalent to 52 percent of the protein contained in the U.S. nonfat dry milk production. By comparison, USDA net removals of nonfat dry milk (removed by purchases under the Price Support Program and by bonuses under the Dairy Export Incentive Program) averaged 30 percent of production. Thus, the volume of milk protein imports exceeded USDA net removals by 74 percent over the 15 years. Imports exceeded USDA net removals every year except 2002 (table 4).

The magnitude of each category of milk protein imports may be better visualized in figure 1. While imports of casein, caseinates, and MPC/casein show gradual increase over the 15-year period, MPC imports increased tremendously since 1995, peaking in 2000.

As a result, total milk protein imports peaked in 2000 (figure 2). Although imports were lower than the previous year in 2001 and 2002, the volume increased again in 2003. It may be inferred from the linear trend line ($Y=9{,}127.8x+147{,}800; R^2=0.7781$) that total milk protein imports grew at a rate of 9 million pounds per year during the 1989-2003 period (a growth rate equivalent to 273 million pounds of milk per year). Figure 2 also shows that milk protein imports exceeded Government net removals every year except in 2002.

Effects of milk protein imports on milk prices. The extent to which milk protein imports have depressed milk prices depends on how much the imports have displaced nonfat dry milk in various applications. The USITC report estimated that imported milk protein products may have displaced approximately 318 million pounds of U.S.-produced milk protein, equivalent to 883 million pounds of domestic nonfat dry milk (using a conversion factor of 36 percent) in 1998-2002. It further estimated that 34 percent of the growth in the Commodity Credit Corporation (CCC) stocks (equivalent to 353 million pounds) of nonfat dry milk between 1996 and 2002 may be attributed to the increase in milk protein imports during the time period (*USITC Publication 3692*, chapters 7 and 9).

The accumulation of nonfat dry milk stocks increased the outlays of the price support program and may have been the impetus causing adjustments to the butter/powder tilt in the CCC purchase prices. On May 31, 2001, CCC purchase price for nonfat dry milk was adjusted downward by 10.32 cents, to $0.9000 per pound, and the purchase price was further reduced by 10 cents, to $.8000 per pound on November 15, 2002.

Because of the substantial amount of CCC nonfat dry milk purchases in recent years, the support purchase price in essence sets the price of nonfat dry milk. Given the pricing formula in use in the Federal Milk Market Orders (FMMO), the nonfat dry milk price in turn determines the Class II and Class IV skim milk prices. During those months when the advanced Class IV price is the Class I price mover, the nonfat dry milk also determines the Class I skim price. To the extent that milk protein imports aggravated the nonfat dry milk surplus situation and helped tilt the powder support purchase price downward, they certainly had adverse impacts on the farm milk prices. (*Jesse*, pp.12-17, for a detailed discussion)

Milk protein imports also lower the cost of standardizing the protein level in the milk for making

Table 4—**Estimated protein content[1] in the consumption imports of milk protein concentrates, casein and caseinates, and in the U.S. production and USDA net removals of nonfat dry milk, thousand pounds of protein**

Year	Milk protein concentrates[2]	Milk protein cencentrates/ casein[3]	Casein	Caseinates	Total imports	Nonfat dry milk, U.S. production	Nonfat dry milk, USDA net removals	Imports vs protein in U.S.nonfat dry milk production	USDA net removals vs. protein in U.S.nonfat dry milk production
	Thousand pounds of protein							*Percent*	
1989	2,165	4,840	125,422	32,907	165,333	314,880	-	52.5	-
1990	1,153	5,681	132,396	32,283	171,514	316,516	42,407	54.2	13.4
1991	1,608	7,345	131,954	33,662	174,568	315,909	97,036	55.3	30.7
1992	5,636	6,961	143,127	33,539	189,262	313,964	49,220	60.3	15.7
1993	8,340	6,737	115,975	33,996	165,049	343,615	109,563	48.0	31.9
1994	17,209	13,467	131,076	41,821	203,572	443,108	104,413	45.9	23.6
1995	10,442	5,972	126,218	49,323	191,955	443,878	109,724	43.2	24.7
1996	20,429	7,673	132,662	51,120	211,885	382,238	20,606	55.4	5.4
1997	24,358	22,607	124,720	52,083	223,767	438,322	107,277	51.1	24.5
1998	41,455	21,666	135,018	60,043	258,182	408,738	117,502	63.2	28.7
1999	64,308	19,260	126,901	65,225	275,694	489,478	194,608	56.3	39.8
2000	75,846	23,654	142,260	67,984	309,743	522,630	249,326	59.3	47.7
2001	40,796	13,759	118,182	76,705	249,441	508,960	178,509	49.0	35.1
2002	48,186	15,506	110,323	69,614	243,629	574,538	295,835	42.4	51.5
2003	50,867	25,344	133,195	69,334	278,740	572,055	231,881	48.7	40.5
Average	27,520	13,365	128,629	51,309	220,822	425,922	127,194	51.8[4]	29.9[4]

[1] Factors used to convert products to protein: milk protein concentrate, 65%; milk protein concentrate/casein, 90%; casein, 87%; caseinates, 91%; and nonfat dry milk, 36%. (Adopted from ITC, p. 3-33.)
[2] Milk protein concentrate imported under HTS 0404901000.
[3] Milk protein concentrate imported under HTS 3501101000.
[4] Weighted average

Sources: Consumption imports of milk protein concentrates, casein and caseinates are compiled from U.S. Trade Internet System, Foreign Agricultural Service, USDA, http://www.fas.usda.gov/ustrade/. Nonfat dry milk production is from Dairy Producs, annual summaries, various issues, Natioanl Agricultural Statistics Service, USDA. USDA net removals data is from Livestock, Dairy, and Poultry Outlook, April 27, 2004, and Dairy Yearbook, Economic Research Service, USDA, http://www.ers.usda.gov/publications/ldp/.

Figure 1—**Estimated protein content in imported milk protein products**

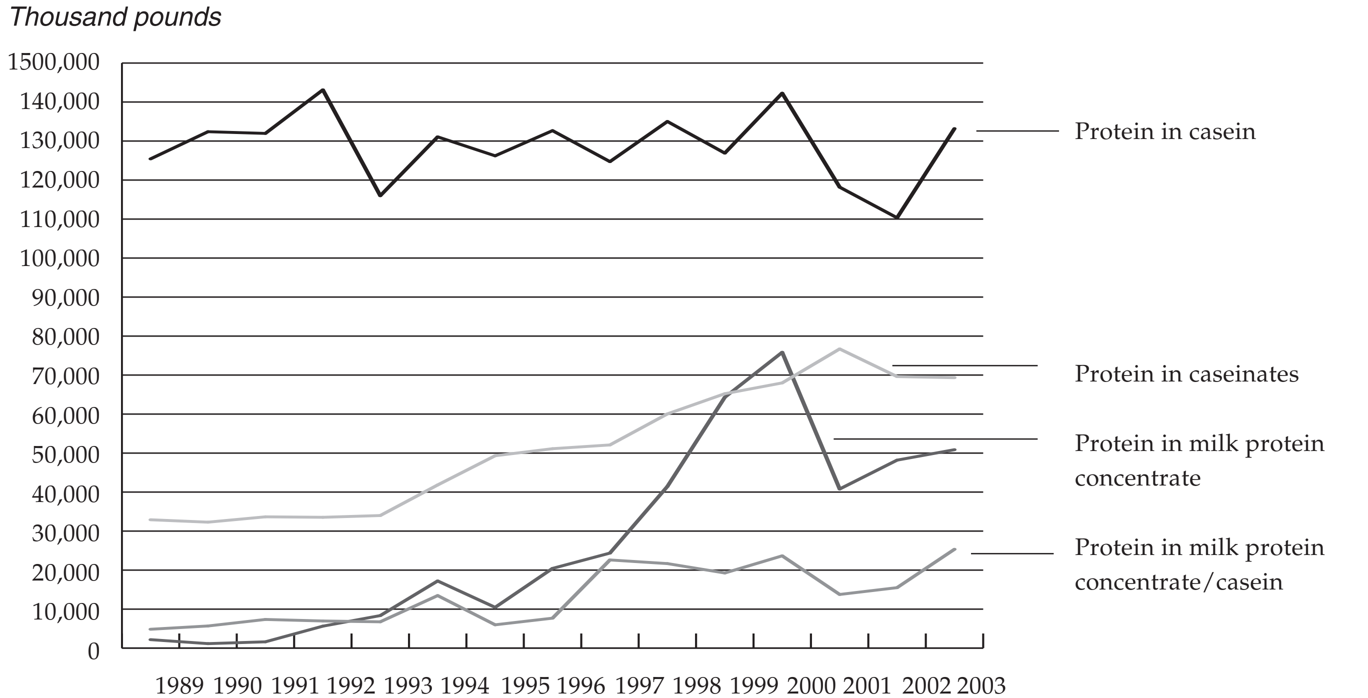
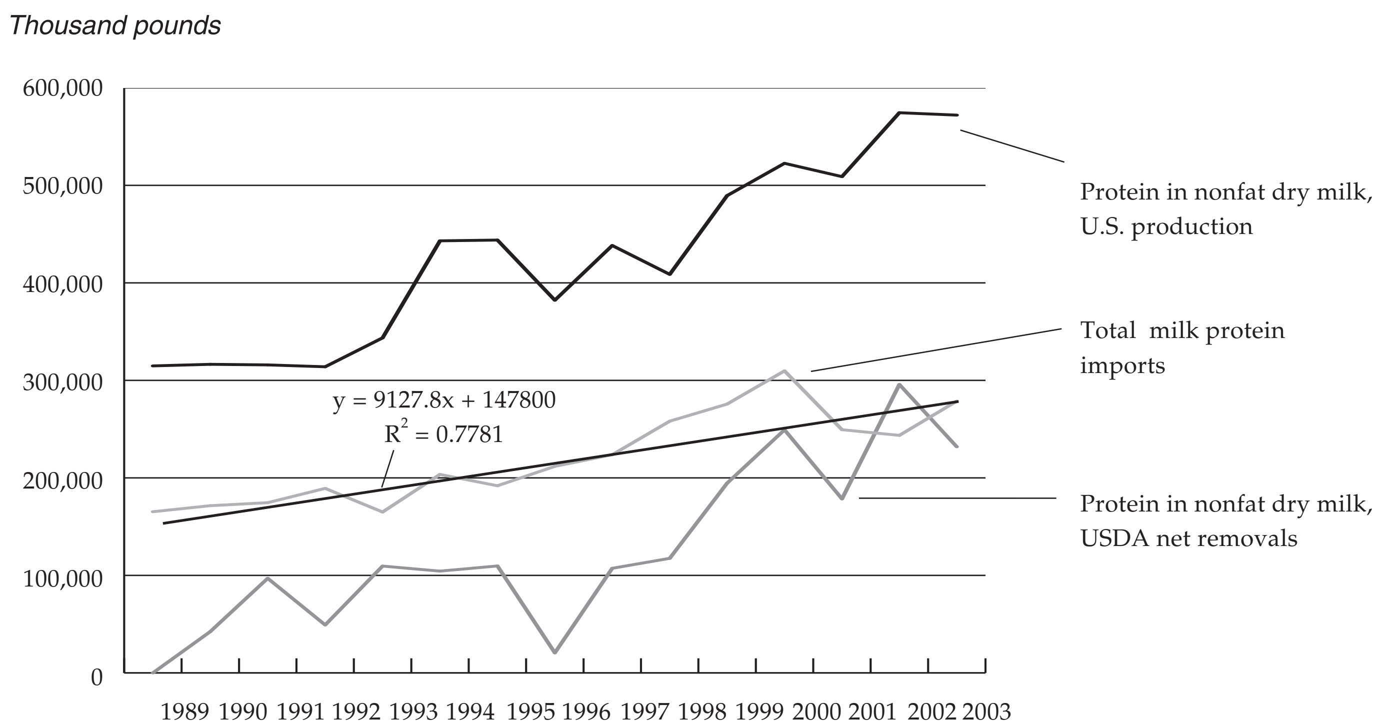


Figure 2—**Estimated protein content in U.S. production and USDA net removals of nonfat milk, and in imports of milk protein products**



cheese. A plant may use nonfat dry milk for standardization, the price of which has been tilted downward. Or it may use less expensive imported milk protein (USITC survey showed that 62 percent of MPC imports were used in processed cheese production in 2002). Either way, the cheese plant would have lower input cost, and the lower input cost would shift the cheese supply curve downward and outward and result in lower cheese prices. Although cheese products made with MPC are outside FDA's standards of identity, their lower prices would lower the price level of all cheeses due to substitution effects. Again, given the FMMO price formula, lower cheese prices would mean lower Class III prices. And in those months when the advanced Class III price is the Class I price mover, lower cheese price means lower Class I price.

So, when nonfat dry milk is displaced by milk protein imports, lower milk prices will be the result. This is simple economics—everything else being equal, the more the supply, the lower the price. The question is: how much lower? Estimates vary. The USITC report estimated that as a result of the 2001 tilt adjustment, farm prices of milk dropped by 44 cents per hundredweight, while the 2002 tilt adjustment caused the farm price of milk to be lowered by 29 cents per hundredweight (*USITC Publication 3692,* chapter 9).

No incentives to produce milk protein products. With all the demand for MPC, casein and caseinates being satisfied by imports, a pertinent question is why is there no domestic production for import substitution (until recent start-ups)?

While the technology for the commercial production of MPC was only developed two decades or so ago, casein production has a much longer history—the United States did produce casein prior to 1970. Several factors led to the cessation of casein production in this country. They are the same reasons why the U.S. dairy industry is reluctant to invest in MPC production. A brief review of these factors is useful information for assessing the current situation (more details can be found in *Manchester* and *in Ling, et al*).

The United States produced 35.3 million pounds of dry casein in 1931 (table 5). Casein production peaked at 67.5 million pounds in 1937. It returned to a relatively "normal" level the following year and stayed relatively stable until 1942, when 42.3 million pounds was produced. Production then dropped to 18.4 million pounds in 1943 and, by and large, was maintained at around that level until 1951 (except for the one-year surge in 1947). It then dropped to 7.5 million pounds in 1952 and further declined to 2.5 million pounds in 1956, the last year the production figure was

Table 5—**U.S. dried casein production (skim milk or buttermilk product) and imports**

Year	Production	Imports	Total
	Thousand pounds		
1931	35,335	3,503	38,838
1932	24,428	1,201	25,629
1933	24,087	8,142	32,229
1934	37,331	1,491	38,822
1935	37,638	3,230	40,868
1936	46,140	16,209	62,349
1937	67,467	5,210	72,677
1938	48,549	417	48,966
1939	40,878	15,832	56,710
1940	46,616	24,523	71,139
1941	47,346	41,518	88,864
1942	42,268	16,819	59,087
1943	18,386	28,052	46,438
1944	15,264	47,225	62,489
1945	12,333	51,610	63,943
1946	18,319	45,346	63,665
1947	35,831	20,887	56,718
1948	14,372	40,585	54,957
1949	18,348	33,061	51,409
1950	18,531	54,552	73,083
1951	21,620	43,386	65,006
1952	7,482	56,836	64,318
1953	5,532	74,246	79,778
1954	5,175	59,833	65,008
1955	3,147	74,480	77,627
1956	2,533	70,674	73,207
1957	(1)	74,604	-
1958	(1)	91,265	-
1959	(1)	94,459	-
1960	(1)	92,155	-
1961-70 Average	(1)	105,959	-

[1] Fewer than 3 plants since 1957 until 1970, the last year reported by the Agricultural Statistics, 1972. Since then, no data has been reported ("-" denotes no data).

Sources: Agricultural Statistics, various years reported in USDA's Agricultural Statistics. Thereafter until 1970, Agricultural Statistics (1972) showed fewer than 3 plants made casein and no production volume was reported. Subsequently, the data series was dropped altogether.

Both casein and nonfat dry milk use skim milk as the raw material for production. This, in effect, dictates that in order to compete for milk supply, casein and nonfat dry milk enterprises must be equally profitable per hundredweight of skim milk. However, since the late 1930s, government programs have provided incentives for the production of nonfat dry milk but not casein.

War-time (World War II) programs provided incentives to processors to operate (then) large-scale, state-of-the-art plants to produce nonfat dry milk. The casein industry could not match the profitability of making nonfat dry milk and was neglected. After the war, the casein industry could not resume the pre-war level of production and could not justify new investment in the sector.

Since 1949, the Milk Price Support Program specifically offers to purchase nonfat dry milk, but not casein. The support purchase price incorporates a "make allowance" that ensures an average manufacturer of nonfat dry milk can recover the processing cost. Market security provided by the Milk Price Support Program ensures that nonfat dry milk production is almost without market risk. This enables processors to invest, with confidence, in nonfat dry milk plants that are of very large scale and very efficient and incur low unit-manufacturing cost. This, conceivably, widens the profitability gap between the two products.

In addition, import tariff systems, to a large extent, shield nonfat dry milk from import competition, while casein, caseinates, and MPC are not accorded such protection and have to compete with low-cost foreign production.

Thus, public policy provides incentives (guaranteed margins and a guaranteed market with low risk) to nonfat dry milk production. No such incentives for casein production or for the recent advent of milk protein concentrate production.

Relative value of casein to nonfat dry milk. Another factor inhibiting ventures into the production of casein, caseinates or milk protein concentrate may be the uncertainty concerning the results of getting into competition with foreign production. The milk used in producing these protein products is usually considered "surplus" milk. Some farmers say that international competition could drive down the price of milk or products to next to nothing—"racing for the bottom," in their words. However, an examination of the history of casein and nonfat dry milk prices does not validate such apprehension (table 6).

During the 22-year period of 1935-56, when domestic casein was produced, the ratio of casein price relative to nonfat dry milk price ranged between 1.64 and 2.90. During the last nine years (1995-2003), when there was no domestic casein production and all casein was imported, the ratio of casein price relative to low/medium-heat nonfat dry milk price was between 1.80 and 2.59. The ratio was between 1.78 and 2.48 if high-heat nonfat dry milk price is considered. (1995 was the first year when the two most recent consistent price series for [low/medium-heat and high-heat] nonfat dry milk used in table 6 became established.)

The casein and nonfat dry milk covered in the two time periods may not be identical. Nevertheless, the rather stable relative price of casein to nonfat dry milk—when there was domestic casein production and no price support for nonfat dry milk and when all casein was imported and nonfat dry milk was supported—suggests that the prices of casein and nonfat dry milk did reflect the component values of the two products. This may serve to refute the notion that producing casein domestically would amount to competing with foreign suppliers, the result being prices racing to the bottom—as long as nonfat dry milk has market value.

Protein Ingredient Production Prospects

The prospects of producing protein ingredients in the United States should be assessed against the following backdrop:

- Technological advances will continue to devise new and better ways of harvesting milk components for uses as dairy ingredients in an ever-expanding array of food, beverages, pharmaceuticals, and other products.

- Among the dairy ingredients that concern dairy farmers the most are protein products, including casein, caseinates and milk protein concentrate. These milk protein products have all been imported, although there were two domestic startups of MPC production in 2003.

- Manufacturing process technology invariably looks for more efficient and economical ways to make dairy products. Technology, such as the wheyless process of making various non-

Table 6—**Casein and nonfat dry milk prices, 1935-56, and 1996-2003**

Year	Casein, ground, New York City	Nonfat dry milk for human food, f.o.b. factory	Relative price, casein/nonfat dry milk
	Cents/pound		*Ratio*
1935	12.8	6.65	1.92
1936	16.6	8.73	1.90
1937	15.2	7.65	1.99
1938	9.0	5.47	1.65
1939	12.4	6.12	2.03
1940	13.1	6.87	1.91
1941	21.8	9.00	2.42
1942	21.5	12.94	1.66
1943	23.2	13.81	1.68
1944	24.0	14.26	1.68
1945	23.0	14.06	1.64
1946	30.1	14.51	2.07
1947	29.8	10.86	2.74
1948	32.0	15.10	2.12
1949	22.6	11.95	1.89
1950	29.5	11.91	2.48
1951	41.7	14.40	2.90
1952	30.5	16.25	1.88
1953	30.0	15.18	1.98
1954	28.7	14.95	1.92
1955	28.6	15.35	1.86
1956	32.2	15.24	2.11

	Acid casein, edible nonrestricted	Nonfat dry milk,West, low/medium heat	Nonfat dry milk,West, high heat	Relative price, casein/nonfact dry milk, low/medium heat	Rrlative price casein/nonfact drymilk, high heat
	Dollars/pound			*Ratio*	
1995	1.9035	1.0549	1.0721	1.80	1.78
1996	2.5472	1.1708	1.2049	2.18	2.11
1997	2.1003	1.0715	1.0979	1.96	1.91
1998	2.0383	1.0549	1.0852	1.93	1.88
1999	1.9009	1.0128	1.0450	1.88	1.82
2000	2.1890	1.0056	1.0419	2.18	2.10
2001	2.5506	0.9860	1.0281	2.59	2.48
2002	1.9983	0.9197	0.9433	2.17	2.12
2003	2.0200	0.8412	0.8409	2.40	2.40

Souces: For 1935-56 prices, Agricultural Statistics, various years; for 1995 on, Dairy Market Statistics, annual Summaries, various years, Agricultural Marketing Service.

standard products (or permissible standard products), tends to promote use of dry ingredients and has many advantages over the conventional method of using fresh milk as the main input. Milk protein products—such as casein, caseinates, and milk protein concentrate—are ideal ingredients for this kind of technology due to their properties and functionalities.

- Between 1989 and 2003, imports of milk protein (in casein, caseinates, and milk protein concentrate) grew at an annual rate of 9 million pounds of protein (273 million pounds of milk equivalent). In 2003, total imports of these protein products were 279 million pounds (8.5 billion pounds of milk equivalent). More imports of these protein products can be expected with the advances of the manufacturing process technology.

It seems that the U.S. dairy industry would want to supply at least a share of a market that uses 8.5 billion pounds of milk and grows at a rate of 273 million pounds a year. If so, somehow a way must be found to make it economically feasible to venture into the production of protein products such as casein, caseinates, and milk protein concentrate. For this to happen, a processor's return from the protein products production per hundredweight of skim milk must be at least equal to the return from drying the same amount of skim milk into nonfat dry milk because both enterprises use skim milk as the raw material.

As explained earlier, largely due to the incentives provided by the Milk Price Support Program, producing nonfat dry milk has a higher return than processing protein products and is free of market risk. To equalize the return, some incentives would have to be provided to the would-be processors of the protein products. There are many proposals as to how this could be achieved, such as production subsidies or import restrictions, but their discussion is beyond the scope of this report. (See the proposal by *National Milk Producers Federation*. For a thorough review of the trade issue, see *USITC Publication 3692*.)

Some advantages of domestic production. When comparing returns from domestic production of milk protein products vs. imports, foreign supplies have a price advantage over domestic production. However, the comparison also should take into account that domestic production may have advantages over imports in other aspects:

- Domestic production would supply fresher protein products at a lower transportation cost to customers than imports.

- Proximity to end-users would enable domestic protein producers to provide better services and have closer interactions with customers regarding their changing needs.

- Some end-users may prefer to use the protein products in the fresh, wet form without having them dried and then reconstituted for further processing. Domestic producers would be in a good position to supply these accounts.

- Some end-users may prefer caseinates made from fresh milk, rather than caseinates made from further processing of imported casein.

Location of protein ingredient plants. Both nonfat dry milk and milk protein ingredient products use skim milk as the main raw material for production. Therefore like nonfat dry milk plants, the logical location for new protein ingredient plants should be a region where an abundant and growing volume of milk needing last-resort handling is available.

In the 10 years since 1993, nonfat dry milk production in the West more than doubled (increased 117 percent) to 1.25 billion pounds in 2003, or 79 percent of the U.S. total (table 7; table 8 for regions). Production in other regions, except the Atlantic, declined. The increase in the Atlantic region was 11 percent in 10 years.

Likewise, milk production has seen major growth in the West during the same period, increasing by 25.7 billion pounds (or 62 percent), to 67 billion pounds. The volume accounted for 39 percent of U.S. total milk production in 2003. The East North Central was the only other region to show milk production increase, but only by 400 million pounds in 10 years. The remaining three regions all showed decreases in milk production.

The trend is likely to continue, as indicated by the costs and returns of milk production (table 7). Milk producers in the West had the lowest operating costs, the lowest ownership costs and, therefore, the lowest total costs among the five regions in 2000, the year of the most recent national survey of milk producers. Although their returns above operating costs, at $3.33 per hundredweight, were the median of the five

Table 7—**Production of nonfat dry milk for human consumption, milk production and milk production costs and returns, by region.**

	Atlantic	East North Central	West North Central	South Central	West	U.S. total
Production of nonfat dry milk for human food[1]:						
	---Thousand pound---					
1993	141,405	63,860	71,291	102,783	575,146	954,485
1998	192,045	56,961	87,151	59,034	740,192	1,135,383
2003	157,620	43,314	67,313	68,615	1,247,179	1,584,041
Region vs. U.S. total in 1993	15%	7%	7%	11%	60%	100%
Region vs. U.S. total in 2003	10%	3%	4%	4%	79%	100%
Milk production[2]:						
	---*Million pounds*---					
1993	36,330	37,668	21,329	14,148	41,162	150,636
1998	36,573	36,928	19,959	12,308	51,580	157,348
2003	35,127	38,107	19,047	11,157	66,875	170,312
Region vs. U.S. total in 1993	24%	25%	14%	9%	27%	100%
Region vs. U.S. total in 2003	21%	22%	11%	7%	39%	100%
Milk production costs and returns, 2000[3]:						
	---*Dollars per cwt. milk sold*---					
Total operating costs	10.53	9.65	13.18	13.73	9.52	
Total ownership costs	3.91	4.75	4.91	4.50	2.06	
Total costs	14.44	14.40	18.09	18.23	11.58	
Returns above operating costs	4.75	4.62	1.22	1.92	3.33	
Returns above total costs	0.84	(0.13)	(3.69)	(2.58)	1.28	

[1] From Dairy Products, annual summaries, USDA/NASS.
[2] Summarized from Milk Production, Disposition and Income, annual summaries, USDA/NASSS.
[3] From Short, table 2; regions are defined on page 3 of the Short's report and are here used as proxies to represent those used in Dairy Products: Northern Crescent-East (Atlantic), Northern Crescent-West (East North Central), Heartland (West North Central), Eastern Uplands (South Central) and Fruitful Rim-West (West). Costs and returns reported are based on the 2000 Agricultural Resource Management Survey, the most recent national survey of milk producers.

Table 8—**Milk production by State and region, 10-year changes**

State by region	1993	2003	10-year change	
	Million pounds			*Percent*
CT	543	413	(130)	(24)
DE	147	136	(11)	(7)
FL	2,558	2,161	(397)	(16)
GA	1,535	1,444	(91)	(6)
MA	478	332	(146)	(31)
MD	1,400	1,232	(168)	(12)
ME	663	624	(39)	(6)
NC	1,498	1,044	(454)	(30)
NH	325	305	(20)	(6)
NJ	363	216	(147)	(40)
NY	11,415	11,952	537	5
PA	10,181	10,338	157	2
RI	32	22	(10)	(32)
SC	418	318	(100)	(24)
VA	1,995	1,731	(264)	(13)
VT	2,504	2,637	133	5
WV	275	222	(53)	(19)
Atlantic total	**36,330**	**35,127**	**(1,203)**	**(3)**
IL	2,514	2,047	(467)	(19)
IN	2,255	2,944	689	31
MI	5,435	6,360	925	17
OH	4,620	4,490	(130)	(3)
WI	22,844	22,266	(578)	(3)
East North Central total	**37,668**	**38,107**	**439**	**1**
IA	4,054	3,780	(274)	(7)
KS	1,080	2,115	1,035	96
MN	9,693	8,258	(1,435)	(15)
MO	2,840	1,886	(954)	(34)
NE	1,125	1,129	4	0
ND	918	554	(364)	(40)
SD	1,619	1,325	(294)	(18)
West North Central total	**21,329**	**19,047**	**(2,282)**	**(11)**
AL	515	252	(263)	(51)
AR	769	352	(417)	(54)
KY	2,120	1,464	(656)	(31)
LA	935	519	(416)	(44)
MS	745	423	(322)	(43)
OK	1,257	1,312	55	4
TN	1,897	1,205	(692)	(36)
TX	5,910	5,630	(280)	(5)
South Central total	**14,148**	**11,157**	**(2,991)**	**(21)**

continued

Table 8—**Milk production by State and region, 10-year changes (continued)**

State by region	1993	2003	10-year change	
	Million pounds			*Percent*
AK	12	17	5	40
AZ	1,876	3,454	1,578	84
CA	22,924	35,437	12,513	55
CO	1,454	2,177	723	50
HI	142	92	(50)	(35)
ID	3,229	8,774	5,545	172
MT	307	346	39	13
NV	348	485	137	39
NM	2,766	6,666	3,900	141
OR	1,692	2,177	485	29
UT	1,332	1,615	283	21
WA	4,980	5,581	601	12
WY	100	54	(46)	(46)
West total	41,162	66,875	25,713	62

Source: Milk Production, Disposition and Income, annual summaries, USDA/NASS.

regions, the West was the most profitable region in terms of returns above total costs, at $1.28 per hundredweight (*Short*).

The returns above operating costs were all positive in the other four regions, and these returns in the Atlantic and the East North Central regions were even higher than in the West. But the high ownership costs in the four regions resulted in only the Atlantic region having positive returns above total costs, at 84 cents per hundredweight. The East North Central region could hardly break even, while the West North Central and the South Central regions had substantial losses.

In the short run, dairying is sustainable for the existing farmers in all regions. For the long term, some dairy farmers in the West North Central and the South Central regions may find it difficult to justify investing in expansion or replacement of obsolete major farm structures or equipment, and milk production in the two regions most likely will continue to decline. Milk production in the Atlantic and the East Central regions may or may not grow. Farmers in the Atlantic region may or may not find the 84 cents per hundredweight margin high enough to induce production expansion, while in the East North Central, they may be able to overcome the small losses and improve their long-term milk production prospect. Thus, the West is the region that is most certain to see continued growth in milk production that would support new plant capacity.

In fact, the growth in milk production in the West requires that every year the region have new plant capacity capable of handling at least 7 million pounds of milk a day. This is the region (especially California, Idaho and New Mexico) where new milk protein plants should be located, if they were to be built. In fact, the first two plants in the United States for MPC production are located in this region.

Location of end-users. End-users of milk protein ingredients, such as manufacturers of dairy products using wheyless process, would have much flexibility in locating their plants. The manufacturing process would use dried or shelf-stable dairy ingredients and some, but probably not a large volume of, fresh milk. Manufacturers would look to locate their plants where it is most convenient and at the least transportation cost to receive the ingredients (including milk) and serve customers. In other words, the plants do not have to be in or near milk-producing areas.

Regional specialization of milk use. Because the West has abundant and growing milk production, it is the region where new capacities for making commodity dairy products have been located in recent years. The advent of milk protein ingredient production would accentuate the trend.

In the regions outside the West, milk production is generally holding steady, if not in decline. The milk-use trend shows demand mainly for fluid purposes and for making traditional (standard) dairy products. There still would be nonfat dry milk plants in these regions, mostly for last-resort processing and milk supply balancing. There may be sufficient milk volume in States such as Kansas, Michigan, Indiana and New York to support some new milk-protein ingredient production facilities. But they probably would be an enterprise within a dairy plant's operations for serving customers in the local areas rather than large scale, stand-alone plants that could take full advantage of the economies of scale.

Roles of Dairy Cooperatives

If the growth of the industry is going be driven by the new technologies involving manufacturing ingredients and making products using alternative methods, then how do cooperatives fit into the scheme of things?

Augmented first-handler role. Dairy cooperatives would continue to be the first-handlers, marketing members' milk to fluid and other processors and manufacturing the remaining volume into various products in their own plants. Even more of the first-handler functions may fall on cooperatives if end-users of dry milk ingredients adopt wheyless processes and do not need much fresh milk, thus having the option of not having to locate their plants close to dairy farms. These end-users most likely would not want to deal with milk procurement, field services, producer payrolls, milk hauling, weather-induced intake variability, and seasonality of milk production and composition.

Besides marketing milk, dairy cooperatives' first-handler role also includes marketing dairy products produced in their plants as dairy ingredients to food manufacturers. These include fluid skim, cream, condensed products, mixes, UF milk, nonfat dry milk, butter or cheese for further processing. In the future it would also include milk proteins.

Cooperatives are potential producers of milk protein ingredients. One important function of dairy cooperatives is supply balancing and last-resort processing of surplus milk, usually carried out in nonfat dry milk plants (or butter-powder plants) owned and operated by dairy cooperatives. Making milk protein ingredients would be an alternative outlet for such milk. Dairy cooperatives are certainly going to play a prominent role in a milk protein ingredient sector if it becomes economically feasible to produce such products domestically.

In 2002, dairy cooperatives owned and operated 43 dry milk plants and marketed 86 percent of the Nation's nonfat dry milk (*Ling, 2004*). As milk production continues to grow, more nonfat dry milk plants must be built to handle the "last-resort" volume, unless alternative uses of the milk could be found. Making milk protein ingredients requires a high volume of skim milk as the input and would be a promising alternative. As a matter of fact, dairy cooperatives have been actively exploring the feasibility of making such alternative products (*Ling, et al*), and two have taken the step towards actual production. The Tempe, A.Z. plant is owned and operated by United Dairymen of Arizona, and the MPC/ingredient plant in Portales, N.M. is a joint venture of Dairy Farmers of America. California Dairies also has studied the feasibility of making milk protein concentrate (*Cotta; Kozak, et al*). More such efforts by dairy cooperatives are likely in the future.

Cooperatives as end-users of milk ingredients. Besides marketing members' milk and making milk ingredients for further processing, many dairy cooperatives also use milk and milk ingredients to produce end-products for the wholesale market, food service industry, or the consumer market. These end-products are usually standard traditional dairy products.

However, some cooperatives have been making nontraditional dairy or related products to satisfy consumers' shifting demand or to have a complete line of dairy and related products to offer customers. In most cases, the nontraditional products are dairy-based, and dairy ingredients constitute the major share of the manufacturing inputs. They are seldom far afield from the dairy base, because it would be difficult for a dairy cooperative to justify to its milk producer-members the rationale of using their precious equities to market products other than milk and milk products.

When cooperatives have ventured into unconventional or trendy new products—such as niche beverages, sports drinks, nutritional food products, or nutraceutical foods, etc.—they often have relied on joint-venture partners who have the technical know-how to make and market the products and to share the substantial market risk. The main purpose of cooperatives in these ventures is to sell milk or milk ingredients.

Dairy Cooperatives' Challenges

In a future that is driven by technology, dairy cooperatives face many challenges. Chief among them are:

- Research and development.
- Product development and marketing.

- Acquiring manufacturing and process technology.
- Equity Financing.

Research and development. Research and development is the foundation of manufacturing and process technology, product development and marketing. Through check-off dollars, dairy farmers have funded many research projects that provide information pertaining to the development of process technology. Many other projects have actually resulted in new or improved products being developed by applying the attributes of various dairy ingredients (*Dairy Management Inc., 2004*).

Valuable as they are, however, such generic efforts by dairy farmers need to be complemented by research and development work of individual cooperatives or processors in the final stages of new product formulation. Only through its own research and development efforts can a cooperative (or processor) identify and have a full grasp of its market niches and develop the products to satisfy the customers' demand. (For a look at one firm's research and development, see *USITC Hearing Proceedings* and *Dairy Companies Association of New Zealand.*)

Product development and marketing. Every year, hundreds of new dairy products are introduced to the consumer market by processors, including cooperatives. In 2003, a total of 794 new products (butter, cheese, milk, yogurt, ice cream/frozen yogurt, and other frozen desserts) debuted. The number of new products was 874 in 2002 (*Prepared Foods*).

New products may be developed by modifying the flavors, taste, colors, forms, packaging or shelf-life of existing products, or by fortifying them for desired functionality. Some may be the organic versions of the products. Genuinely new varieties of specialty cheese or products also have been introduced (*Roberts, Jr.*). In many areas of the country, efforts by dairy farmers to add value to milk have produced many kinds of artisan/farmstead cheeses, yogurts, and other dairy products.

Product development also refers to using dairy ingredients (or dairy products as ingredients) to develop or improve foods and beverages. Successful development of dairy ingredients depends on finding ways (or helping customers to find ways) to apply the functionality and health benefits of the ingredients in the formulation of new products. (See *Haines* for some recent development.)

Developing new products is only the first step in opening up new markets for the dairy industry. Consumer acceptance of newly developed dairy products or new products that are formulated to exploit the functionality of dairy ingredients is vital to ultimate success.

Marketing new consumer products requires market research, test marketing, advertising and promotion, consumer education, shelf space acquisition (possibly by paying slotting fees to retailers to put products on the shelf), merchandizing, and servicing the products. Although the rewards of developing and marketing new consumer products may be substantial, the risks involved also may be great.

In marketing new dairy ingredients, the challenge is to provide end-users (processors) with information on the attributes and functionality of an ingredient. Such information must be scientifically documented. The marketer also must be ready to serve the needs of the processors. For example, the marketer may have to show the processors, or work with them, on the best way to use the ingredient in formulating end products and the best way to process the end products.

Acquiring manufacturing and processing technology. Machinery and equipment are the embodiment of manufacturing technology. Cooperatives usually acquire new manufacturing technology by buying new machinery and equipment. However, as the scale of dairy plants grows larger, the cost of building a new plant with new machinery and equipment is substantial. The challenge is whether dairy cooperatives could afford the new plant, both in financial terms and in terms of milk volume that is needed to sustain the operations, to keep up with technology advancement. This is a particular challenge for cooperatives that engage in processing commodity dairy products. (See box 2 for examples of the required milk volumes and costs of some recent plants.)

To differentiate value-added products and gain competitive advantages, cooperatives, like other processors, adopt new ways to manufacture or package them or enhance the particular attributes of the products (nutritional benefits, functionality, flavors, shelf life, etc.). Such undertakings often require modifying the manufacturing or packaging process. The challenge for cooperatives is to devote adequate resources to develop or acquire the process technology.

The other aspect of process technology development is finding new ways to make existing products. An example is the wheyless process for the production of "mozzarella cheese" cited earlier in this report.

Milk volume and the costs of some new cooperative plants

A new plant for making Cheddar cheese in 640-pound block packages is being built in Clovis, New Mexico, at a cost of $190 million. When fully operational, the plant will process 2.4 billion pounds of milk a year, or about 7 million pounds of milk a day (*Dairy Farmers of America*). Also, two new mozzarella cheese plants in California will each have a capacity of 6 million pounds of milk a day when in full operation (*Dairy Foods, Vol. 104, No. 2* and *Vol. 105, No. 4*).

A new butter churn commissioned in 2003 in Washington has a capacity of 28,000 pounds of butter per hour (*Northwest Dairy Association*). That amount of butter is equivalent to the butterfat contained in 625,000 pounds of milk per hour or 5 million pounds of milk in an 8-hour day.

A plant capable of handling 5 million pounds of milk a day to make nonfat dry milk and MPC is estimated to cost more than $108 million (*Cotta*). A state-of-the-art "green-field" (instead of add-ons) nonfat dry milk plant would handle 5 million pounds of milk a day and would cost about $70 million.

On the other hand, plants that engage in making "value-added" products (vs. commodity products) are usually of smaller scale, although they may be similarly expensive. An example is a block cheddar cheese plant with a capacity of 1.6 million pounds of milk a day that was completed in late 2001 in Oregon at a cost of $50 million (*Phillips*). Another example is a cooperative organized by a group of Amish dairy farmers in northern Iowa and southern Minnesota five years ago. It has invested more than $1 million in a plant that has a capacity of processing about 20,000 pounds of milk daily into specialty blue cheese (*Perkins*).

For an example of a milk-protein fraction plant, Fonterra, a New Zealand cooperative, started lactoferrin production in September 2004 in a new plant in Hautapu, New Zealand, that cost $15 million (*Fonterra News*).

The Ultimate Challenge—Equity Financing

All of this—building new plants, buying new equipment, developing and modifying manufacturing processes, developing and marketing new products, and engaging in research and development to compete in a technology-driven industry—requires adequate financing.

Unique equity financing of cooperatives. There are two broad sources of financing: debt financing (borrowing) and equity financing. A dairy cooperative's debt financing may work much the same way as any business. Its equity financing, however, is unique and may have the following features:

- Common stock: Some cooperatives may issue common stock to cooperative membership which is usually of nominal value.

- Retained patronages: Net savings that are allocated to members based on patronage but are retained to finance the cooperative's operations after paying members the cash portion. Members must treat the entire allocated patronages as income for tax purposes. Cooperatives usually revolve retained patronage back to members after a certain period of time.

- Capital retains: Money that is withheld at a certain rate per hundredweight of milk to finance the cooperative's operations. Members must treat capital retains as income for tax purposes. Capital retains are also revolved back to members after a certain period of time.

- Base capital plan: Under the plan, a target base capital level is established at a rate per hundredweight of milk marketed during a representative period. This provides an adequate level of equity capital for the operations of the cooperative. The base capital may be funded by retained patronage and/or capital retains, or by other means of member contribution. Once a member attains the prescribed base capital level, patronage earnings allocated to the member are paid in cash.

- Retained earnings: Retained net savings that are earned on non-member business. (A cooperative may jeopardize its Capper-Volstead status if its non-member business is more than 50 percent of the total.)

Financing challenges. Managing the cooperative's unique way of equity financing is a constant challenge that is three-pronged:

- Member-producers—Members must treat the retained patronages, when allocated, as income for tax purposes. The same applies to capital retains. Although the retains are revolved back to members as permitted by cooperative earnings, their value is heavily discounted because the revolving period is usually several years or longer. The retains also compete with the capital needs on the farm. It is only natural that members want as little retains and as short a revolving period as possible.

- Cooperative operations—Cooperatives require an adequate level of capital to finance their operations and satisfy the covenants of lending institutions. This capital need is in conflict with members' desire of having little retains and a short revolving period.

- Lending institutions—To lower the risk of loan exposure, lending institutions usually require a cooperative to maintain a certain level of equity vis-à-vis its assets and have ample working capital for operations. This again runs counter to members' desire for as little retains as possible. Furthermore, because cooperatives usually revolve retains to members after a certain period of time, some lending institutions may not consider member equity as permanent capital and would rather cooperatives have as long a revolving period as possible. (This is one reason why cooperatives need special lending institutions that understand the cooperative form of business.)

The base capital plan may be viewed as a compromise among the three conflicting interests. Under the plan, a target base capital level that would adequately finance a cooperative's operations is established. An advantage of the plan is that once the prescribed base capital level is attained, a member can expect to receive all allocated patronage earnings in cash. Furthermore, base capital is revolved only after a member is retired from the cooperative. This gives base capital a certain degree of permanency that helps relieve the risk concerns of lending institutions. The decision-making process of setting the base capital level may be easier for members to understand and may help allay members' anxieties over whether all the capital retained by the cooperative is necessary.

Equity financing alternatives. In 2002, equity per hundredweight of milk averaged $2.10 for cooperatives that responded to a marketing operations survey by USDA Rural Business-Cooperative Service (*Liebrand*). For that same year, the survey showed that milk volume per member-producer was 2.3 million pounds (*Ling)*. Therefore, average equity per member-producer was $48,000 (rounded). This was an increase of 60 percent from $30,000 in 1997, based on the findings from the same survey conducted 5 years earlier that equity per hundredweight was $2.07 and milk per member-producer was 1.4 million pounds.

It is noteworthy that the 60-percent increase in equity per member-producer from 1997 to 2002 was almost entirely attributable to the 59-percent increase in per-producer milk volume. On a per hundredweight basis, the equity needed to market members' milk barely changed in 5 years. It increased by about 1 percent, from $2.07 in 1997 to $2.10 in 2002.

However, during the same 5-year period, cooperative assets per hundredweight of member milk increased by 97 cents (18 percent) from $5.25 to $6.22, while cooperative liabilities increased by 95 cents per hundredweight (30 percent) from $3.18 to $4.13. On a per hundredweight basis, almost all increases in capital needs of cooperatives were from debt financing. Contribution by cooperative member-producers to the increased capital needs was close to nothing. Cooperative growth was mostly financed by debts.

Depending on the type of operations a cooperative is engaged in, its equity per hundredweight may vary widely from the average. In 2002, although the average was $2.10, equity in bargaining cooperatives was only 27 cents per hundredweight; commodity manufacturing cooperatives, $1.60; niche marketing cooperatives, $5.80; and diversified and fluid-processing cooperatives, $2.80. Nevertheless, the fact remains that financing cooperative operations is a major financial commitment for all member-producers.

There have been various alternative equity financing methods proposed for reducing cooperative members' fiscal burden and investment risks. Except for the joint-venture model, none of the alternatives is particularly useful for dairy cooperatives.

- Public stock corporation—Cooperatives may be organized as a stock corporation and sell some or all stock to the public. The idea is to attract investors' capital into the cooperative to lessen the financial burden of member-producers. And, if the business performs well, stock would appreciate in value and member-producers have an efficient stock market to cash in.

However, it is difficult to operate a public stock corporation on a cooperative basis because of one or all of the following: (1) Investors would have problems with operating the corporation on a cooperative basis, especially its one-person-one-vote democratic control; (2) Producers support the cooperative's business by patronizing it while investors do not; (3) With investor capital, the cooperative is likely to lose its Capper-Volstead status; (4) In a dairy cooperative, the distinction between milk pay prices and premiums on the one hand and profits on the other is not clear-cut, and the conflicts between producers and investors may be very difficult to reconcile; and (5) There are fundamental conflicts between benefits for member-producers and investors' focus on returns on investment.

There was one known case of public offering of a dairy cooperative's common stock. In April 1988, a dairy cooperative converted its fluid business subsidiary into a publicly traded stock company with the idea of using investor financing and stock as tools for expansion and growth, while maintaining the majority ownership of the business (*Farmer Cooperatives*). However, by the end of 1991, the cooperative bought back all outstanding stock from minority owners.

- Some cooperatives may issue preferred securities or bonds to tap non-member capital. But these usually carry a fixed interest rate and do not have bearing on ownership issues and should be considered as debts rather than equity capital.

- Limited liability company (LLC)—An LLC is a state-approved, unincorporated association, just like a partnership except that it protects its owners and agents from personal liability for debts and other obligations of the LLC. Earnings pass through to the owners (no non-qualified retains) and enjoy single tax treatment. An LLC may operate on a cooperative basis. Or it may allocate earnings and losses and assign votes among themselves as they see fit (*Frederick*).

  The LLC form of business organization became popular after tax rules over them were modified in 1997. Some producers perceive the flexibility provided by an LLC as a vehicle for tapping outside capital. However, the combination of producers and investors in an LLC would encounter the same issues as in a publicly traded corporation that attempts to operate on a cooperative basis. There is no dairy cooperative known to have been organized as an LLC.

- Joint venture—The LLC may be a useful model for established cooperatives to form joint ventures with other cooperatives or with other firms. On the marketing side, a joint venture LLC may be used by a cooperative and its partner to develop and market certain dairy products. The cooperative supplies the milk and the partner its technical and marketing know-how to the LLC.

  The joint-venture partners share the financing and the risk of the business activities of the LLC. This organizational model reduces cooperative members' financing burden and risk exposure, while a market outlet for milk is secured.

  Many recent joint ventures formed by cooperatives with other business entities are organized as LLCs.

- "New-generation" cooperative—A new-generation cooperative usually requires significant equity investment as a prerequisite to membership and delivery right, in order to ensure that an adequate level of capital is raised and the plant capacity is fully utilized. The delivery right is in the form of equity shares that can be sold to other eligible producers at prices agreed to by the buyer and seller, subject to the approval of the board of directors. The transferable delivery right is appealing to members because it allows them to cash in any increase in the value of their cooperative upon retirement.

Interest in new-generation cooperatives surged in the 1980s and 1990s, largely in response to the market condition prevailing during that time period. Cooperative development leaders believed that this form of cooperative organization would solve the problem of depressed farm income by engaging in value-added processing.

The new-generation cooperative model has its strengths, but its characteristics also have created a host of problems. After the turn of the 21st century, the so-called fever for it has cooled down substantially. (For a succinct evaluation of new generation cooperatives, see *Torgerson*.)

There was only one dairy cooperative known to have been organized using the new-generation model. In 1995, Dakota Dairy Specialties was established to make specialty cheese (*Campbell,* 1995). But its remote location, the capital investment needed to renovate its plant and the skill required to make and market specialty cheese posed major problems, and the new-generation model proved no help. It suffered the same fate as Hebron Cooperative Creamery, the struggling cooperative it was formed to replace. By 1999, Dakota Dairy Specialties ceased to operate.

Conclusion

Technology opens up opportunities for using milk and dairy ingredients in new ways and in new products. Along with its advances, dairy industry dynamism also evolves. The promising rewards of adapting to new technology could be exciting but the necessary industry adjustment could be challenging to dairy farmers and their cooperatives. This report suggests that success depends upon:

- Adequate member equity capital.
- Well thought-out business strategy and plans that focus on the core business of marketing milk, milk products and milk-based ingredients.
- Identification of new products and markets through research and development.

Epilogue: Parallel to Processing Tomato Industry

Advances in technology have caused milk production to undergo dramatic changes and induced the westward production expansion (table 7; also see *Blayney*). The abundant milk supply in the West makes the region most conducive to manufacturing commodity dairy products. The West has become the major supplier of milk-based ingredients (commodity dairy products and, potentially, fractionalized components) for further processing across the United States, while the traditional dairy regions now mostly provide fresh milk to satisfy the demand of the fluid market and the demand of the manufacturing sector that makes cheese, butter and other value-added or niche dairy products. The evolution of the milk industry has a striking resemblance to the development in the tomato industry.

Like milk, tomatoes are produced in every State in the Nation and have two use categories: tomatoes for fresh market and tomatoes for processing (*ERS*).

In 2003, commercial-scale production of field-grown tomatoes for fresh market was reported in 17 States, a decrease from 32 States in the 1950s. (Cherry, grape, tomatillo and the fast-expanding production of greenhouse tomatoes are excluded from reporting.) However, production increased 70 percent over the time period. Florida, with 43 percent of the Nation's production in 2003, was the leading producer of fresh-market tomatoes, followed by California's 28 percent (table 9). Fresh-market tomatoes are hand-picked and sold on the open market, at prices that are far higher than tomatoes for processing.

In contrast, production of tomatoes for processing is highly concentrated in California, usually under contracts between growers and processors. The State has accounted for around 95 percent of the Nation's production since the mid-1990s (table 10). In 2003, only six other States were reported to have some significant but very minor shares of production. This is a far cry from the 1950s, when the production of 33 States was reported and California's share was 55 percent. Three broad categories of technological advances changed the landscape: (1) Development of tomato varieties that were able to withstand the rigors of machine harvesting and bulk handling; (2) development of a mechanical harvester; and (3) development of bulk storage of tomato products.

Efforts to develop a variety of tomato able to withstand the rigors of machine harvesting and bulk handling started in the late 1940s in California, followed by the development of a mechanical harvester.

Table 9—**Tomatoes for fresh market, production by State, average 1951-60 and 2003**[1]

State	Average 1951-60	Share of U.S.	2003	Share of U.S.
	1,000 cwt	*Percent*	*1,000 cwt*	*Percent*
FL	4,865	25.3	13,984	42.8
CA	5,655	29.5	9,240	28.3
VA	502	2.6	1,482	4.5
TN	218	1.1	1,225	3.8
OH	509	2.7	1,155	3.5
SC	295	1.5	1,023	3.1
NC	157	0.8	896	2.7
NJ	806	4.2	682	2.1
GA	387	2.0	544	1.7
PA	328	1.7	420	1.3
MI	706	3.7	396	1.2
AR	183	1.0	384	1.2
NY	786	4.1	322	1.0
AL	270	1.4	303	0.9
IN	328	1.7	248	0.8
MD	280	1.5	171	0.5
TX	1,566	8.2	169	0.5
MA	256	1.3		
WA	210	1.1		
CO	150	0.8		
IL	110	0.6		
MO	109	0.6		
OR	98	0.5		
NM	95	0.5		
HI	58	0.3		
LA	47	0.2		
RI	46	0.2		
MS	44	0.2		
DE	44	0.2		
KY	38	0.2		
CT	34	0.2		
IA	21	0.1		
United States	19,201	100.0	32,644	100.0

[1] Cherry, grape, tomatillo and greenhouse tomatoes are excluded.

Sources: Agricultural Statistics, various years; Vegetables, Annual Summary, various years, USDA/NASS.

By 1962, both the machine and the tomato plant were ready to be implemented. Subsequently, the U.S. Government in 1964 refused to extend the provision of a law by which foreign nationals were allowed to come into this country to help with crop production and harvesting (*Webb, et a*l). This gave impetus to adopting harvesting machines by tomato growers. By 1970, 100 percent of California growers had shifted to mechanical harvesting (*Busch, et al)*.

California has several advantages over other regions in producing processing tomatoes. California's growing season is from 250 to 300 days, longer than the East and Midwest (*Gould*, p. 103). The crop is grown almost entirely on irrigated ground and the moisture is easier to control. The high-yield tomato varieties developed for California may not be suitable for other areas. At harvest time, there is generally no rainfall and the condition is ideal for machine harvesting *(King, et al)*.

The mechanical harvester further enhances California's advantages, because the State is most suitable to meet its requirements of operating on a large scale: The machine is capital-intensive and tomato farms must specialize; fields must be flat and well graded; the rows must be long (recommended no less than 600 feet) to minimize turning the harvesting equipment (*Busch, et al*).

As a result, California became a low-cost producer of tomatoes, which led to rapid development of the processing industry in the State. Improvements in bulk storage and transportation technology have created the situation in which processors in the Midwest and East serve as final fabricators of raw product grown and partially processed in California (*King, et al*). Tomato products may be stored in bulk containers by various methods: aseptic storage or freezing storage of concentrated products, or acidified bulk storage of whole tomatoes. These methods allow the processors to store products during the harvest season and make various finished products on a year-round basis. This enables the industry to match finished product production with market demand and save on transportation cost by producing finished product close to its distribution point (*Gould,* pp. 227-228).

In essence, the tomato industry has developed into two separate sectors—fresh market and the processing sector—each with its specific varieties of tomatoes and distinctive characteristics. While the milk industry conceivably may not be differentiated to such extremes, the evolution of the tomato industry nevertheless provides some food for thought as milk producers ponder the future brought about by technological advances.

Table 10—**Tomatoes for processing, production by State, selected years 1951-2003 (tons)**

State	Average 1951-60	1965	1970	1975	1980	1985	1990	1995	2000	2003
CA	2,044,030	2,468,300	3,362,950	7,270,550	5,540,780	6,102,040	9,306,200	10,606,820	10,286,500	9,252,000
IN	281,970	315,200	295,200	209,300	106,560	140,080	193,040	157,450	229,020	202,290
OH	224,830	544,300	545,650	423,000	252,000	404,970	434,510	269,670	158,710	173,280
MI	70,070	80,900	55,150	63,300	73,680	166,320	169,860	135,000	84,000	117,800
PA	170,610	131,100	151,000	108,100	40,390	54,460	34,920	36,600	42,560	
CO	25,260	6,000	8,600	6,110	17,300	2,390	1,840			
NJ	227,810	349,700	280,000	154,000	61,990	92,190	57,020			
NY	135,560	89,600	39,300	39,800						
MD	103,480	105,000	59,850	53,300	26,900	41,170				
VA	51,710	66,600	35,300	33,850	17,960	25,200				
DE	30,920	35,900	24,750	13,940						
TX	42,840	46,800	30,200	37,900	9,940					
NM	4,240	3,300	7,000	8,600						
FL	40,520	55,400	43,500							
IL	115,240	140,800	71,900							
SC	3,140	3,500								
UT	63,450	16,100								
Other States[1]	50,940	42,640	57,200	133,250	74,280	119,460	117,520	78,660	57,450	66,740
United States	3,686,620	4,501,140	5,058,950	8,503,750	6,210,590	7,177,130	10,355,260	11,286,040	10,858,240	9,812,110
CA share of U.S. production:	55%	55%	66%	85%	89%	85%	90%	94%	95%	94%

[1] Other States in 1951-60 - 16; 1965 - 13; 1970 - 14; 1975 - 12; 1980 - 9; 1985 - 10; 1990 - 8; 1995 - 7; 2000 - MD and NJ; 2003 - MD, NJ and PA.

Sources: Agricultural Statistics, various years; Vagetables, Annual Summary, various years, USDA/NASS.

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