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DIVERSIFICATION OF THE CHEDDAR CHEESE INDUSTRY THROUGH SPECIALTY CHEESE PRODUCTION:

AN ECONOMIC ASSESSMENT

by
John C. Martin
David M. Barbano
Richard D. Aplin

Part 3 of a Research Effort on Cheddar Cheese Manufacturing

Department of Agricultural Economics
Department of Food Science
Cornell University Agricultural Experiment Station
New York State College of Agriculture and Life Sciences
A Statutory College of the State University
Cornell University, Ithaca, New York, 14853

PREFACE

John C. Martin, David M. Barbano, and Richard D. Aplin are former graduate student, Department of Agricultural Economics; Associate Professor of Food Science; and Professor of Agricultural Economics, College of Agriculture and Life Sciences, Cornell University, respectively.

This publication is the third in a series of publications on Cheddar Cheese manufacturing costs. The series of publications will report the results of a major research effort aimed at helping to answer questions such as the following:

1. How do aged Cheddar cheese plants in the Northeast differ from plants in Wisconsin, Minnesota and other important cheese-producing states with respect to efficiency and other key factors affecting their economic performance?

2. How much do operational factors, such as number of operating days per week, number of shifts per day, yield potential of milk supplies and recovery of solids at the plant affect the costs of production?

3. What are the differences in costs among plants using the most modern commercial technologies (e.g., continuous systems) and those using more traditional batch systems for manufacturing Cheddar cheese?

4. How large a cost advantage do large Cheddar cheese plants have over smaller-scale plants?

5. What is the feasibility and what would be the impact on plant costs of using some of the production capacity in Cheddar cheese plants to produce other cheeses including, perhaps, some specialty, European-style cheeses? In other words, what are the growth opportunities in the other cheeses for the Cheddar cheese industry as it faces increasing competitive pressures?

6. What would be the impact on manufacturing costs of using milk concentration processes (i.e., ultrafiltration, reverse osmosis and evaporation) in Cheddar cheese plants?

7. What are the costs and relative profitability of producing whey powder and whey protein concentrate? What are key factors affecting the costs of producing these whey products?

This publication focuses on question #5 above. It reports the results of using the economic-engineering approach to estimate and analyze the costs of producing European-style specialty cheeses, Jarlsberg-type and Havarti, in modified Cheddar cheese plants as well as in plants designed to produce only specialty cheese. Also, an initial assessment is made of the potential profitability of producing these specialty cheeses in the United States.

Questions 1 through 4 above are addressed in earlier publications which involved the study of 11 plants operating in the Northeast and North Central regions. The study of the 11 plants is reported in a 1987 publication entitled "Economic Performance of 11 Cheddar Cheese Manufacturing Plants in Northeast and North Central Regions." Data from these plants were used as part of the base for an economic-engineering study with the results reported in "Cheddar Cheese Manufacturing Costs -- Economies of Size and Effects of Difference Current Technologies," also issued in 1987.

Two other phases of the research should be published in 1989. One focuses on determining the costs and profitability of sweet whey processing in six different size whey plants producing either whey powder or whey protein concentrate.

The second remaining phase of the project is aimed at providing a basis for determining the cost impact of adopting milk concentration or fractionation technologies, especially reverse osmosis and ultrafiltration, in Cheddar cheese manufacturing. Work has begun to superimpose new milk concentration technologies (i.e., ultrafiltration, reverse osmosis and energy efficient MVR evaporators) on a number of the model plants developed in the first phase of the study.

Financial assistance for the overall cheese manufacturing cost project has been provided from four sources. One was a research agreement with the Agricultural Cooperative Service of the United States Department of Agriculture. Another source was the Agricultural Research and Development Grants Program of the New York State Department of Agriculture and Markets. The research also is supported in part by funds provided by the dairy farmers of New York State under the authority of the New York State Milk Promotion Order. Still a fourth source is a research agreement with the Wisconsin Milk Marketing Board.

Many have contributed importantly to the development and success of this project. Cornell University contracted with Mead & Hunt, Inc., an engineering consulting firm based in Madison, Wisconsin, with broad experience in various industries including cheese, to provide much of the information needed to budget costs. On the research reported in this publication, we actually worked with Daniel Surfus of Mead & Hunt, Inc. Ian P. Brockwell, formerly of Alfa-Laval, now with Darleon, Inc., was instrumental in designing the production systems and in providing technical expertise in specialty cheese manufacturing. Alfa-Laval, Inc. provided data on cheese production practices and equipment specifications. Several other dairy equipment companies provided cost and engineering data on general dairy equipment.

We also wish to thank several of our colleagues at Cornell. Professor Deborah H. Streeter served on the senior author's Masters committee and made a number of helpful contributions. Susan Hurst did significant amounts of analysis. Craig Alexander and Jim Pratt provided support and input. Scott McPherson helped write the computer programs needed for data analysis. Tina Weyland did an able job in typing and processing the manuscript, and Joe Baldwin did the excellent graphics work. We thank them all.

Constructive criticisms of the manuscript were made by K. Charles Ling of the Agricultural Cooperative Service, Edward McLaughlin, Andrew Novakovic and James Pratt of Cornell's Department of Agricultural Economics, and a number of people in industry.

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For copies of this publication or others in the series, contact:

R. D. Aplin
Department of Agricultural Economics
Cornell University
357 Warren Hall
Ithaca, New York 14853

DIGEST AND HIGHLIGHTS

Objectives and Methods

The primary objective of this study was to determine the production costs for a rindless European-style Jarlsberg-type and Havarti cheeses in the United States. A secondary objective was to make an initial assessment of the potential profitability of producing these specialty cheeses. Both cheeses were considered to possess a good market potential and to be compatible enough to be manufactured in a modified Cheddar cheese plant.

Three manufacturing scenarios were considered. The first, called "alternate-day", consisted of modifying a Cheddar cheese plant to produce either specialty or Cheddar cheese, but not both, on any given day. The second scenario, called "concurrent", consisted of modifying a Cheddar cheese plant to produce both specialty and Cheddar cheese on some or all days. The third scenario, called "specialty-only", consisted of modeling two sizes of plants to produce only specialty cheese. Two levels of automation were modeled for specialty cheese production in all three manufacturing scenarios.

A three-step economic-engineering or synthetic costing approach was used to estimate production costs for the sixteen plant designs. For estimating potential profits from specialty cheese production, all costs (except marketing and administration) and revenues were included.

Results

Specialty Cheese Production in Cheddar Plant

Alternate-day production for both Jarlsberg-type and Havarti cheeses was the least-cost method of producing the cheeses in a Cheddar plant. Alternate-day manufacturing had a higher capital cost than concurrent manufacturing, but lower labor and utility costs. Higher costs of labor and utilities in concurrent manufacturing were due to relative inefficiencies inherent when both Cheddar and specialty are manufactured simultaneously. The inefficiencies in concurrent production stem from the use of smaller scale specialty cheese equipment, higher utility and cleaning costs to run both cheddar and specialty cheese equipment everyday, and the inefficiencies in labor and equipment utilization.

Specialty-Only Plants

Significant economies of size were found in specialty-only plants. When both large and small plants operate at full capacity, large plants have a large production cost advantage. The large plants have significantly lower labor and utility costs per pound of product. The large plants have significantly higher initial investment costs, but significantly lower capital costs per pound of specialty cheese when operated reasonably close to capacity.

Specialty Cheese Production In Cheddar Plant vs. Specialty-Only Plant

Large specialty-only plants can produce large volumes of specialty cheese at a lower cost than alternate-day manufacturing in a Cheddar plant. But alternate-day manufacturing of specialty cheese in a Cheddar plant has a cost advantage over the large specialty-only plants at levels of production consistent with sales levels of specialty cheese achievable in the domestic market.

Automation Levels

Specialty cheese production costs are consistently lower for high automation than low automation, for all production quantities in all manufacturing scenarios. However, automation level has a smaller effect on the cost per pound than manufacturing scenarios or production schedules.

Profitability Assessment

The comparison of profitability for each of the cheeses involved in this study revealed a considerable profit potential for specialty cheese compared to Cheddar cheese, assuming marketing is successful. The Havarti cheese, which is a creamy Havarti with a soft texture, was found to be the most profitable cheese studied. High profits for the creamy Havarti were due mainly to a high cheese yield and a favorable wholesale price compared to Cheddar cheese. A firmer Havarti product with lower moisture and/or lower fat on a dry basis would have a lower yield and a higher manufacturing cost per pound. The profits from Jarlsberg-type, while not as high as Havarti, are also considerably higher than Cheddar cheese profits.

Profits from cheese and whey for Jarlsberg-type are from $3.00 to $4.00 higher per cwt of raw milk than Cheddar. Profits for Havarti are from $5.10 to $6.50 higher per cwt of raw milk than Cheddar. These results are based on an assumed premium price of approximately $1.30 per pound for Cheddar cheese at wholesale and a relatively high Cheddar cheese yield of 10 lbs/cwt milk.

Further profitability analysis for alternate-day manufacturing in a Cheddar plant under two milk supply situations (unlimited and limited milk supply) revealed that specialty cheese increased profits to the plant in all but two cases. In both the unlimited and limited milk supply situations, specialty cheese production was found to increase the profits of the cheese plant, if a plant produced approaching 10% of the current domestic production of one of the cheeses. This would be true even if there were erosion in the price premium currently enjoyed by the specialty cheeses over cheddar.

These results were consistent across a wide range of assumed cheese prices. Jarlsberg-type cheese price was allowed to vary from $1.80 (the estimated FOB domestic price) to $1.60 per pound and Havarti from $1.65 (the estimated FOB domestic price) to $1.45 per pound. Cheddar price was allowed to vary from $1.30 to $1.20 per pound. Only when Jarlsberg-type and Havarti cheese prices were assumed low, Cheddar price assumed high, and specialty cheese was produced at low volumes did the investment in specialty production not increase profits to the plant.

Internal rates of return on the investments for alternate-day specialty cheese manufacturing were very high. Depending on the Cheddar and specialty cheese prices used, the IRR for both specialty cheeses ranged from 23 to over 700 percent.

Results indicate specialty cheese has the potential to be manufactured profitably in the United States by a few manufacturers, although marketing opportunities are limited and still need to be studied. A particularly attractive opportunity appears to be the production of a variety of related specialty cheeses.

Further Considerations and Cautions

The optimistic economic potential for specialty cheese production must be tempered by some limitations. Many questions remain concerning the production of specialty cheese in the United States. Three areas of uncertainty that need to be assessed include specialty cheese quality, specialty cheese marketing, and disruptions in production due to the technological aspects of implementing alternate-day manufacturing of specialty cheese in a Cheddar cheese plant.

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MOTIVATION FOR STUDY

Management in the Cheddar cheese industry constantly searches for ways to increase profitability and expand market share. However, since the beginning of the 1980's significant changes within the cheese industry and markets have made these goals difficult to achieve.

In response to increasing competitive pressures, some industry leaders have called for diversification of the Cheddar industry through the production of European-style specialty cheeses. Some Cheddar cheese manufacturers view this as a possible means to utilize plant capacity more profitably. Diversifying into specialty cheeses also would allow producers to enter faster growing markets.

To appraise the feasibility of the Cheddar industry diversifying into European-style specialty cheese production, several questions must be answered. Questions regarding the marketing of the new products include: Will consumers purchase sufficient quantities of domestically produced European-style specialty cheese? Can Cheddar manufacturers establish viable distribution channels?

However, before marketing issues can be addressed, production feasibility and potential profitability must be considered: Can specialty cheese be produced in a cost effective manner? Do Cheddar manufacturers have a cost advantage over plants producing only specialty cheese? The research reported in this publication is aimed at answering the latter sorts of questions.

Current Industry Characteristics

This specialty cheese production research was carried out in the context of a changing United States dairy industry and cheese market. The amount of milk used for manufactured dairy products increased 32 percent from 1965 to 1987 with virtually all the increase in cheese, while butter and other products actually lost ground in terms of their share of raw milk used (Table 1). Cheese production grew from 26 percent to 48 percent of all milk used for manufacturing between 1965 and 1987, while milk used in butter production fell from 46 to 31 percent, and all other uses declined from 28 to 22 percent during the same time period.

Traditionally, American cheese has accounted for the largest proportion of cheese produced in the United States. American cheese is here defined to include all Cheddar, colby, jack and washed curd type cheese. Between 1980 and 1987 there were only slight fluctuations in American cheese market share, maintaining 51 to 62 percent of the total U.S. cheese production (Table 2).

Swiss cheeses represented only about four percent of the total production, remaining stable over this period. Other varieties of cheese, except Blue, have grown rapidly. Despite their rapid growth rates, these cheeses represent relatively small proportions of all cheese manufactured. Mozzarella is an exception, representing 26 percent of the total cheese production.

Data on United States' specialty cheese production are not widely available. The United States Department of Agriculture (USDA) groups many specialty cheeses into the "All Other Varieties" category which includes all cheeses produced other

Table 1 Milk Utilized for Manufactured Dairy Products by Dairy Plants in the United States, 1965-1987

Year	Total Milk Marketed	Milk Used in Manufactured Products		Whole Milk Equivalents Used in Manufactured Products		
				Cheese	Butter	Other
	(Bil. lbs)	(%)	(Bil. lbs)	(Percent[1])		
1965	118.2	52	61.5	26	46	28
1970	113.0	53	59.9	33	40	28
1975	112.3	54	60.6	40	33	28
1980	126.1	58	73.1	46	31	23
1981	130.5	60	78.3	47	32	22
1982	133.1	61	81.2	48	31	21
1983	137.3	61	83.8	49	31	21
1984	132.5	58	76.9	50	28	22
1985	140.7	59	83.0	46	34	21
1986	141.0	59	83.2	46	33	21
1987	140.3	58	81.4	48	31	22

[1]May not add to 100% due to rounding.
Source: USDA. Dairy Products, Annual Summary, National Agricultural Statistics Service, Washington, D.C. (selected issues).

than American, Swiss, Muenster, Brick, Limburger, Italian Types, Cream, Neufchatel, and Blue cheese. Although this "All Other Varieties" category only represented two percent of total cheese production in 1987, it is the category which has shown the largest increase in production, 87 percent in the last eight years.

Despite these growth rates, the market for cheese still has room to grow. For example, other countries, especially those in Europe, have a much higher per capita cheese consumption than the U.S. In 1984 the European Community (EC) per capita cheese consumption was 31.7 pounds, compared to 21.6 pounds in the United States (Organization of Economic Community Development & USDA). A study by Business Trend Analysts (1986) predicted that the United States' per capita cheese consumption could reach as high as 49.9 pounds by 1995. Thus, cheese consumption in the United States still has the potential to grow.

Table 2 U.S. Production of Cheeses by Selected Type (1980-1987)

Variety	1980	1981	1982	1983	1984	1985	1986	1987	% of 1987 Total
	-----------(Million Pounds)-----------								(%)
Total American[1]	2376	2642	2752	2928	2648	2859	2798	2717	51
Swiss	219	214	221	209	208	222	227	227	4
Brick & Muenster	85	81	86	84	92	102	109	122	2
Cream & Neufchatel	228	241	263	270	276	294	322	342	6
Blue	33	30	31	31	34	33	34	36	1
Mozzarella	689	685	762	862	953	1045	1249	1365	26
Other Italian	294	309	325	339	366	385	384	435	8
All Other Types	53	67	92	91	92	85	82	99	2
Total Cheese	3984	4278	4542	4819	4673	5024	5209	5344	100

[1]Includes all Cheddar, colby, monterey jack and washed curd type cheeses.
Source: USDA, Dairy Products, National Agricultural Statistics Service, Washington, DC, (selected issues).

Specialty Cheese Outlook

Forecasts of future specialty cheese supply and demand are not widely available and are difficult to quantify. A study by Putler, Siebert, and Angular[1] on the sales potential of specialty cheese in California found that Danish, flavored, semisoft, specialty Italian, and Swiss would have the highest probability of success for California cheese manufacturers. The probability of success for each cheese was determined by sales volume in California, sales growth trends, price correlation to Cheddar, and the extent to which Californian manufacturers already were established in the production of the particular specialty cheese.

The 1986 Gorman Research Survey[2] revealed that many cheese producers expect and are preparing for a growing specialty cheese market. The survey predicted "the continuation of the trend: a larger percentage of the industry production

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[1]Putler, D.S., Siebert, J.W., & Agular, D.J. (1984, October) Sales Potential for California Specialty Cheese. Davis, CA: University of California, Agricultural Economics Extension.

[2]Dryer, J. (1986). Exclusive Report: The State of the Cheese Industry. Dairy Foods, 87 (7), 37-46.

capacity is being allocated to specialty cheeses, and a smaller percentage to commodity-type products." The survey also revealed that 13 percent of the 348 manufacturers responding to the survey plan to add new varieties of cheese to their current production schedules.

According to Jerry Kelly, Director of Development for the Vermont Department of Agriculture, Havarti, Jarlsberg-type, and blue cheeses will lead the development of domestically produced European-style cheeses.[3] Most market observers agree that consumer awareness and sophistication will dictate specialty cheese consumption in the future.

U.S. import quotas, EC milk production quotas, and the decline in the value of the dollar, currently contribute to a favorable environment for domestic manufacture of European-style specialty cheeses. Cheeses covered by government quota must be licensed to be imported into the United States. The quotas on imported cheeses were between 95 and 99 percent full between 1982 and 1985 (Table 3). Thus, any increase in demand for specialty cheese will have to be filled by domestic production, unless import quotas are raised.

Recent reductions in the levels of export subsidies by European governments is another obstacle to foreign imports.[4] Without these subsidies and a decline in the value of the dollar, imported cheeses become less competitive in U.S. markets.

Table 3 Percent of Annual Import Quota Filled for Selected Cheese Imports (1982-1985)

Imported Type	Annual Quota	Percent of Quota Filled 1982	1983	1984	1985
	(1,000 lbs)	-------------(%)-----------			
American	17,913	98.2	99.4	97.6	98.9
Italian	13,924	98.0	98.7	97.5	99.1
Swiss	86,707	96.2	98.0	98.9	97.7
Edam & Gouda	12,360	98.5	98.2	99.0	96.8
Blue	5,470	95.4	99.1	98.0	96.0
Other	102,088	96.3	96.2	98.8	97.5

Sources: Adapted from USDA, Meat and Dairy Monthly Imports, Foreign Agricultural Service, Circular Series (Selected Issues).

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[3]"Heightened Consumer Awareness Expands Specialty Cheese Market." (1986, February). Dairy Field, 30-31, 40.

[4]Dryer, J. (1987). "Domestic Cheese Production Higher; Imports Below 1985." Cheese Market News.

STUDY OBJECTIVES

The primary objective of this study was to determine the production costs of European-style specialty cheeses in the United States. A secondary objective was to make an initial assessment of the potential profitability of specialty cheese production. The production of a round-eye, Jarlsberg-type cheese and a granular cheese, Havarti, were studied.

The specific objectives of the study were to:

1. Determine whether it is less costly in a medium size Cheddar cheese plant (960,000 pounds of milk per day) to produce only specialty cheese on alternate days or to produce specialty cheese concurrently with Cheddar on the same day.

2. Measure the economies of scale and the production cost behavior over a range of production in two different size specialty-only plants.

3. Determine the cost savings of producing specialty cheese in a Cheddar cheese plant with the use of some common production centers as compared to producing the same quantity of specialty cheese in a specialty-only cheese plant.

4. Estimate the costs of producing specialty cheese under each manufacturing scenario (alternate-day and concurrent Cheddar/specialty plants and specialty-only plants) with two different levels of automation.

5. Measure the effects of different specialty cheese yields and labor wage rates on the cost of specialty cheese production.

6. Provide an initial assessment of the potential profitability of producing European-style specialty cheese in the United States, assuming marketing relationships can be established.

7. Compare the potential profitability of manufacturing Cheddar, Jarlsberg & Havarti cheeses in New York and Wisconsin.

METHODOLOGY

Methodological Considerations

Estimation of plant cost relationships has been done for many different products using different approaches. In general, cost estimation approaches fall into one of three broad categories: 1) descriptive analysis of accounting data, which mainly involves combining point estimates of average costs into various classes for comparative purposes, 2) statistical analysis of accounting data, which attempts to estimate functional relationships by econometric methods, and 3) the economic-engineering approach, which "synthesizes" cost relationships from technical engineering data on factor usages, factor prices and other estimates of the components of the cost functions.

Each method has its advantages and disadvantages. The computational procedures involved in the accounting data approach are straightforward and simple. The popularity of the descriptive analysis relies mainly on its use of actual data and the interest among plant operators in comparing their own cost experience to the experience of others. However, there are significant limitations to the accounting data approach. Differences among plants in record keeping and accounting classification, as well as differences in managerial efficiency, scale, production methods, input prices, degree of plant utilization and other operational and environmental conditions, make cross classifications and comparisons of limited value in determining the importance of individual cost-influencing factors. Moreover, the accounting data approach requires information on a number of plants, making it of limited use in studying new production processes.

Statistical analysis uses much of the same data as descriptive analysis but the former tries to develop quantitative estimates of cost functions. Weaknesses of the statistical method are: 1) data limitations and defects which usually lead to biased estimates, 2) inability to clearly isolate the effects of various cost-influencing factors (e.g. technology, scale and utilization of the plant), and 3) extreme sensitivity to the functional form chosen for estimation.

The alternative to descriptive or statistical analyses of plant accounting data is to synthesize cost functions from engineering input-output specifications. This approach is known as the synthetic or economic-engineering analysis. It focuses exclusively on technical economies since input prices, managerial effectiveness and other factors can be held constant across all plants modeled. The technique allows for comparisons among systems where different physical and operational characteristics are standardized or varied systematically. For this reason, it is appropriate to the estimation of economies of size, the minimum efficient size plant, and the effects of different technologies. Moreover, the economic-engineering approach can be used for the analysis of plants or systems that may not actually be in use yet. Some find objectionable the artificial aspect introduced with the synthetic approach. The probability that operational efficiencies may be influenced by unidentified factors which are not evenly distributed among plants is another shortcoming of this method. The technique is also more sensitive to omitting some costs because they are never identified. This should lead to caution in the use of final results.

Because the objectives of this study required the comparison of costs of various production scenarios and technological systems not currently used in the United States, at least on any broad scale, the synthetic method was chosen as the means to estimate specialty cheese production costs.

Overview of Research Methodology Used

To ascertain the costs and potential profitability of manufacturing European-style specialty cheeses in the United States, model plants were specified, a costing procedure defined, and production costs estimated.

The model cheese plants were designed to simulate the production of one of two specialty cheese types: a round-eye, Jarlsberg-type cheese or a granular cheese like Havarti. The research determined production costs for different quantities of specialty cheese produced; for different manufacturing scenarios; for different technologies; and for different operating conditions. Finally, costs and possible revenues were compared to assess potential profitability of these two cheeses.

Jarlsberg-type and Havarti cheese were chosen as the specialty cheeses to be manufactured because of their compatibility with Cheddar production, their similarity to other round-eye and granular cheeses, and their likely market potential. Production technology similar to that used for Jarlsberg could be adapted for the manufacture of other round-eye cheeses such as Edam, Emmentaler, Gouda, Gruyere, Swiss, Samso, Tilsit and Tybo. The granular cheese production systems were modeled for Havarti cheese production, although the production technology could be adapted to process other granular cheeses such as Merister & Esrom.

Three production scenarios were considered. The first, called "Alternate-day," consisted of modifying a model Cheddar cheese plant, developed in an earlier phase of the cheese cost project, to produce either specialty or Cheddar cheese, but not both, on any given day. The second scenario, called "concurrent," consisted of modifying the model Cheddar cheese plant to produce both specialty and Cheddar cheese on some or all days. The third scenario, called "specialty-only," consisted of building plants to produce only specialty cheese. Two levels of automation were also modeled in all specialty cheese production scenarios: high and low.

A matrix of all production combinations explored in this research is presented in Table 4. In addition, depending on the specific objective, analyses were performed to determine the sensitivity of costs to various factors such as changes in production and changes in input costs.

A three-step economic-engineering or synthetic costing approach was used to estimate production costs for the sixteen plant designs. The first step was to define the production process. After careful investigation of production practices for Jarlsberg-type and Havarti cheese manufacture, process flow diagrams and production recipes were constructed. The production process was divided into operating stages, or centers, which were delineated on the basis of: identifiable operations, flow of the product and materials, and importance of the operations.

In the manufacturing scenarios that modified an earlier modeled Cheddar cheese plant[5] the functions of the existing plant centers were compared with the center functions required for specialty cheese production. From this comparison it was determined which Cheddar plant centers could be used to produce both cheeses as presently designed without modifications, which centers would need modification, and which additional centers would be needed to incorporate specialty cheese production into the Cheddar plant.

The second step identified the particular method and equipment used in the operation of each center. Then the processing costs of activities in each center were estimated over different output rates. When the function of a center could be performed in more than one way (i.e., at high and low levels of automation), the costs were determined separately.

In the third step the production costs of each center were summed along with cost components associated with the overall plant that are not tied to any single operating stage or center. This cost represented the total cost of production for each plant. In all plants, production costs were reduced to an average cost per unit of cheese.

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[5]Mesa-Dishington, J.K.; Barbano, D.M.; & Aplin, R.D. Cheddar Cheese Manufacturing Costs Economies of Size and Effects of Different Current Technologies, A.E. Res. 87-3, Ithaca, NY: Cornell University, Department of Agricultural Economics.

Table 4 Matrix of Specialty Cheese Production Combinations Studied and Identifying Acronyms[1]

Manufacturing Scenario:	Automation Level: High	Low
	Jarlsberg-Type Cheese	
Alternate-Day	AHJ	ALJ
Concurrent	CHJ	CLJ
Large Specialty-Only	LHJ	LLJ
Small Specialty-Only	SHJ	SLJ
	Havarti Cheese	
Alternate-Day	AHH	ALH
Concurrent	CHH	CLH
Large Specialty-Only	LHH	LLH
Small Specialty-Only	SHH	SLH

[1]First letter in acronym indicates manufacturing scenario (i.e., alternate-day, concurrent or specialty-only plant); second letter, level of automation (i.e., high or low); and the third letter the type of specialty cheese (i.e., Jarlsberg or Havarti).

MODEL PLANT SPECIFICATIONS

Manufacturing Scenarios

Three manufacturing scenarios were used to produce rindless European-style specialty cheeses. In two of the three manufacturing scenarios the earlier modeled Cheddar cheese plant[6] was modified for specialty cheese production, either Jarlsberg-type or Havarti cheese.

The first scenario (alternate-day manufacturing: AHJ, ALJ, AHH, and ALH) modifies the Cheddar plant to produce specialty cheese on the days the plant does not manufacture Cheddar cheese. These Cheddar plants were modified to manufacture either Cheddar or specialty cheese on any given day, but not both cheeses simultaneously.

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[6]Ibid.

In the second scenario (concurrent manufacturing: CHJ, CLJ, CHH, and CLH) the Cheddar cheese plant was modified to produce one of the specialty cheeses concurrently with Cheddar. In these plants, both specialty and Cheddar cheese can be manufactured simultaneously (using the same pasteurizer and cheese vats) on any given day, but the option remains to manufacture just Cheddar cheese as the plant did before modification.

The primary purpose of these two scenarios was to measure the costs and benefits of using the excess production capacity found in many Cheddar cheese plants for specialty cheese, assuming additional milk supplies are available. Mesa-Dishington, Barbano, and Aplin surveyed eleven Cheddar cheese plants and found an average plant capacity utilization of 71 percent, indicating substantial unused capacity in these plants.[7] However, these two scenarios are also used to assess the substitution of specialty cheese production for some Cheddar production under a limited milk supply situation.

In the third scenario, specialty cheese was manufactured in two sizes of entirely new plants designed specifically for only specialty cheese production.

Production Capacities

The production capacities of the models in the three manufacturing scenarios were based on a model "average size" Cheddar cheese plant (960,000 pounds of milk per day capacity) operating at 71 percent of capacity; i.e., the plant is assumed to operate 24 hours a day, five days a week, using 4.8 million pounds of milk a week for Cheddar cheese. The specialty cheese capacity for the alternate-day and concurrent manufacturing scenarios was designed to use the remaining 29 percent of unused Cheddar plant capacity for specialty cheese. The capacity for the small, specialty-only model plants was designed to match the weekly specialty cheese capacities of the modified Cheddar plants.

The maximum quantity of Jarlsberg-type specialty cheese produced in any single alternate-day, concurrent and small specialty-only plant analyzed is 9.5 million pounds a year. This quantity of Jarlsberg-type cheese represents approximately 14 percent of the total Swiss/Emmenthaler cheeses imported into the United States in 1986. But it represents closer to 54 percent of the domestic market for Jarlsberg-type specialty cheese.

The maximum annual production of Havarti cheese with each of the three scenarios is 14.1 million pounds, which corresponds to a maximum milk utilization of 1.8 million pounds of milk per week, given a cheese yield of 14.08 pounds of cheese per hundredweight of standardized milk. At this maximum capacity, the model Havarti plants could supply approximately 56 percent of the current U.S. domestic market.

Besides these maximum production levels, production costs also were budgeted for annual production levels representing as little as 9 percent of the U.S. market for Jarlsberg-type cheese and 10 percent of the Havarti market.

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[7]Mesa-Dishington, J.K.; Aplin, R.D.; & Barbano, D.M. Economic Performance of Eleven Cheddar Cheese Manufacturing Plants in Northeast and North Central Regions A.E. Res. 87-2. Ithaca, NY: Cornell University, Department of Agricultural Economics.

First Scenario - Alternate-Day Manufacturing. The specialty cheese production capacity of each plant in the alternate-day manufacturing scenario is 960,000 pounds of milk per day, used exclusively for specialty cheese on the two days per week the plants did not produce Cheddar cheese. Thus, for basic cost comparisons, the plants used the same 4.8 million pounds of milk for Cheddar cheese each week as before the modification and up to 1.92 million additional pounds of raw milk for specialty cheese.

Second Scenario - Concurrent Manufacturing. The specialty cheese production capacity of each model plant in the concurrent scenario is 275,000 pounds of raw milk a day for specialty cheese processed simultaneously with 685,000 pounds of milk a day for Cheddar cheese when the plant operates on a 24-hour schedule. When producing Cheddar and specialty cheese concurrently seven days a week, each plant used 71 and 29 percent of plant capacity for Cheddar and specialty cheese, respectively. With this operating schedule, the weekly milk utilization of each plant in the concurrent manufacturing scenarios (i.e., 4.8 million pounds of milk for Cheddar and 1.92 million pounds of milk for specialty) was the same as the weekly milk utilization of each plant at capacity in the alternate-day scenario. Thus, weekly milk utilization is designed to be the same in the alternate and concurrent manufacturing scenarios, although the daily production patterns are different.

Third Scenario - Specialty-Only Plants. The production capacity of the small specialty-only plants is 385,000 pounds of raw milk per day. Each plant used 1.92 million pounds of milk a week for specialty cheese when it operated at the average capacity of 71 percent as reported by Mesa-Dishington. Thus, the alternate-day, concurrent, and small specialty-only manufacturing scenarios have the same weekly milk utilization for specialty cheese.

In an attempt to assess the economies of scale for specialty-only plants, large specialty-only plants also were modeled. The production capacities of the large plants are 960,000 pounds of unstandardized milk a day. The capacity of these plants is very large in relation to the domestic specialty cheese market, but sheds light on the economies of scale for specialty-only plants.

Automation Levels

For all manufacturing scenarios, European-style specialty cheesemaking was modeled with two production technologies, or levels of automation, which differed with respect to the relative labor intensity of the production processes: a high automation technology using state-of-the-art specialty cheesemaking equipment; and a low automation technology using more traditional, labor-intensive, specialty cheese making technologies.

Model Cheese Plants

Sixteen basic model plants were designed for this study:

To produce two possible European-style specialty cheeses:

1. Jarlsberg-type, and
2. Havarti;

In three manufacturing scenarios:

1. Production of specialty cheese in a modified Cheddar plant on days when Cheddar is not produced,
2. Production of specialty cheese in a modified Cheddar plant concurrently with Cheddar production, and

3. Production of specialty cheese in separate specialty-only plants of two sizes; and

At two levels of automation:

1. High automation, and
2. Low automation.

These models are summarized in Table 5.

Table 5 Specifications of Specialty Cheese Type, Manufacturing Scenario, and Level of Automation in the Sixteen Model Cheese Plants

Modified Cheddar Plants

Production Combination	Pounds of Milk Per Day 960,000 AHJ	ALJ	CHJ	CLJ	AHH	ALH	CHH	CLH
Manufacturing Scenario:								
Alternate-Day	X	X			X	X		
Concurrent			X	X			X	X
Automation:								
High	X		X		X		X	
Low		X		X		X		X
Specialty Cheese:								
Jarlsberg-type	X	X	X	X				
Havarti					X	X	X	X

New Specialty-Only Plants

	Pounds of Milk Per Day							
	385,000				960,000			
Production Combination	SHJ	SLJ	SHH	SLH	LHJ	LLJ	LHH	LLH
Automation:								
High	X		X		X		X	
Low		X		X		X		X
Specialty Cheese:								
Jarlsberg-type	X	X			X	X		
Havarti			X	X			X	X

Production Stages

A process flow diagram for the production of either granular or round-eye European-style specialty cheese is presented in Figure 1. The manufacturing stages or centers are presented and arrows indicate the direction of the process flow. In addition to centers directly involved in specialty cheese manufacturing depicted in Figure 1, other supporting centers were modeled: laboratory, dry storage room, maintenance and boiler room, cleaning center (CIP), waste treatment room, water well, offices, lockers and restrooms, and lunch room.

The process flow diagram in Figure 2 illustrates the production flow in a Cheddar cheese plant modified for specialty cheese production. Again, manufacturing centers are presented and the arrows indicate the direction of the process flow. The centers within the box represent new centers added to the Cheddar plant. The centers with asterisks represent the existing Cheddar plant centers requiring modification in order to incorporate specialty cheese production.

Production Process

Raw milk (3.70% fat, 3.20% protein) arrives at the cheese plant in refrigerated bulk tank trucks. It is tested, weighed, and then held in milk silos in the receiving center. In the plants that produce Havarti cheese, cream arrives at the plant every other day; it is tested, weighed, and temporarily stored in the receiving center. The milk is pumped to the treatment center as it is needed for processing, where it is standardized. The standardization process for Havarti cheese involves adding cream stored in the receiving center to the raw milk to increase overall fat content. For Jarlsberg-type cheese, the standardization process reduces the milk fat by removing cream, which is shipped out of the plant periodically. After standardization the milk is passed through a high-temperature, short-time (HTST) pasteurization process.

The standardized pasteurized milk is pumped into vats in the cheese vat center. At this point, the curd making process begins. The cheesemaking recipes for the Jarlsberg-type and Havarti cheeses studied are presented in Tables 6 and 7 respectively. The procedures, including the temperature and timing described in the recipes, are extremely important for the cheese to develop the desired characteristics during ripening and aging. The recipes are strictly adhered to for each vat of cheese produced at the plants.

Soon after a cheese vat begins to fill with the standardized pasteurized milk, starter culture is added. Starter cultures begin the milk ripening process which leads to lactic acid formation in the milk. Lactic acid helps to determine the final cheese moisture and texture. After the vat is filled, high quality calf rennet is added to the ripened milk to initiate curd formation through coagulation of the milk.

Once the curd coagulum reaches the necessary firmness and consistency, it is cut to permit the whey to escape. The curds are cut into pea-sized cubes and stirred. After stirring is complete, about a third of the whey is drained from the vat and hot water is added. Hot water helps dilute the lactic acid that forms in the cheese curds and helps raise the temperature of the curds for the second stirring and curd scalding. The second stirring and curd scalding take place at a much higher temperature than the previous cheesemaking steps. After the scalding is complete, most of the whey is drained from the vat and the remaining curd and whey slurry is pumped out of the vat to the prepress. Although the curds for both Jarlsberg-type and Havarti are cooked and processed in similar fashions, as

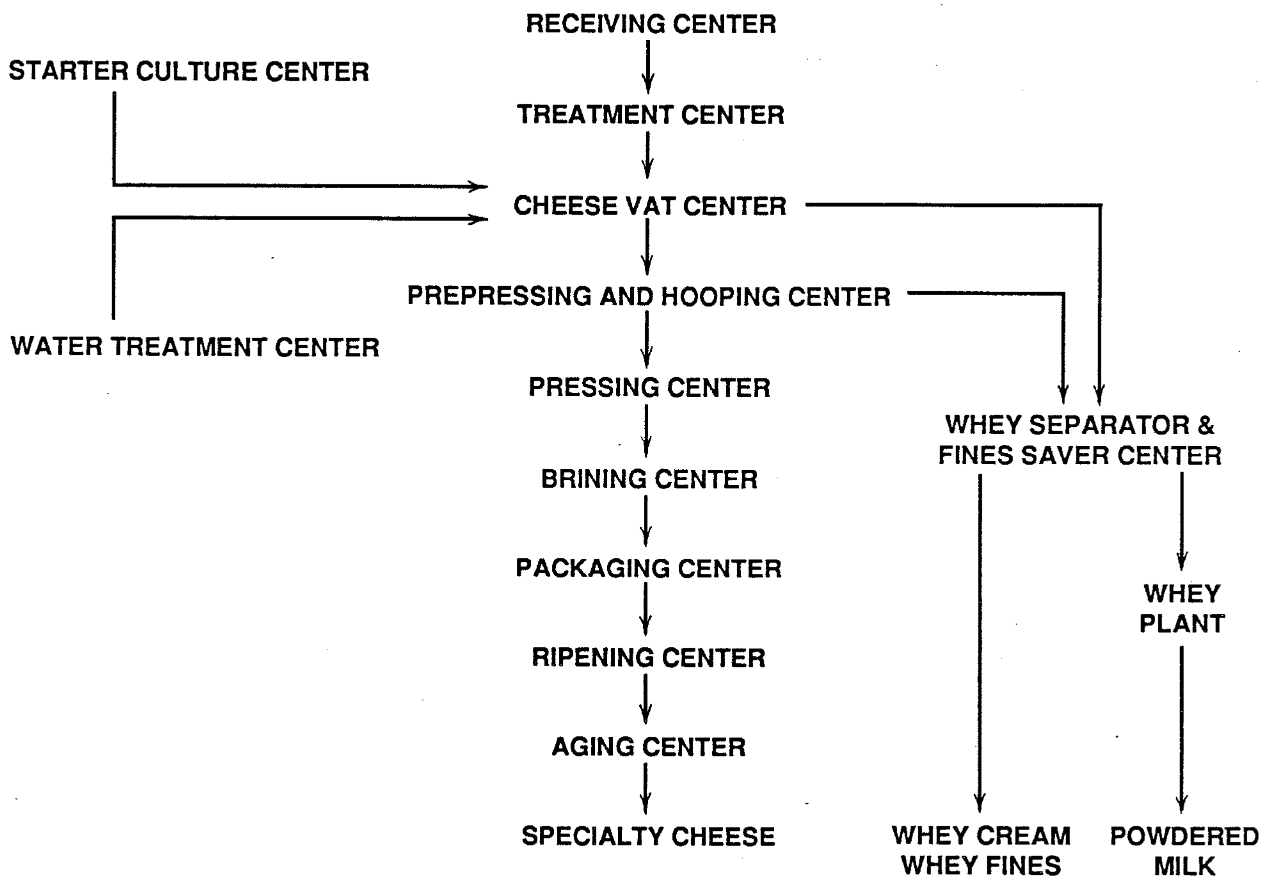

Figure 1. Process Flow Diagram for the Production of Round-Eye and Granular European-Style Specialty Cheese

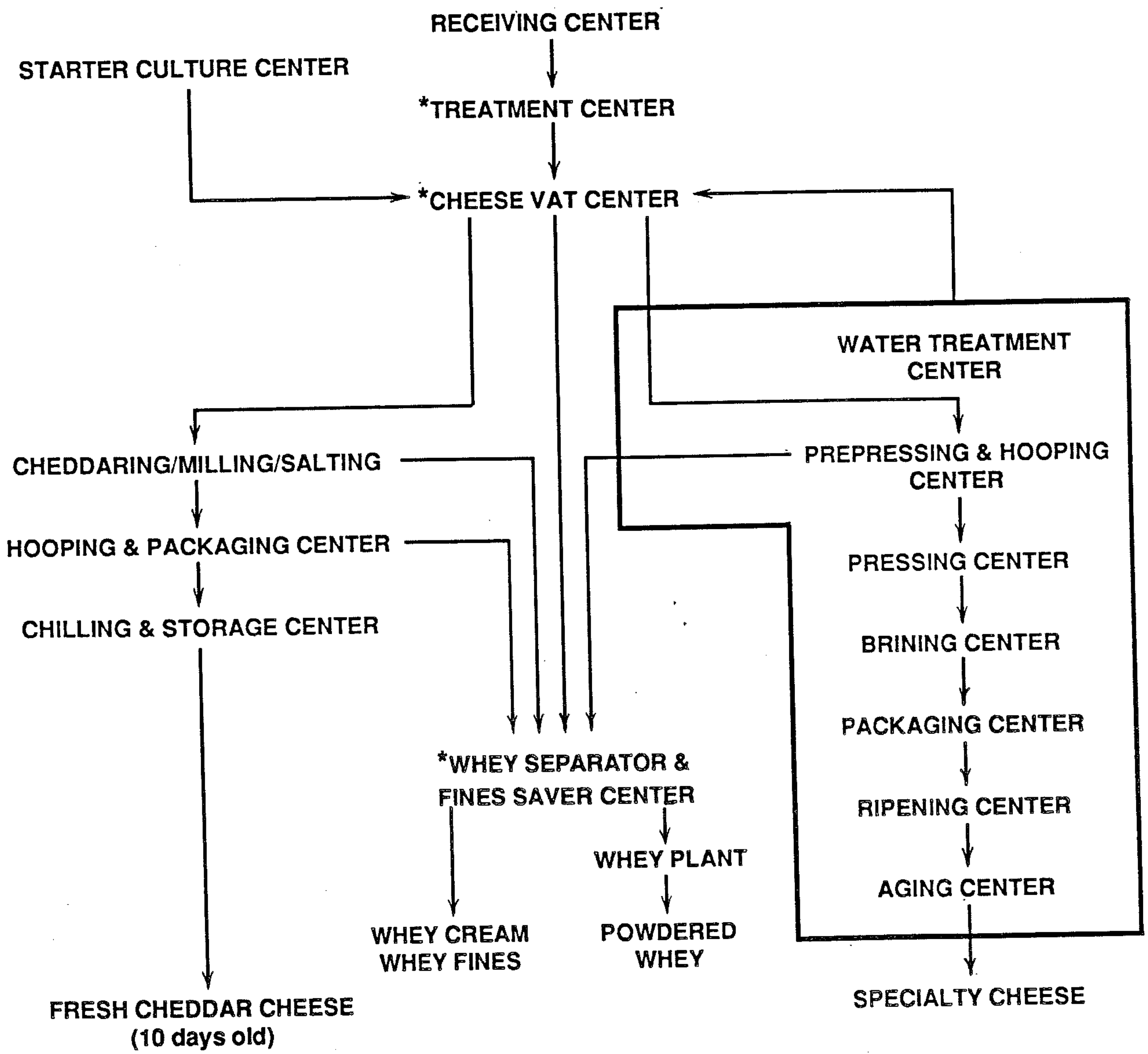

Figure 2. Process Flow Diagram of Modified Cheddar Plant for Production of European-Style Specialty Cheese

The centers with asterisks represent the existing Cheddar plant centers requiring modification in order to incorporate specialty cheese production.

Table 6 Procedure for Manufacturing Jarlsberg-Type Specialty Cheese

Summary of Compositions:

STANDARDIZED MILK		JARLSBERG-TYPE CHEESE		
Fat	2.88 %	Fat on Dry Weight Basis	47.0 %	Minimum
Protein	3.23 %	Moisture	43.0 %	Maximum
		Salt	1.3 %	

Manufacturing Procedure:

Production Steps	Temperature	Time
Adding Starter & Ripening	88 F	10 Minutes
Renneting	88 F	30 Minutes
Curd Cutting & 1st Stirring	88 F	35 Minutes
Draining Whey (33 % by volume) Adding Hot Water (15 % by volume)	101 F	10 Minutes
2nd Stirring & Curd Scalding	113 F	30 Minutes
Predrawing of Whey (67 % by volume) Transferring 3:1 Curd/Whey Slurry to Prepress		15 Minutes
Prepressing the Curd	71 F	20 Minutes
Holding Curd Before Pressing and Hooping	71 F	10-20 Minutes
Pressing the Curds	71 F	55 Minutes
Holding Curds in Hoops	68 F	6 Hours
Brining Hooped Cheese (21 % NaCl solution)	54 F	32-48 Hours
Packaging Fresh Cheese	Time depends on the system	
Ripening the Fresh Cheese	66 F	7 Days
Aging the Ripened Cheese	45 F	3 Months

Source: Adapted from information on cheesemaking practices provided by Alfa-Laval, Inc. (1986).

described above, their unique characteristics are developed by different cultures, temperatures, and timing.

For Jarlsberg-type cheese the curd is prepressed under the whey into blocks, which allows the whey to drain off during the process. The curd is pressed under the whey to create a consistent close-knit curd mat. For Havarti cheese, the curd and whey are separated before prepressing to instill the desired open granular texture. After prepressing is complete, the cheese blocks are placed in hoops and prepared for the final pressing.

Table 7 Procedure for Manufacturing Havarti Specialty Cheese

Summary of Compositions:

STANDARDIZED MILK		HAVARTI CHEESE		
Fat	6.41 %	Fat on Dry Weight Basis	62.0 %	Minimum
Protein	3.12 %	Moisture	42.0 %	Maximum
		Salt	2.0 %	

Manufacturing Procedure:

Production Steps	Temperature	Time
Adding Starter & Ripening	91 F	30 Minutes
Renneting	91 F	35 Minutes
Curd Cutting & 1st Stirring	91 F	25 Minutes
Draining Whey (33 % by volume) Adding Hot Water (20 % by volume)	105 F	10 Minutes
2nd Stirring & Curd Scalding	105 F	20 Minutes
Predrawing of Whey (67 % by volume) Transferring 3:1 Curd/Whey Slurry to Prepress		15 Minutes
Prepressing the Curd	71 F	20 Minutes
Holding Curd Before Pressing and Hooping	71 F	10-20 Minutes
Pressing the Curds	71 F	55 Minutes
Holding Curds in Hoops	68 F	6 Hours
Brining Hooped Cheese (20 Baume brine)	54 F	32-48 Hours
Packaging Fresh Cheese	Time depends on the system	
Ripening the Fresh Cheese	74 F	2 Weeks
Aging the Ripened Cheese	45 F	2 Months

Source: Adapted from information on cheesemaking practices provided by Alfa-Laval, Inc. (1986).

Before final pressing, the cheese sits for several minutes in the hoops to continue acid development and give the curd a chance to fuse. After final pressing the hooped cheese is allowed to sit for several hours until proper acid development has occurred.

The cheeses are removed from their hoops and placed in a brining tank where they remain for 32 to 48 hours. After the cheeses have absorbed the proper amount of salt from the brine solution, they are dried and packaged in plastic bags and reinforced corrugated cardboard boxes.

The packaged cheeses are transferred to a warm ripening room where the cheeses continue flavor and texture development. From the ripening room the cheeses are transferred to the aging room for the final stages of product maturation. In the aging room Jarlsberg-type cheese forms large, uniformly distributed eyes and develops its characteristic mild, nutty aroma and flavor. Havarti cheese at this stage develops its mild flavor, soft and sliceable consistency, and granular texture with many irregular, uniformly distributed spaces.

Center Technologies

The specifications of major pieces of equipment in each specialty cheesemaking center and cheese plant are provided in Table 8. The major pieces of Cheddar cheesemaking equipment found in the existing Cheddar plant modified for the first eight models are presented in Table 9. The structural area of each cheese plant is presented in Table 10. Since the yields of Havarti cheese from a hundredweight of milk are approximately 50% higher than for Jarlsberg, the requirements for space and equipment after pasteurization for Havarti are greater than for Jarlsberg.

The structural area for the model whey plants is 13,178 square feet for the alternate-day, concurrent and large specialty-only plants. The structural area of the whey plant for the small specialty-only model plants is 9,951 square feet.

Receiving Center. The receiving center handles all incoming milk (and cream for Havarti production). Milk tank trucks deliver the milk (and cream for Havarti) which is transferred to storage silos where it is kept until pumped to the milk treatment center. Empty milk trucks are cleaned with a cleaning-in-place (CIP) system in this center.

Treatment Center. The standardization and pasteurization processes are monitored and controlled at the treatment center. Milk is pumped to this center to be standardized and pasteurized before it is pumped to the cheese vat center. During milk standardization in Havarti cheese plants, cream stored in silos is added to the raw milk. During standardization in the Jarlsberg-type plants, cream is removed by centrifugal separation from the raw milk and stored for later sale. Standardized milk is pasteurized in a plate (HTST) pasteurizer.

For specialty cheese production in the Cheddar plant cream storage tanks were added to the existing Cheddar treatment center.

Starter Culture Center. Starter cultures are prepared and grown here and then added to milk in the cheese vat. Media tanks, a small pasteurizer, and starter process tanks are located in this center to facilitate culture preparation. For alternate-day and concurrent manufacturing, no modifications were made in this center for specialty cheese production.

Water Treatment Center. Water from the water well center is filtered and heated to provide the necessary quantity of hot potable water to be added to the specialty cheese curds in the cheese vats.

The Cheddar cheese plant modified for specialty cheese production did not originally have a water treatment center, so it was necessary to add one.

Table 8 Selected Specifications for Specialty Cheesemaking Equipment and Technological Systems in Model Plant Centers

Model	Prepresses[1]	Presses[2]	Brine Cages[3]
AHJ	4/Casomatics	6x45 Conveyors	7/10.6x2
ALJ	2/Strainer Vats	20/5x3 Trollies	7/10.6x2
CHJ	2/Casomatics	4x33 Conveyors	3/9.4x2
CLJ	1/Strainer Vat	5/3x5 Trollies	3/9.4x2
AHH	5/Casomatics	6x72 Conveyors	11/10.6x2
ALH	2/Strainer Vats	32/5x3 Trollies	11/10.6x2
CHH	2/Casomatics	6x35 Conveyors	5/9.4x2
CLH	1/Strainer Vat	7/3x5 Trollies	5/9.4x2
SHJ	2/Casomatics	4x36 Conveyors	7/9.4x2
SLJ	2/Strainer Vats	10/5x3 Trollies	7/9.4x2
SHH	2/Casomatics	6x32 Conveyors	11/9.4x2
SLH	2/Strainer Vat	10/3x5 Trollies	11/9.4x2
LHJ	4/Casomatics	6x45 Conveyors	7/10.6x2
LLJ	2/Strainer Vats	20/5x3 Trollies	7/10.6x2
LHH	5/Casomatics	6x72 Conveyors	11/10.6x2
LLH	2/Strainer Vats	32/5x3 Trollies	11/10.6x2

[1]Number of prepresses / Type of prepress: Casomatic towers or DBS strainer vats.
[2]Number of presses / Number of press heads wide X Number of press heads long
[3]Number of brine cages / Length X Width of cage in meters. All brine cages are nine layers deep.

<u>Cheese Vat Center</u>. The standardized milk is pumped into the cheese vats in this center where the cheese making process begins. Controls for monitoring and regulating the curd production process are located in this center. Pumps and piping to transfer the whey and curds out of the vats are included here. The number and size of cheese vats for the specialty-only plants are reported in Table 11.

In the modified Cheddar cheese plant models, specialty cheese is made in the existing Cheddar vats. Additional pumps, piping, and controls are used to add hot water to the curds during specialty cheese making. Table 8 provides the cheese vat sizes in the Cheddar plant modified for specialty production.

For the concurrent manufacturing scenario, specialty and Cheddar cheese are processed in every other vat fill. Thus, the first vat filled is processed into Cheddar; the second vat filled is processed into specialty cheese, and so on. Vats processing specialty cheese are only partially filled to regulate the quantity of specialty cheese curds to correspond with the size of downstream equipment. Vats used for specialty cheese curd production are never used for Cheddar curd production and vice versa when the plants produced Cheddar and specialty cheese concurrently.

Table 9 Specifications for Selected Cheddar Cheesemaking Equipment and Technological Systems in Cheddar Plant (960,000 Pounds of Milk per Day) Modified for Specialty Cheese Manufacturing

- Six X 35,000 pounds of milk Enclosed Cheese Vats.
- 5,000 pounds of cheese curd per hour Alf-o-matic.
- Four Wincanton Tower Block Formers.

Source: Mesa-Dishington et al. (1987b)

Table 10 Structural Area for Model Cheese Plants

Added Structural Area In Modified 27,483 Square Foot Cheddar Cheese Plant

Model[1]	Added Structural Area
	Square Feet
AHJ	37,871
ALJ	44,503
CHJ	33,847
CLJ	38,929
AHH	49,847
ALH	55,399
CHH	41,624
CLH	47,078

[1]Reference Table 5

Table 10 (Continued) Structural Area for Model Cheese Plants

Structural Area in Exclusively Specialty Cheese Plants

Model[1]	Structural Area
	Square Feet
SHJ	49,725
SLJ	54,598
SHH	63,188
SLH	69,422
LHJ	91,675
LLJ	98,307
LHH	121,131
LLH	126,683

[1]Reference Table 5

Table 11 Number and Size of Cheese Vats In Large and Small Specialty-Only Model Plants

Model	Cheese Vat Number and Size[1]
LHJ	6/35,000
LLJ	6/35,000
LHH	6/35,000
LLH	6/35,000
SHJ	6/ 8,800
SLJ	5/11,000
SHH	5/11,000
SLH	5/11,000

[1]Cheese Vat Number / Size in Pounds of Milk

Prepressing/Hooping/Hoop Washing Center. Specialty cheese curd and whey slurry are pumped from the cheese vat center to this center where the cheese is prepressed, placed in hoops, and prepared for the final pressing. Two methods of prepressing are modeled in this study. In the low automation system, the curds are placed on a presser-strainer vat for the prepressing process. The curd mass then is cut into blocks and manually placed in hoops on trolley carts for pressing.

The high automation prepressing system uses Alfa-Laval Casomatic draining prepressing column. The curd whey slurry from the cheese vat center is placed in a buffer tank and is pumped into the top of the Casomatic tower. If Havarti is being produced, the curd is separated from the whey at this point with a Rotostrainer, which is a rotating perforated drum that separates the curd from the whey before prepressing. Whey drains off as the curd slowly moves down the curd column (this is the prepressing). At the bottom of the column, curd blocks are automatically cut off and placed into hoops on a conveyer. The conveyer carries the hoops to the pressing center.

With both automation systems, empty hoops returning from the pressing center are automatically tunnel washed and prepared for filling. The prepressing center is added to the Cheddar cheese plant for production of specialty cheese.

Pressing Center. In the pressing center the prepressed and hooped cheese is pressed and held for acid development before brining. Two methods of pressing the cheeses are modeled which corresponded with the high and low automation prepressing systems above. The low automation pressing system uses trolley presses. Hooped blocks of cheese on trolley carts from the prepressing center are manually wheeled under a trolley pressing station where the cheese is pressed under pneumatic air cylinders. The escaping whey is collected and channeled into a whey discharge system. The sanitary quality of this whey may not be satisfactory for addition to the whey from the prepressing and cheese vat centers.

After pressing, the trolleys are removed from the pressing station and the cheeses are removed from the pressing hoops and manually placed in holding boxes with lids. The holding boxes are automatically placed on a crate conveyor. As the boxed cheese moves along the conveyor, acid development in the cheese continues.

When the cheese has reached the proper level of acidification, the boxed cheese is removed from the crate conveyor with the lid and box manually placed on conveyors to be washed.

The high automation pressing system uses a Tunnel Press which automatically unloads hooped cheese off the conveyer from the high automation prepressing system. The cheeses are automatically pressed with a pneumatic system, automatically unloaded, removed from the pressing hoop, placed into holding boxes with lids, and then placed on the crate conveyor to continue acid development.

After sufficient acid development occurs, the boxed cheese is automatically removed from the crate conveyor, deboxed, and placed on a conveyer where cheeses are prepared for brining. The boxes and lids are sent to be washed as in the low automation system.

The pressing center is added to the existing Cheddar cheese plant for specialty cheese production.

Brining Center. Cheeses are floated automatically into racks of a deep brining system which are lowered into the brine tank. The cheeses are automatically washed in brine until the desired salt level is reached. When the brine racks are lifted from the tank the brine flow carries the cheeses to a discharge conveyer. The brine system includes a brine filter and an ultraviolet brine sterilizer.

The brining center, as with the other specialty cheese making centers, was added to the existing Cheddar plant.

Packaging Center. The brined cheeses are vacuum packed in plastic bags and placed into reinforced corrugated boxes. Jarlsberg-type cheese is produced in 4" x 11" x 14" rindless blocks. Traditionally, Jarlsberg-type cheese is produced in wheels with a rind. This results in high levels of trim losses during marketing. A high quality, rindless Jarlsberg-type cheese would be desirable for the U.S. market. For Havarti cheese, the 4" x 11" x 14" cheese blocks are cut into three cheese loafs with a wire knife before packaging. Havarti is packaged in 4" x 4.66" x 11" loafs.

The cheese shapes are slightly different than typical imported Jarlsberg-type and Havarti cheese. The model plants use typical block Cheddar cheese hoop width and length dimensions (11" x 14"). This shape was chosen for its compatibility with existing United States cheese production equipment and existing cut and wrap operations handling Cheddar cheese. Thus, the researchers believe this shape would help minimize adoption costs for specialty production and reduce the cost of downstream marketing services.

Modifications to the existing Cheddar cheese plant included the addition of this packaging center.

Ripening Center. The packaged specialty cheese is held here at a relatively warm temperature for several days as flavor and texture development continues. For Jarlsberg-type cheese, ripening takes place at 66 degrees F for 7 days. For Havarti cheese, ripening is at 74 degrees F for 14 days.

This center was added to all model Cheddar plants to modify them for specialty cheese production.

Aging Center. After ripening, the cheese is transferred to a cooled aging room where it is held until the desired flavor, consistency (and eye formation in the Jarlsberg-type cheeses) is achieved. Aging takes place at 45 degrees F for three months for Jarlsberg-type cheese and for two months for Havarti. After aging, the specialty cheeses are transferred to markets for sale and distribution.

Like the ripening center, the aging center was added to the existing Cheddar cheese plant in order to incorporate specialty cheese production.

Whey Separator and Fines Saver Center. Unseparated whey collected from the cheese vat center, the prepressing/hooping/hoop washing center, and the pressing center is temporarily stored in a silo before processing in this center. From the unseparated whey silo the whey passes through a fines saver and a separator, which removes the whey cream from the whey. The whey cream is pasteurized and then stored in a tank until it is moved to market. The separated whey then is transferred to the whey plant for further processing.

In the Cheddar cheese plant modified for specialty cheese, the whey separator and fines saver center were modified to accommodate the added whey from the specialty cheese curds. Since water is added to the specialty cheese curds in the vats, the volume of whey is increased. A reverse osmosis (RO) system was installed in the whey separator and fines saver center to remove the cooking water added at the vat so that the existing Cheddar cheese whey plant would not have to increase its processing capacity.

Whey Plant

A condensed and grade A powdered whey plant processes the whey from the cheese plant into grade A whey powder. The evaporator is a single effect mechanical vapor recompression with turbo fan thermorecompression evaporator and finishing concentrator stage. The spray dryer uses the filter mat dryer process. The whey plant was designed with its own refrigeration/maintenance/ electricity center, as well as a CIP center. The waste water is monitored by the cheese plant's waste treatment center. Neither the cheese plants nor the whey plants were modeled with any sewage treatment system. All sewage is handled by a municipal sewage treatment system.

Since the whey separator and fines saver center in the Cheddar cheese plant was modified to accommodate the added volume of whey from the specialty cheese, there is no modification to the existing whey plant to incorporate specialty cheese production.

Support Centers

The support centers are not directly involved in cheese making or whey processing, yet they are necessary for the operation of the cheese plant. The characteristics of these centers are described briefly below.

For the incorporation of specialty cheese in the Cheddar cheese plant, none of these centers required modifications, except the dry storage center.

Laboratory Center. This center includes all of the equipment required to test the raw milk, standardized milk, cheese, whey and waste water.

Dry Storage Center. This room is sized to hold the inventory of packaging materials, as well as the spare parts and equipment. In the Cheddar cheese plant modified for specialty cheese production, the area of the center was increased to accommodate additional specialty cheese packaging materials, parts, and equipment.

Refrigerator/Boiler/Maintenance/Electrical Center. Heating, cooling, and maintenance services for the entire plant are provided by this center.

Cleaning In Place Center. The controls, valves, and the control system for CIP are located here. This system is connected to each piece of equipment in the plant that has an automatic cleaning system.

Waste Treatment Center. All waste water passes through this center on the way to a municipal water treatment plant. The waste water is sampled here for biological oxygen demand (BOD), suspended solids, and nitrogen determinations.

Water Well Center. All of the water used in the cheese and whey plant for cheesemaking and cleaning is provided by a water well on the plant property.

Office Center. The plants are designed with an office for production administration. No space or equipment investments are made for company organizational office space.

Locker and Restroom Center. This includes changing rooms for all employees and restroom facilities.

Lunch Center. This center provides space and furniture for the employees to eat their meals.

Production Schedules

Since the rate of milk processing or cheese production is fixed, the annual production is determined by the daily and weekly schedule. Production schedules were varied to obtain the desired quantity of cheese output depending on the manufacturing scenario and study objective. The specific production schedules used for the analysis are described later.

In the first scenario, alternate-day manufacturing, the hours-per-day for specialty-only days is independent of the hours-per-day for Cheddar-only days. In the second scenario, concurrent manufacturing, hours of production for days of Cheddar-only production is independent of the hours-per-day for days when Cheddar and specialty cheese are produced concurrently.

COST ESTIMATION

Introduction

The economic-engineering or synthetic cost estimating technique requires detailed information on technical input-output relationships of production and on the costs of resources used in the manufacturing processes.

This section presents the methods used to determine production costs for plants manufacturing only specialty cheese and for the modified Cheddar cheese plants manufacturing specialty and Cheddar cheese. Assumptions concerning raw materials and composition of outputs are discussed, along with data sources. Finally, production cost items and methods of calculating costs are described.

Assumptions

Certain assumptions were made so that valid comparisons of manufacturing costs could be drawn among plants producing the same type of specialty cheese. The assumptions concern inputs, outputs, and production techniques of all the model plants, whether specialty-only plants or modified Cheddar cheese plants.

It is assumed that operation of each of the model cheese plants reflects good management practices. Plants are assumed to operate at a high, but achievable, level of efficiency with respect to input usage and product yields.

Each plant receives good quality milk, containing 3.7 percent fat and 3.2 percent protein. The cream required for the plants producing Havarti is assumed to contain 40 percent fat and 1.92 percent protein. Seasonal variations in milk and cream compositions are assumed to affect all plants similarly and, thus, were not considered. Similarly, seasonal variations in supplies of milk and cream were not considered.

The costs per unit of inputs for the cheesemaking process were held constant across all plants. Wages, fringe benefits, utility rates, material costs, and other factor prices reflect Spring 1987 conditions.

The characteristics and compositions of cheeses and by-products produced in the model plants are assumed to be equivalent across all plants producing the same cheeses regardless of technology (i.e., high or low automation) or production method (i.e., specialty-only plants or modified Cheddar cheese plants). The modified Van Slyke formula, product yields and cheese composition for Jarlsberg-type and Havarti cheeses are presented in Tables 12 and 13. The Havarti is a creamy Havarti with a soft texture. A firmer product with lower moisture and/or fat on a dry-weight basis would have a lower yield and a higher manufacturing cost per pound.

The yield of Havarti cheese per hundredweight of raw milk is more than 60% higher than for Jarlsberg. The higher yield for Havarti is due to the high fat content of the cheese.

The Cheddar cheese manufactured in the plants modified for specialty cheese production is assumed to possess the same high quality characteristics, after the modifications, as before (current 40-pound blocks with 37 percent moisture suitable for aging). The Van Slyke formula and product yields for Cheddar cheese are presented in Table 14.

The model plants are assumed to operate with consistent production practices. All plants have uniform cheesemaking and cleaning times for any given manufacturing scenario, production schedule, and cheese type.

Data Sources

Data used to estimate specialty cheese production costs and prices of the outputs were obtained from several sources. Mead & Hunt, Inc. of Madison, Wisconsin, an engineering consulting firm with extensive experience in the cheese industry, provided the technical coefficients used in this study. Information provided by the consulting engineers included cost information on land, building structures, production equipment, labor requirements, utility demands and other expenses. Mead & Hunt, Inc. compiled the technical data on the Cheddar cheese plants modeled in the earlier study[8], one of which is modified for use in this study. Data concerning modifications of existing Cheddar plants for specialty cheese production and new specialty-only cheese plants were developed specifically for this study.

Alfa-Laval, Inc., provided technical information on specialty cheese equipment and production technologies used in Europe and available on the United States market. Alfa-Laval, Inc., in conjunction with the authors and Mead and Hunt, Inc., determined production schedules, production equipment specifications, equipment prices, labor requirements, utility demands, and other expenses for specialty cheese production. The cooperation of the equipment suppliers with experience in European design and operation of specialty cheese plants was sought because few U.S. firms currently manufacture specialty cheese equipment or produce European-style specialty cheese in the volumes that this study addresses.

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[8]Mesa-Dishington, J.K.; Barbano, D.M.; & Aplin, R.D. Cheddar Cheese Manufacturing Costs Economies of Size and Effects of Different Current Technologies A.E. Res. 87-3. Ithaca, NY: Cornell University, Department of Agricultural Economics.

Table 12 Jarlsberg-Type Cheese: Modified Van Slyke Formula, Milk and Cheese Composition, and Product Yields

Milk Composition, Standardized By Cream Removal

	Weight Pounds	Fat %	Fat Lbs	Casein %	Casein Lbs
Standardized Milk	97.80	2.88	2.82	2.52	2.47
Fresh Cream	2.20	40.00	0.88	1.50	0.03
Raw Milk	100.00	3.70	3.70	2.50	2.50

Cheese Yield Per 100 Pounds Standardized Milk

$$\frac{[0.880 * (2.88) + (2.52 * 0.94)] * 1.10}{1 - (43.00 / 100)} = 9.47 \text{ Lbs Cheese/Cwt}$$

Cheese Yield Per 100 Pounds Raw Milk

9.47 Lbs * (97.80 / 100) = 9.26 Lbs

Cheese Composition

Moisture	- 43%
Fat Dry Weight Basis	- 47%
Casein/Fat Ratio	- .875

By-product Yields Per 100 Pounds Raw Milk

Fresh Cream[1]	- 2.20 Lbs
Whey Cream[2]	- 0.85 Lbs
Whey Powder[3]	- 5.72 Lbs

[1]Fresh Cream (40% Fat)
[2]Whey Cream (40% Fat)
[3]Whey Powder, 3% moisture in powder

Industry suppliers provided cost data on production materials and cleaning supplies, as well as other inputs.

Many cost estimations and costing procedures from the Mesa-Dishington et al.[9] study were used in this study. The 960,000 pounds of milk a day model Cheddar cheese plant modified for specialty cheese production is from Mesa-Dishington et al.'s work. This plant manufactured Cheddar cheese with advanced Cheddaring and

[9]Ibid.

Table 13 Havarti Cheese: Modified Van Slyke Formula, Milk and Cheese Composition, and Product Yields

Milk Composition, Standardized By Cream Addition

	Weight Pounds	Fat %	Fat Lbs	Casein %	Casein Lbs
Raw Milk	100.00	3.70	3.70	2.50	2.50
Fresh Cream	8.07	40.00	3.23	1.50	0.12
Standardized Milk	108.07	6.41	6.93	2.43	2.62

Cheese Yield Per 100 Pounds Standardized Milk

$$\frac{[0.85 * (6.41) + (2.43 * 0.96)] * 1.05}{1 - (42.00 / 100)} = 14.08 \text{ Lbs Cheese/Cwt}$$

Cheese Yield Per 100 Pounds Raw Milk

14.08 Lbs * (108.07 / 100) = 15.22 Lbs

Cheese Composition

Moisture	-	42%
Fat Dry Weight Basis	-	62%
Casein/Fat Ratio	-	.378

By-product Yields Per 100 Pounds Raw Milk

Whey Cream[1]	-	2.60 Lbs
Whey Powder	-	5.93 Lbs

[1]Whey Cream (40% Fat)
[2]Whey Powder, 3% moisture in powder

block forming technology and equipment (i.e., Alf-O-Matic Cheddaring and Wincanton tower block formers).

Specialty cheese, whey powder, milk, and cream prices were obtained from several sources: specialty cheese importers and wholesalers, agricultural economists at Cornell University, the USDA's Dairy Market News, and the New York-New Jersey Milk Marketing Administration's Weekly Fact Sheet.

Land, Building and Equipment Costs

Land. Land requirement factors were estimated to determine total land acres needed for each model plant. Land factors were determined based on land necessary for building area, and for car and truck parking and turn-around areas in typical cheese and whey plant operations.

Table 14 Cheddar Cheese: Van Slyke Formula, Milk and Cheese Composition, and Product Yields

Milk Composition

	Weight Pounds	Fat %	Fat Lbs	Casein %	Casein Lbs
Raw Milk	100.00	3.70	3.70	2.50	2.50

Cheese Yield Per 100 Pounds Raw Milk

$$\frac{[0.915 * (3.70) + (2.50 * 0.96)] * 1.09}{1 - (37.00 / 100)} = 10.00 \text{ Lbs Cheese/Cwt}$$

Cheese Composition

Moisture	-	37%
Fat Dry Weight Basis	-	53.7%
Casein/Fat Ratio	-	.675

By-product Yields Per 100 Pounds Raw Milk

Whey Cream[1]	-	0.78 Lbs
Whey Powder[2]	-	5.80 Lbs

[1]Whey Cream (40% Fat)
[2]Whey Powder, 3% moisture in powder

Land factors for the additional land needed to modify the existing Cheddar cheese plant were based on the new building areas in added specialty cheese centers and the additional building areas needed in the existing Cheddar cheese plant centers that were modified for specialty cheese production.

Land factors for added land needed in the modified Cheddar plant reflect the fact that as much of the existing Cheddar cheese plant land was used for plant expansion as possible. Thus, the land requirement factor for modifications to the Cheddar plant is smaller than the factor for the existing Cheddar plant or the specialty-only plants..

Land factors are presented in Table 15. These land factors are based on 10,000 square feet of building area floor space, and estimated separately for the existing Cheddar plant, each specialty-only plant, and modifications to the existing Cheddar plant.

Land purchase cost is assumed to be $30,000 per acre for all land. Costs of site preparation, which includes rough and finish grading, paving, landscaping, and underground electrical, plumbing, gas, and sewer utilities are assumed to be $28,000 per acre for all land. Land for a waste treatment facility is not included in this study, since all waste is assumed to be handled by a municipal waste system.

Table 15 Land Requirement Factors For Model Plants

Type of Building Area	Land Factor[1]
Existing Cheddar Cheese Plant	1.461
Modified Cheddar Cheese Plants	0.835
Small Specialty-Only Cheese Plants	0.921
Large Specialty-Only Cheese Plants	0.677
Whey Plants for Existing Cheddar Plant	0.973
Whey Plants for Small Specialty-Only Plants	1.196
Whey Plants for Large Specialty-Only Plants	0.973

[1]Land acres per 10,000 square feet of building area.

Building. The consulting engineers calculated the building area needs based on the equipment sizes and layouts specified by equipment manufacturers for each cheese plant center. A building cost factor per square foot of building area was determined for each new specialty cheese center and for additions to existing centers in the modified Cheddar plant. Each center building cost factor includes electricity, plumbing, pneumatics, refrigeration, structure, ventilation costs and engineering fees, as well as the cost of capital tied up between the time of initial capital outlay for the building to commencement of cheese production. The building cost factors for added area in modified plants also include the costs of center modifications (e.g., moving walls and existing equipment, and connecting additional electricity, plumbing, pneumatics, and refrigeration to existing systems). See Table 16 for the total building costs for each cheese plant.

The building cost for the original Cheddar plant seems low when compared to the building expansion for specialty cheese. The reason for this is that the original Cheddar plant only was modeled to hold Cheddar cheese for 10 days production before shipping. In contrast, the specialty cheese needs to be aged 2 to 3 months prior to being a saleable cheese. Therefore, the specialty cheese building additions on the specialty-only plants need much more temperature controlled cheese aging space than the original Cheddar plant, which results in higher cost. A manufacturer of specialty cheese could reduce by 15 to 20% the capital costs in building and equipment by contracting for outside cheese aging storage rather than building additional temperature controlled space.

Whey plant building costs for the alternate-day, concurrent, and large specialty-only model plants are $2,098,469. Whey plant building costs for the small specialty-only plants are $1,537,034. These costs include building, sitework costs, engineering fees, and capital costs. Investment costs for the whey plant land are not included in these costs.

Equipment. Lists of equipment for each center in every model plant were prepared for both specialty-only plants and for the additional equipment needed in modified Cheddar plants. The equipment list for the existing Cheddar cheese plant came from Mesa-Dishington et al. research. See earlier section on center technologies for descriptions of the equipment in all model plants.

New equipment was integrated into all plants in a manner considered most efficient by the consulting engineers and equipment manufacturers. All model plants use present-day control automation, with manual overrides.

Equipment costs in all model plants reflect Spring 1987 prices. Equipment costs for the Cheddar plant designed in 1985 for the Mesa-Dishington et al. study were updated to Spring 1987 prices. All prices included delivery, installation costs, engineering fees, and capital costs. The total purchase price of equipment in each plant for all of the model cheese and whey plants are summarized in Tables 17 and 18.

Table 16 Building Costs, Not Including Land, for Model Cheese Plants

Model	Building Costs[1]
	(Dollars)
Existing Cheddar Plant[2]	1,673,582
	Cost Of Building Added To Existing Cheddar Plant
AHJ	3,051,040
ALJ	3,641,171
CHJ	2,609,879
CLJ	3,064,891
AHH	4,086,946
ALH	4,568,039
CHH	3,265,382
CLH	3,759,249
	Building Costs For Specialty-Only Plants
SHJ	4,174,947
SLJ	4,617,516
SHH	5,297,796
SLH	5,855,567
LHJ	6,839,838
LLJ	7,429,969
LHH	9,373,430
LLH	9,854,523

[1]Includes investment in building, sitework cost, engineering fees, and capital costs. Equipment costs for office, lunch room, lockers & restrooms, and waste treatment centers are included in building costs. Does not include investment in land.

[2]Building cost for existing Cheddar cheese plant from Mesa-Dishington et al., updated to Spring 1987 costs.

Table 17 Equipment Costs for Model Cheese Plants[1]

Model	Minimum Useful Life Categories 5 Years	10 Years	15 Years	Total Cost
	(Dollars)			
Existing Cheddar Plant[2]	105,093	591,458	3,656,981	4,353,532
	Cost Of Equipment Added To Existing Cheddar Plant			
AHJ	102,019	819,072	2,658,611	3,579,702
ALJ	157,525	611,379	2,622,311	3,391,215
CHJ	80,387	629,757	1,788,743	2,498,887
CLJ	133,293	426,427	1,466,225	2,025,945
AHH	117,827	1,022,935	3,028,962	4,169,724
ALH	173,333	810,864	3,214,231	4,198,428
CHH	105,093	439,628	1,939,889	2,484,610
CLH	134,958	484,748	1,508,491	2,128,197
	Equipment Cost For Specialty-Only Plants			
SHJ	186,260	1,298,950	3,377,546	4,862,756
SLJ	239,166	1,119,682	3,164,274	4,523,122
SHH	191,980	1,415,853	3,718,343	5,326,176
SLH	244,887	1,205,850	3,730,248	5,180,985
LHJ	208,198	1,442,918	6,502,485	8,153,601
LLJ	256,560	1,223,213	6,467,584	7,947,357
LHH	218,389	1,635,799	6,968,670	8,822,858
LLH	271,760	1,428,885	7,146,813	8,847,458

[1]Equipment costs include purchase price, installation, engineering fees, and capital costs. Equipment costs for office, lunch room, lockers & restrooms, and waste treatment centers are included in building costs.
[2]Equipment costs for original Cheddar cheese plant from Mesa-Dishington et al., updated to Spring 1987 costs.

Table 18 Equipment Costs For Model Whey Plants[1]

Model	Minimum Useful Life Categories 5 Years	10 Years	15 Years	Total Cost
	(Dollars)			
Large Whey Plant[2]	0	13,462	3,259,995	3,273,457
Small Whey Plant[3]	0	95,368	2,381,070	2,476,438

[1]Equipment costs include purchase price, installation, engineering fees, and capital costs.
[2]Whey plant for 960,000 pounds of milk per day plants: alternate-day, concurrent, and large specialty-only plants.
[3]Whey plant for 385,000 pounds of milk per day plants (i.e., small specialty-only plants).

Engineering Fees And Capital Costs

In addition to the purchase price for land, building, and equipment, other asset costs include engineering fees and a cost of capital for the time between new asset purchase and commencement of cheese production. The engineering fees are 6.5 percent on land and building costs and one percent of the equipment costs.

The capital outlays for the purchase of land are assumed to take place two years before the beginning of cheese production. The cash expenditures for sitework and structure are assumed to be made 1.5 years before production of cheese for 30 percent of the costs and one year for the remaining 70 percent. Equipment is assumed to be purchased six months before the initial plant operation. A six percent real interest rate was used to calculate the cost of capital tied up in assets before the commencement of cheese production, as well as for the annual capital investment cost described in the following section.

The total capital investment costs, in Table 19, include the initial investment for land, building and equipment, engineering fees, and the cost of capital prior to initiation of cheese production. Capital investment for specialty cheese, depending on the production scenario, is from 78 to 130 percent of the capital investment for the 960,000 pounds of milk per day existing Cheddar cheese plant for alternate-day and concurrent manufacturing and from 150 to 262 percent for specialty-only plants. Total whey plant capital investment cost for the alternate-day manufacturing, concurrent manufacturing, and large specialty-only plants is $5,417,664. Whey plant capital investment cost for the small specialty-only plants is $4,055,914. This cost includes investment in land, structure, equipment, engineering fees, and capital costs.

Capital Depreciation and Interest Charge

An annual charge was calculated to account for capital costs and economic depreciation over the life of the assets. The methodology used to estimate annual capital costs is the same as in the Mesa-Dishington et al. study and is presented in Appendix A. A six percent real interest rate was used as the opportunity cost

Table 19 Total Capital Investment (Land, Building and Equipment) for the Model Cheese Plants[1]

Model Plant	Total Capital Investment
	(Dollars)
Existing Cheddar Plant[2]	6,560,211
	Total Capital Investment Added To Existing Cheddar Plant
AHJ	6,676,673
ALJ	7,086,359
CHJ	5,149,816
CLJ	5,138,049
AHH	8,317,125
ALH	8,833,656
CHH	5,980,124
CLH	5,944,543
	Total Capital Investment For Specialty-Only Plants
SHJ	9,223,943
SLJ	9,335,388
SHH	10,832,687
SLH	11,257,979
LHJ	13,402,509
LLJ	13,812,195
LHH	16,725,512
LLH	17,192,854

[1]Includes investment in land, structure, equipment, engineering fees, and capital costs. Does not include investment in space for Cheddar cheese aging beyond 10 days or organizational office space (just production office space).
[2]Total capital investment costs for existing Cheddar cheese plant from Mesa-Dishington et al., updated for Spring 1987 costs.

of money. Because the cost of production factors were estimated in Spring 1987 prices and do not reflect future inflation, six percent was viewed as a reasonable interest rate, net of inflation.

Annual land cost using the six percent real interest rate is assumed to equal the opportunity cost of capital tied up in land. Possible appreciation or depreciation of land values over the duration of the investment is not incorporated into the cost.

Costs of the building and equipment were annualized by using present value techniques, assuming a six percent real interest rate and reflecting the expected lives of the individual pieces of equipment. These techniques are designed to capture the cost of money tied up in the investment and the expected economic depreciation of assets.

For the building, a minimum useful life of 25 years with 100 percent capacity utilization is assumed with no salvage value. Percent of utilization is a function of operating hours per day and operating days per week. As the building utilization decreases, the life was allowed to increase. Thirty-five years is assumed to be the maximum allowable life of the building to take into account the likelihood of obsolescence.

Minimum useful life with 100 percent plant utilization was determined for three useful life categories of equipment: five years, ten years, and 15 years. These categories of equipment life were established from estimates provided by equipment manufacturers. As with the building life, equipment life was allowed to increase as percent utilization decreased. A maximum life of 15 years was allowed for equipment to account for likely obsolescence.

In the modified Cheddar cheese plants, the three useful life categories of equipment were classified into three use groups: newly added equipment used only for specialty cheese, existing equipment used only for Cheddar cheese, and existing equipment used for both cheeses.

The percent utilization of the three equipment groups depend upon the operating schedules of the modified plants. By changing the production schedules, the annual output of Cheddar and specialty cheese can be varied; thus the percent utilization of the equipment in the three use groups also varies. Equipment operating lives in three use groups were determined by their percent of utilization.

Repairs and Maintenance Costs

Repair and maintenance cost factors were determined by the consulting engineers for each model plant. The maintenance cost factors were determined for each piece of equipment and for the building area in each center. Although they differ for each piece of equipment, the variable maintenance cost factor for each piece of equipment was considered variable with the volume of milk processed by the plant.

The consulting engineers gathered data on structural maintenance costs from several comparable size operating cheese plants. Estimated average cost of building maintenance is $0.6033 per square foot per year. This cost was categorized into a fixed and variable maintenance cost for each center.

It should be noted that the repair and maintenance cost item only reflects purchased parts and maintenance. Most of the labor for repair and maintenance is provided by plant staff. The cost of the labor for repair and maintenance is in the plant labor expense category and amounts to at least twice as much as the purchased repair and maintenance category.

Insurance Costs

Insurance for model plants includes fire insurance and extended coverage on building, equipment, and stored product. The annual insurance rate estimated by the consulting engineers is $5.15 per $51,000 of building, equipment, and inventory values. The values of the building and equipment for insurance cost are assumed to be 85 percent of their initial cost.

Property Taxes

A representative property tax rate of $36 per $1,000 of market value of land, building, and equipment was used to calculate annual property taxes for the plants. This is assumed to be an average rate for city, township, and state property taxes, which would vary by location. Market values of assets for property tax purposes are assumed to be 100 percent of the initial investment cost for land and building and 50 percent of the initial cost of equipment.

Salaries, Wages, and Labor Costs

Labor requirements for cheese plants vary according to the cheeses produced, cheesemaking technology, plant layout, labor management policies, operating schedule, and plant location. Except for the Mesa-Dishington et al. study[10], very little published information is available detailing labor costs in cheese plants. Labor requirements for the model plants were determined based on cheesemaking schedules, production times, technology used, and activities performed in each center. These labor estimates were established by the consulting engineers and equipment suppliers, and evaluated by the authors.

Labor requirements were budgeted on the basis of two major categories: supervisory labor and direct labor. Supervisory labor, which includes the plant manager and assistants, is assumed to be fixed per operating day. The average salary for managers is assumed to be $33,700 per year.

Direct labor is viewed as having a fixed and a variable component. Direct fixed labor included labor used in cleaning, in setting up equipment and in those activities required regardless of the volume of milk processed. Direct fixed labor was determined on a daily basis. On the other hand, direct variable labor changes in proportion to the volume of milk used per day. It includes all labor in the cheese plant not categorized as supervisory or as direct fixed labor.

For the modified Cheddar cheese plants, labor requirements used in the Mesa-Dishington et al. study were used for days that only Cheddar cheese was produced. In the alternate-day scenario, new labor requirements were determined for the specialty-only days. Furthermore, new labor requirements were determined for the concurrent plants for "concurrent days" (i.e., days when both cheeses are produced simultaneously). New direct labor requirements also were determined for the large and small specialty-only plants. Labor requirements for the model plants are summarized in Appendix B.

The wage rate used in this study is $9.30 per hour for all direct labor. This rate represented the average cost for part-time, full-time, and over-time labor in the eleven Cheddar cheese plants surveyed in the Mesa-Dishington et al. field study[11], indexed to reflect 1987 rates. The fringe benefits costs are assumed to be 32 percent of wages in both of these studies. Fringe benefits included allowances for a welfare fund, a retirement fund, social security, life

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[10]Mesa-Dishington, J.K.; Aplin, R.D.; & Barbano, D.M. Economic Performance of Eleven Cheddar Cheese Manufacturing Plants in Northeast and North Central Regions A.E. Res. 87-2. Ithaca, NY: Cornell University, Department of Agricultural Economics.

[11]Ibid.

insurance, medical and dental expenses, unemployment insurance, workmen's compensation, sick leave, and paid vacations.

Actual cheese plants have different labor policies that depend on labor availability, seasonality, wages, and management practices. In general, most labor forces are flexible in the number of hours available. Management usually can adjust employee work schedules and the number of employees according to fluctuations in milk supply and other production factors. This study assumes that any management decision which reorganized or adjusted the labor force had no effect on average hourly labor rates, and that only the actual labor required for each operation is used and paid for.

Utility Costs

The utilities estimated for the model plants were electricity, natural gas, water and sewage. Gas and electricity requirements for each piece of equipment were calculated by the consulting engineers from data provided by equipment manufacturers. All hot water and steam requirements for each center were translated into the natural gas necessary to heat water or produce steam. Water consumption was calculated from equipment flow rates and estimated usage rates.

As with the labor requirements in the modified Cheddar plants, Mesa-Dishington et al.'s utility requirements were used for Cheddar-only days. New utility requirements were estimated for the specialty-only days in the scenario one plants that produced specialty and Cheddar on alternate days. New utility requirements also were estimated for the days when specialty and Cheddar cheeses are produced simultaneously in concurrent plants.

Electricity. Electricity requirements for the model plants include fixed and variable components. The fixed portion is based on the number of kilowatt hours required per hour for each plant center. For each plant center, the variable portion is based on number of kilowatt hours required per million pounds of milk. A flat rate of $0.0582 per KWH is charged for electricity. The rate is considered an average energy cost which takes into account demand charges and energy charges for electricity. Use of an average cost figure facilitates the summation of electricity costs across the plant centers. No center was charged a higher initial energy rate or a lower subsequent rate. Electricity requirements for model plants are summarized in Appendix C.

Natural Gas. As in the Mesa-Dishington et al.[12] model plants, natural gas was selected as the fuel used for model plants in this study. A fixed and variable portion were calculated for each center requiring gas. Fixed gas is based on therms per operating day and the variable portion on therms per million pounds of milk. An average charge of $0.37 per therm is assumed. Natural gas requirements are summarized for each model plant in Appendix D.

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[12] Mesa-Dishington, J.K.; Barbano, D.M.; & Aplin, R.D. Cheddar Cheese Manufacturing Costs Economies of Size and Effects of Different Current Technologies A.E. Res. 87-3. Ithaca, NY: Cornell University, Department of Agricultural Economics.

Water and Sewage. In the Mesa-Dishington et al. study[13], water and sewage requirements were estimated on a fixed daily basis for each center. They took into account water and sewage required for cleaning the building and equipment on each operating day. A variable portion was included in this study because of the large quantities of hot water added to specialty cheese curds in the vats. Variable water and sewage requirements are based on gallons of water used in each center per million pounds of milk. Each plant is designed with its own water well; thus, no direct charge for water was made. However, capital investment costs and operating expenses of the water supply center were included as cost items.

A sewage cost is charged equal to $1.50 per 1,000 gallons of fluid disposed. This rate was determined for Mesa-Dishington et al.'s study by averaging the sewage costs of several Cheddar cheese plants with new sewage contracts or with old sewage contracts that had been revised recently by local municipalities. Water and sewage requirements for each model plant are summarized in Appendix E.

Supplies and Other Service Costs

Production, packaging, laboratory, and cleaning supplies together with other expenses are a significant proportion of the total cost of specialty cheese production. In all of the modified Cheddar plants, new costs were estimated for the days when only specialty cheese is produced in the alternate-day scenario and for days when both cheeses were produced concurrently. Mesa-Dishington et al. estimates, updated to Spring 1987 prices, were used for the Cheddar-only days. New costs also were estimated for the specialty-only plants.

Production Supplies. Production supplies for plants considered in this study depended upon the type of specialty cheese produced and manufacturing scenario (i.e., specialty-only or modified Cheddar plants). Both Jarlsberg-type and Havarti cheesemaking require starter culture, rennet and salt, but of different types and quantities. The particular supplies needed were determined from information supplied by three sources: Alfa-Laval, Inc., published manufacturing procedures for these cheeses[14], and industry suppliers' recommendations.

Production supplies for Cheddar cheese in the modified Cheddar plants include calcium chloride, color, rennet, salt and starter culture. The quantities of these materials for Cheddar cheese were determined from standard acceptable manufacturing requirements. The costs of these supplies reflect spring 1987 prices and shipping charges, without any allowances for special discounts.

Production supply costs were obtained from product suppliers and cheese plants located in the Northeast and North Central regions of the United States. Combined costs of all production materials are estimated to be $2.71 per 1,000 pounds of milk for Jarlsberg-type cheese, $2.46 per 1,000 pounds of milk for Havarti cheese, and $2.60 per 1,000 pounds of milk for Cheddar cheese. Appendix F details the type, quantity and cost of production supplies used for each cheese.

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[13] Ibid.

[14] Scott, R. (1981). Cheesemaking Practice. London: Elsevier Applied Science Publishers.

Packaging Supplies. All cheeses manufactured in the model plants are packaged in vacuum packed plastic bags and then placed in corrugated cardboard boxes. The costs of the packaging supplies are estimated at $0.35 per 24-pound block Jarlsberg-type cheese, $0.21 per 8-pound block of Havarti cheese, and $0.52 per 40-pound block of Cheddar cheese.

Laboratory Supplies. The cheese plants in this study perform all of the standard control and quality tests recommended for cheese operations. The tests are used to determine the quantities of antibiotics in milk, milk bacteria count, milk fat, milk protein, pH, fat and protein in unseparated whey, pH of whey at draw, fat in separated whey, fat in whey cream, cheese moisture, cheese fat, cheese pH, and cheese salt. Laboratory tests are performed on each incoming load of raw milk and every vat of cheese produced. BOD tests are determined for the fluids entering the municipal sewage system.

Laboratory costs in the modified Cheddar cheese plants are assumed to be the same as in the plant before the modification for specialty cheese production. Separate factors for laboratory supplies were determined for the small and large specialty-only plants. Estimated laboratory costs for the plants are summarized in Appendix G.

Cleaning Supplies. Costs of cleaning supplies for model plants are considered fixed per operating day. All equipment used each day goes through a cleaning process at the end of the day. Cleaning supplies costs were determined by the consulting engineers from cleaning costs in actual cheese plant operations. Cleaning costs for the model plants are provided in Appendix H.

Other Expenses

This group of expenses includes accounting and office supplies, communications and travel, laundry, telephone, and other services. These expenses are assumed to be fixed on a yearly basis. They were estimated by interviews with managers of actual cheese plants and adjusted for the two plant sizes. Appendix I summarizes these expenses for all model plants.

Production Inventory Costs

The production inventory costs reflect the opportunity cost for the capital expense of resources used in production. It was calculated from the time the resources were first used in production to the time the product moves out of production. Time considered for this expense is different for each cheese type (i.e., Cheddar, Jarlsberg-type, and Havarti) since each has a different production, ripening, and aging time. The time considered for Jarlsberg cheese is 150 days, for Havarti 77 days, and for fresh Cheddar cheese 10 days. Inventory cost for the cheese was determined by using a six percent annual real interest rate on the value of the resources that comprise variable costs of production, cost of milk, and, in the plants producing Havarti, cost of the cream.

Milk and Cream Cost

For production inventory costs purposes, and for assessing the profitability potential of each cheese, the cost of milk used in the plants for cheese production was calculated using an average price of $11.85 per hundredweight of milk with 3.70 percent fat test. In plants producing Havarti cheese the cost of cream purchased is calculated by using a price of $1.60 per pound of fat. The plants producing Jarlsberg-type cheese are credited with the sale of the cream removed from the raw milk before cheese making.

COSTING METHODS

From the estimates of the cost items previously described, which take into account resource requirements for production processes and their costs, daily costs of producing the cheeses were estimated with the synthetic estimating technique. This section describes the methods used to determine production costs for the specialty-only plants, as well as, the production costs for the modified Cheddar plants.

Specialty-Only Plants

The production costs for the small 385,000 pounds of milk per day and the large 960,000 pounds of milk per day specialty-only plants were calculated by summing the cost items from each center. The total daily cost, on a per unit of production basis, represents the average cost per pound of producing a given specialty cheese (e.g., Havarti or Jarlsberg-type) in a plant with a given level of automation, operating on a given production schedule.

The 960,000 pounds of milk per day, specialty-only plants were developed by adapting alternate-day modified Cheddar plants. The plants' ripening and aging centers were expanded to accommodate specialty cheese production seven days a week. The plants were restricted to producing only specialty cheese, and no Cheddar. No costs for the strictly Cheddar centers or associated land were considered in the cost estimation process. This adaptation of the alternate-day modified Cheddar plants may not represent the most efficient design for a large specialty-only plant at this capacity, but they should provide estimates of the economies of size in plants producing only specialty cheese.

Modified Cheddar Plants

The total production costs for the plants producing both Cheddar and specialty cheese were calculated in a fashion similar to the costs for the specialty-only plants. Costs associated with each plant center and the overall plant were summed to arrive at an average daily cost of production. However, the average daily costs of producing both cheeses in a plant are not useful for comparing production costs with the specialty-only plants, and do not provide estimates of the costs to produce the specialty cheese per se. Therefore, costs of producing specialty cheeses in these plants were estimated on an incremental cost basis.

To determine the incremental costs of manufacturing specialty cheeses in a modified Cheddar plant, average daily production costs of the plant producing only Cheddar cheese before the modification were subtracted from average daily production costs of the plant operating after the modifications and producing both cheeses.

Incremental costs incorporate the capital costs to modify existing Cheddar plants and added operating costs required to manufacture specialty cheese in a modified Cheddar plant. Incremental costs include costs of added land, costs to establish new production centers, costs to modify existing centers, costs of resources used in specialty cheese production, and all positive or negative changes in the Cheddar cheese production costs that result from specialty cheese incorporation into the plant. The incremental costs reflect the minimum cost of producing specialty cheeses in the plants, or the costs that the revenue from specialty cheese must cover in order to break even.

Before the modification to include specialty cheese, the Cheddar cheese plant was assumed to produce Cheddar cheese five days a week, 24 hours per day. The corresponding average daily cost was used in calculating the incremental cost for specialty cheese after the modification. This schedule corresponds to the 71 percent average capacity utilization found in the eleven Cheddar plants surveyed by Mesa-Dishington et al[15]. The production costs for the existing Cheddar cheese plant before modification are provided in Appendix J.

The schedules used for the modified Cheddar cheese plant hold the Cheddar production at, or nearly at, the original level before the modification. An average daily cost to produce both cheeses was estimated, and the average daily production cost from the original plant was subtracted to arrive at the incremental daily costs of specialty cheeses. The incremental daily cost of specialty cheese was divided by the average daily specialty cheese production to determine the average incremental cost per pound of specialty cheese.

Limited milk supply profitability assessment analyses maintained the number of days per week of operation, but changed the number of Cheddar-only days and specialty-only days. This leads to varying quantities produced of both Cheddar and specialty cheese. For this profitability analysis, total production costs for the plant producing both Cheddar and specialty cheese were compared with total revenues from both Cheddar and specialty cheese. When the quantities of both Cheddar and specialty produced change, the corresponding increases and decreases in revenues, as well as, costs are considered in order to evaluate the relative profitability of specialty cheese production.

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[15] Mesa-Dishington, J.K.; Aplin, R.D.; & Barbano, D.M. Economic Performance of Eleven Cheddar Cheese Manufacturing Plants in Northeast and North Central Regions A.E. Res. 87-2. Ithaca, NY: Cornell University, Department of Agricultural Economics.

RESULTS

PRODUCTION COSTS AND PROFITABILITY

Introduction

This study focused on estimating European-style specialty cheese production costs under various manufacturing scenarios, plant sizes, and technologies, using the economic-engineering methodology. The study also was designed to assess the profitability of Jarlsberg-type and Havarti cheese production under various manufacturing and price situations. Production costs were determined by estimating the cost for each plant center and costs associated with the overall plant operation.

Cheese production was modeled for two European-style specialty cheese types: a rindless Jarlsberg-type and a rindless, creamy Havarti with a soft texture[16]. Cost estimates were budgeted for each specialty cheese being produced under three manufacturing scenarios. Two of the scenarios involve modifying a Cheddar cheese plant to manufacture specialty cheese as well as Cheddar. In the third scenario, specialty cheese is manufactured in plants devoted only to specialty cheese production. Two technologies or levels of production automation were modeled for each of the manufacturing scenarios: a high automation system representing a state-of-the-art specialty cheese production system, and a low automation system representing a more traditional specialty production system. Sixteen plants were modeled in total.

Costs for specialty cheese manufactured in the Cheddar cheese plant reflect the costs of modifying the Cheddar plant and manufacturing specialty cheese in addition to Cheddar. These costs include the added capital items, labor and other inputs for specialty production, as well as any changes in the production cost of Cheddar cheese that would result from producing specialty cheese in the same plant. This <u>incremental</u> cost measures the increase in the total cost of operating the Cheddar plant to produce both Cheddar and specialty cheese over the cost of producing Cheddar cheese alone.

<u>The production cost estimates included are the costs associated with the cheese production from receipt of raw milk through, and including, aging of the specialty cheese before marketing</u>. The production costs do <u>not</u> include the cost of raw milk or cream, milk assembly, whey handling, cheese marketing, or administration and management, other than direct plant management. The cheese production cost estimates do <u>not</u> include credits or charges for whey or whey cream or for cream removed from the raw milk in Jarlsberg-type production or added to raw milk for Havarti.

<u>However, when estimating potential profitability of specialty cheese production, all costs (except marketing and administration) and credits are included</u>. The costs of raw milk, cream (for Havarti), and whey powder processing, plus all revenues from cheese, cream (from Jarlsberg-type), whey cream, and whey

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[16]The Havarti studied is a creamy Havarti with a soft texture. A firmer product with lower moisture and/or fat on a dry basis would have a lower yield and a higher manufacturing cost.

powder were considered together with the manufacturing costs to determine net returns to specialty cheese production.

The estimated production costs reflect feasible production systems operated with good management under the assumptions made in this study. Plants currently manufacturing Jarlsberg-type, Havarti, and/or Cheddar cheese may be using other production methods, operating with different factor costs, and using partially or fully depreciated assets. Thus, the cost estimates may not necessarily reflect the production costs of cheese plants in actual operation. However, this study provides useful information about the dynamics of the manufacturing scenarios, the effects of automation levels and plant size, as well as an assessment of the profit potential of specialty cheese production.

Specialty Cheese Production in a Cheddar Plant

Objective Overview

A primary objective of this study was to determine whether it is less costly for a medium size Cheddar cheese plant (960,000 pounds of milk per day) to produce specialty cheese on alternate days or to produce, at least some days, specialty cheese concurrently with Cheddar.

For both alternate-day and concurrent manufacturing scenarios, a Cheddar cheese plant was modified to allow the manufacture of specialty cheese, as well as Cheddar. The first scenario (alternate-day manufacturing) allows specialty cheese or Cheddar cheese, but not both, to be produced on a given day. The second scenario (concurrent manufacturing) allows manufacturing of specialty at the same time as Cheddar cheese, but the plant still can manufacture only Cheddar cheese on any given day.

The concurrent scenario is a very specific approach that attempts to use the Cheddar milk processing equipment and Cheddar cheese vats for making both cheeses in rotation throughout the day, to minimize added capital costs. This approach spreads the production of specialty throughout the day and minimizes the amount and size of specialty cheese equipment needed after the vats, again to minimize capital costs. As indicated in Table 19, the total investment required to modify the model Cheddar plant to produce specialty cheese with the assumed concurrent scenario runs 23 to 31% less than for the assumed alternative day scenario. The concurrent scenario is <u>not</u> a design where separate milk processing equipment and cheese vats are used for specialty cheese and the cheese is made during one 8 hour shift or part of one shift. This would be nearly identical to a small specialty only plant from the point of view of manufacturing cost per pound of cheese.

<u>In both cases, costs of producing specialty cheese were determined by estimating the total operating costs of the Cheddar plant after modification, and subtracting the total production costs of the basic Cheddar plant before modification to permit specialty cheese production</u>.

Production costs were compared over a range of possible weekly production schedules. The quantity of specialty cheese produced ranges from 9.5 to 1.8 million pounds per year for Jarlsberg-type cheese or from 14.1 to 2.7 million pounds of Havarti cheese annually (Table 20).

The total United States' market for specialty (as opposed to a high quality commodity grade) European-style Jarlsberg-type cheese, according to confidential contacts involved in marketing and importing these specialty cheeses, is currently estimated to be between 15 and 20 million pounds annually. These same sources estimate current Havarti consumption in the U.S. to be between 20 and 30 million pounds annually. Thus, the market share, represented by the production schedules studied, ranges from approximately 9 to 63 percent of the Jarlsberg-type market and from about 10 to 56 percent of the current domestic Havarti market. If a market niche for domestic production of these cheeses can be established, continued expansion of the market would be likely.

In the model plants, the quantities of Jarlsberg-type and Havarti cheese produced differ for a given production schedule due to different cheese yields (Table 20). Cheese yields for Jarlsberg-type and Havarti are 9.26 and 15.22 percent, respectively, for a given quantity of raw milk. Quantities of a given specialty cheese produced with alternate-day and concurrent manufacturing scenarios, although quite similar in most cases, are not exactly the same, due to technical differences in plant operating schedules (Table 20).

Throughout this specialty cheese cost comparison, the Cheddar plant capacity utilization for Cheddar cheese production is assumed to remain at 71 percent, with some or all of the remaining capacity used for specialty cheese manufacturing.[17] The quantity of Cheddar produced annually was not allowed to change so that the costs of specialty cheese production could be studied independently.

Annual Cheddar cheese production is assumed to remain at about 24.96 million pounds a year, which corresponds to the quantity produced in the existing Cheddar plant operating at 71 percent capacity (i.e., five days, 24 hours a day per week, or six days, 21 hours per week). A 960,000 pound per day Cheddar plant modeled by Mesa-Dishington et al.[18] was used as the existing Cheddar plant. Production costs for this plant were updated with Spring 1987 factor prices (Appendix J). The base production costs were used to determine the incremental specialty cheese costs in the modified Cheddar Cheese plant.

When quantities of both cheeses change, both costs and revenues must be considered. In the profitability section, this situation is investigated for plants operating under production situations which vary the quantities of Cheddar as well as specialty production.

The production costs used to compare alternate-day and concurrent manufacturing scenarios in a Cheddar cheese plant are reported on a cost per pound basis and only for the high automation level. High automation consistently has a lower production cost than low automation, except in one case (i.e., concurrent manufacturing of Havarti at the lowest production level studied). Later, results from both high and low production automation levels are reported.

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[17] Seventy-one percent was the average Cheddar plant utilization found in a field survey of 11 Cheddar plants in the Northeast and North Central United States.

[18] Mesa-Dishington, J.K.; Barbano, D.M., & Aplin, R.D. Cheddar Cheese Manufacturing Costs Economies of Size and Effects of Different Current Technologies A.E. Res. 87-3. Ithaca, NY: Cornell University, Department of Agricultural Economics.

Table 20 Production Schedules and Annual Cheese Production for Alternate-Day and Concurrent Manufacturing Scenarios in Cheddar Cheese Plant, High Automation

Production of Specialty & Cheddar Cheese On Alternate-Day(s)

Weekly Schedule				Annual Cheese Production		
Specialty-Only		Cheddar-Only				
Days	Hours	Days	Hours	Jarlsberg-Type	Havarti	Cheddar
				(Thousands of Pounds)		
2	24	5	24	9,455	14,057	24,960
2	21	5	24	7,879	11,715	24,960
2	18	5	24	6,303	9,372	24,960
1	24	5	24	4,727	7,029	24,960
1	21	5	24	3,940	5,857	24,960
1	18	5	24	3,152	4,686	24,960
1	13	5	24	1,838	2,733	24,960

Production of Specialty & Cheddar Cheese Concurrently

Weekly Schedule				Annual Cheese Production		
Specialty & Cheddar		Cheddar-Only				
Days	Hours	Days	Hours	Jarlsberg-Type	Havarti	Cheddar
				(Thousands of Pounds)		
7	24	0	0	9,479	14,094	24,960
6	24	1	18	8,125	12,081	24,722
5	24	2	18	6,771	10,067	24,484
5	21	2	24	5,643	8,389	24,841
4	18	3	24	3,611	5,369	24,485
2	18	4	24	1,806	2,685	24,723

Production Cost Estimates

Alternate-day production of both cheeses was found to be the lower cost method to manufacture specialty cheese in a Cheddar plant. Although alternate-day manufacturing has a higher capital cost, it has a lower cost of labor, utilities, and materials than concurrent manufacturing. The higher costs of labor and

utilities in concurrent manufacturing are due to relative inefficiencies inherent when both Cheddar and specialty are manufactured simultaneously.

Alternate-day manufacturing is less expensive than concurrent manufacturing by about 6.2 to 12.7 cents per pound of Jarlsberg-type and 0.4 to 8.2 cents per pound of Havarti, over the production range studied (Tables 21 and 22, and Figures 3 and 4). Labor and capital costs represent from half to two-thirds of the total production costs in both scenarios (Tables 23 and 24).

Capital Costs. Capital depreciation and interest cost per pound of Jarlsberg-type or Havarti cheese with alternate-day manufacturing are consistently higher than with concurrent manufacturing. Capital costs in Jarlsberg-type cheese production range from 6.5 to 32.0 cents per pound for alternate-day manufacturing, and from 5.6 to 25.2 cents per pound in concurrent manufacturing. Havarti capital costs range from 5.3 to 26.4 cents per pound for alternate-day production, and from 4.1 to 19.2 cents per pound concurrent manufacturing over the production ranges. The higher capital cost per pound of specialty cheese in alternate-day manufacturing is due to the higher initial capital investment required to modify the existing Cheddar plant (Table 19). Alternate-day manufacturing capacity allows the same quantity of specialty cheese to be processed in two days as the concurrent manufacturing capacity allows in seven days (Table 20). Thus, alternate-day manufacturing of specialty cheese can process 960,000 pounds of raw milk into specialty cheese per day, while concurrent manufacturing can process only 275,000 pounds of raw milk per day into specialty cheese. The higher capacity, alternate-day manufacturing was designed with larger equipment, requiring more space to process more pounds of milk per day.

Of all cost items, capital cost per pound of cheese has the largest variability over the production range. Capital costs for Jarlsberg-type vary by 25.5 cents per pound for alternate-day manufacturing and 19.6 cents per pound for concurrent production over the production range. Capital costs for Havarti vary by 21.1 cents per pound for alternate-day manufacturing, and by 15.1 cents per pound for concurrent manufacturing over the production range. This variability in the depreciation and interest charge is due mainly to the fairly fixed annual capital cost being spread over relatively small quantities of cheese at the low end of the specialty cheese production range.

The sensitivity of capital costs per pound to the quantity of production, and the higher initial capital investment for alternate-day manufacturing help to explain why the cost advantage of alternate-day over concurrent manufacturing diminishes as the quantity of cheese decreases (Tables 21 and 22, and Figures 3 and 4). The higher capital costs for alternate-day over concurrent manufacturing becomes a larger and larger cost influence as production quantities decrease.

Labor Costs. It may be surprising to some that alternate-day manufacturing of specialty cheese, requiring a higher investment cost, would have a lower production cost per pound of specialty cheese. The driving force for this relationship is a much higher cost of labor for concurrent manufacturing than for alternate-day manufacturing.

Table 21 Jarlsberg-Type Cheese: Cost Advantage of Alternate-Day Over Concurrent Manufacturing in Cheddar Cheese Plant, High Automation

Approximate Jarlsberg-Type Cheese Production[1]	Cost Advantage of Alternate-Day Production
(1,000/Lbs/Year)	(Cents per Pound)
9,479	12.7
8,125	12.4
6,771	12.0
5,643	11.4
3,611	10.6
1,806	6.2

[1]Production schedules are adjusted so that equivalent quantities of Jarlsberg-type cheese are manufactured with alternate-day and concurrent manufacturing scenarios.

Table 22 Havarti Cheese: Cost Advantage of Alternate-Day Over Concurrent Manufacturing in Cheddar Cheese Plant, High Automation

Approximate Havarti Cheese Production[1]	Cost Advantage of Alternate-Day Production
(1,000/Lbs/Year)	(Cents per Pound)
14,094	8.2
12,081	7.8
10,067	7.5
8,389	6.8
5,369	7.0
2,685	0.4

[1]Production schedules are adjusted so that equivalent quantities of Havarti cheese are manufactured with alternate-day and concurrent manufacturing scenarios.

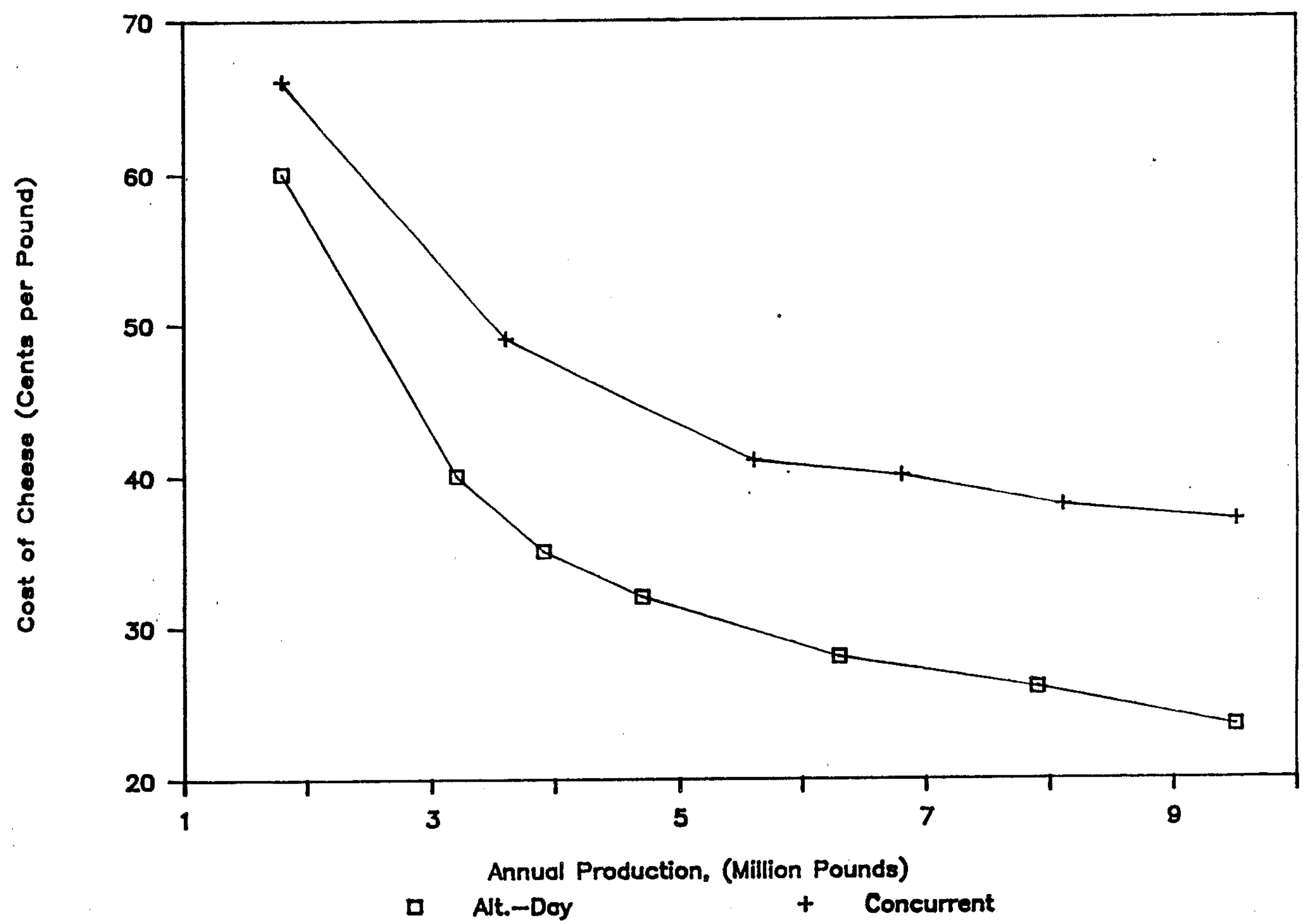

Figure 3 Jarlsberg-Type Cheese: Alternate-Day and Concurrent Manufacturing Costs Over Production Range, High Automation

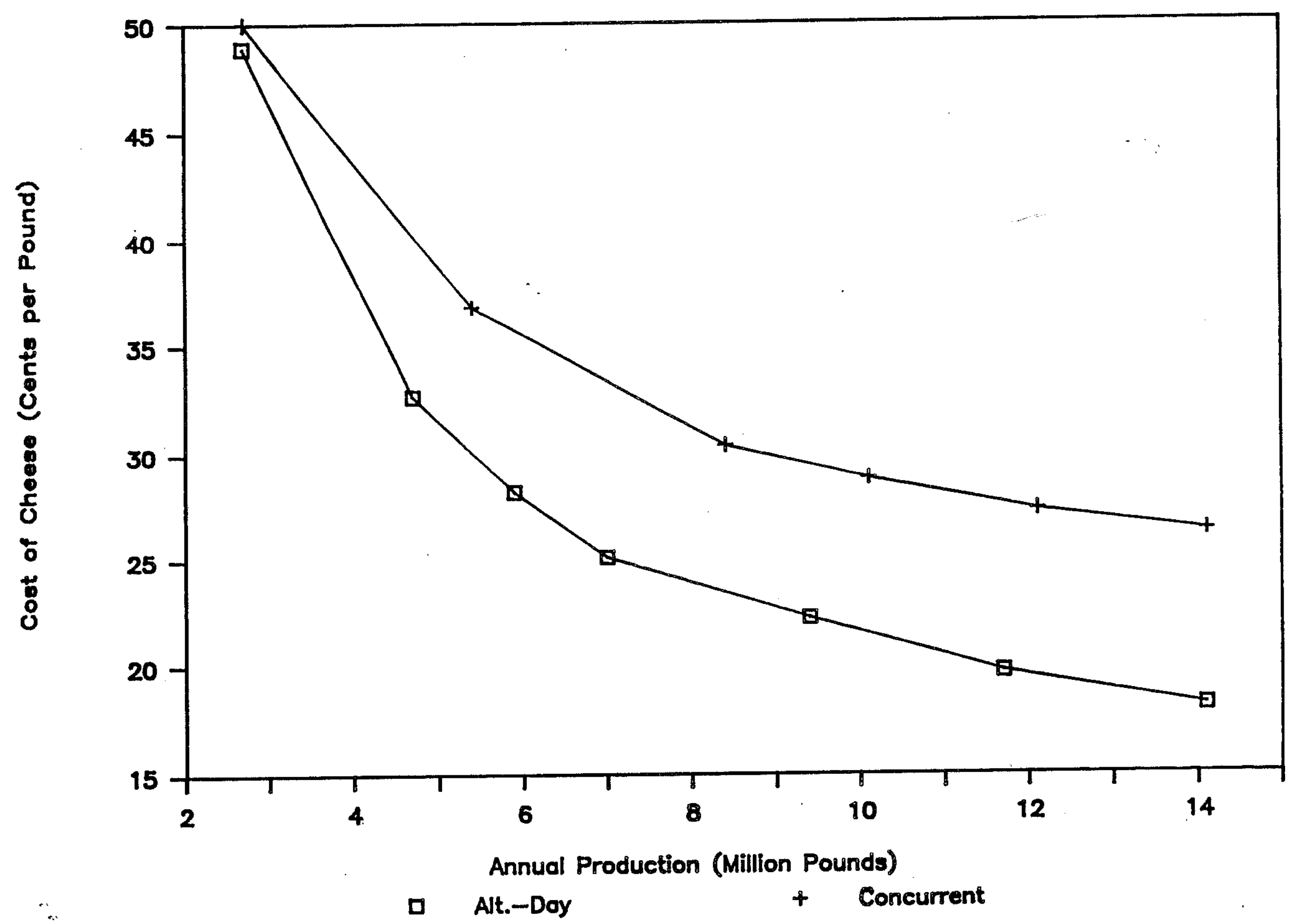

Figure 4 Havarti Cheese: Alternate Day and Concurrent Manufacturing Costs Over Production Range, High Automation

Table 23 Jarlsberg-Type Cheese: Variability in Incremental Production Costs in Cheddar Plant Under Various Production Schedules, High Automation

Cost Item	Alternate-Day Manufacturing: Cost Range Over Production Schedules[1]	Concurrent Manufacturing: Cost Range Over Production Schedules[2]
	-----------(Cents per Pound)-----------	
Labor		
Supervisory	(0.5 - 1.3)	(0.5 - 1.3)
Direct Fixed	(0.6 - 1.5)	(1.3 - 2.7)
Direct Variable	(4.0 - 4.0)	(14.7 - 14.7)
Total Labor	(5.0 - 6.7)	(16.5 - 18.7)
Capital Costs		
Deprec. & Interest	(6.5 - 32.0)	(5.6 - 25.2)
Utilities		
Electricity	(0.2 - 0.4)	(0.5 - 0.6)
Fuel	(0.4 - 0.4)	(1.3 - 1.5)
Water & Sewage	(0.1 - 0.2)	(0.4 - 0.6)
Total Utilities	(0.7 - 0.9)	(2.2 - 2.7)
Materials		
Laboratory	(0.1 - 0.1)	(0.1 - 0.1)
Production	(2.9 - 2.9)	(2.9 - 2.9)
Packaging	(1.5 - 1.5)	(1.5 - 1.5)
Cleaning	(0.2 - 0.6)	(0.5 - 1.2)
Total Materials	(4.7 - 5.0)	(5.0 - 5.7)
Repair & Maintenance[3]	(0.6 - 0.9)	(1.0 - 1.3)
Property Tax & Insurance	(2.2 - 11.1)	(1.7 - 9.1)
Production Inventory	(3.0 - 3.1)	(3.3 - 3.3)
Other Expenses[4]	(0.0 - 0.0)	(0.0 - 0.0)
TOTAL	(22.6 - 59.8)	(35.3 - 66.0)

[1] The upper and lower ranges correspond to the costs of producing 9,454,848 and 1,838,443 pounds of Jarlsberg-type cheese annually, with alternate-day manufacturing of Jarlsberg-type and Cheddar cheese.

[2] The upper and lower ranges correspond to the costs of producing 9,479,470 and 1,805,613 pounds of Jarlsberg-type cheese annually, with concurrent manufacturing of Jarlsberg-type and Cheddar cheese.

[3] Most of the cost of labor for maintenance and repair is in the labor costs above.

[4] Other expenses (e.g. accounting, office supplies, travel, telephone and communication) would increase little, if at all, in a Cheddar plant which added specialty cheese production.

Table 24 Havarti Cheese: Variability in Incremental Production Costs in Cheddar Plant Under Various Production Schedules, High Automation

Cost Item	Alternate-Day Manufacturing Cost Range Over Production Schedules[1]	Concurrent Manufacturing Cost Range Over Production Schedules[2]
	----------(Cents per Pound)----------	
Labor		
Supervisory	(0.3 - 0.8)	(0.3 - 0.9)
Direct Fixed	(0.5 - 1.2)	(1.0 - 1.9)
Direct Variable	(3.3 - 3.3)	(11.0 - 11.0)
Total Labor	(4.1 - 5.3)	(12.3 - 13.8)
Capital Costs		
Deprec. & Interest	(5.3 - 26.4)	(4.1 - 19.2)
Utilities		
Electricity	(0.1 - 0.2)	(0.4 - 0.5)
Fuel	(0.3 - 0.3)	(0.9 - 1.0)
Water & Sewage	(0.1 - 0.1)	(0.3 - 0.4)
Total Utilities	(0.5 - 0.6)	(1.6 - 1.9)
Materials		
Laboratory	(0.04 - 0.04)	(0.04 - 0.04)
Production	(1.6 - 1.6)	(1.6 - 1.6)
Packaging	(2.6 - 2.6)	(2.6 - 2.6)
Cleaning	(0.1 - 0.4)	(0.3 - 0.8)
Total Materials	(4.3 - 4.6)	(4.5 - 5.0)
Repair & Maintenance[3]	(0.4 - 0.7)	(0.7 - 1.0)
Property Tax & Insurance	(1.9 - 9.5)	(1.4 - 7.2)
Production Inventory	(1.5 - 1.6)	(1.6 - 1.6)
Other Expenses[4]	(0.0 - 0.0)	(0.0 - 0.0)
TOTAL	(18.0 - 48.7)	(26.2 - 49.7)

[1]The upper and lower ranges correspond to the costs of producing 14,057,472 and 2,733,397 pounds of Havarti cheese annually, with alternate-day manufacturing of Havarti and Cheddar cheese.

[2]The upper and lower ranges correspond to the costs of producing 14,094,080 and 2,684,587 pounds of Havarti cheese annually, with concurrent manufacturing of Havarti and Cheddar cheese.

[3]Most of the cost of labor for maintenance and repair is in the labor costs above.

[4]Other expenses (e.g. accounting, office supplies, travel, telephone and communication) would increase little, if at all, in a Cheddar plant which added specialty cheese production.

The labor costs for Jarlsberg-type cheese production in alternate-day manufacturing are approximately 12.0 cents per pound lower than in concurrent manufacturing (Table 23). Labor costs for Havarti are approximately 8.5 cents per pound lower in alternate-day than in concurrent manufacturing, over the production range (Table 24).

Concurrent manufacturing of specialty cheese with Cheddar cheese has several inefficiencies relative to alternate-day manufacturing which lead to higher labor and utility costs. First, alternate-day manufacturing provides some economies of size over concurrent manufacturing because of the greater specialty cheese production capacity for alternate-day manufacturing. Someone must operate a machine whether it processes 960,000 pounds of milk per day (as with alternate-day manufacturing) or 275,000 pounds of milk per day (as with concurrent manufacturing).

Second, concurrent manufacturing of specialty cheese is not as continuous as alternate-day manufacturing, because specialty cheese vat fills take place between Cheddar vat fills. This leads to labor and equipment utilization inefficiencies because of gaps in the production processes. Not only is specialty cheese production affected, but Cheddar production as well. At the highest level of production in the concurrent schedule, the plant produces the same total pounds of Cheddar cheese in 7 days as it used to produce in 5 days 24 hours. This adds labor and cleaning costs to Cheddar production. Thus, concurrent manufacturing of Cheddar and specialty cheese interrupts continuity of production for both cheeses.

Cheddar production inefficiencies introduced by concurrent manufacturing are an unavoidable cost incurred when specialty and Cheddar cheese are manufactured concurrently. Because these added costs of producing Cheddar are a direct result of manufacturing specialty cheese, they are included in the cost of specialty cheese.

It might be argued that this added cost and inefficiencies could be avoided by manufacturing the specialty cheese at the beginning or end of each day rather than throughout the day. This manufacturing method would essentially be the alternate-day manufacturing scenario stretched over the entire week, since the specialty cheese line would need to be sized to the pasteurizer rate of the original Cheddar plant (as is the case in alternate-day manufacturing). This manufacturing method might have a lower production cost than concurrent manufacturing, but would be more expensive than alternate-day manufacturing because spreading specialty production over the entire week would increase the fixed start-up and cleanup costs incurred for both specialty and Cheddar cheese.

Utility Costs. Utility costs are higher for concurrent manufacturing than for alternate-day manufacturing for the same reasons labor costs are higher: alternate-day has economies of size, and concurrent manufacturing of specialty and Cheddar leads to inefficiencies in the production process for both Cheddar and specialty cheese.

Repair and Maintenance Costs. Repairs and maintenance costs of the building and equipment are lower for the alternate-day than for concurrent manufacturing. It might be expected that a more expensive, higher capacity alternate-day production system would have a higher maintenance cost. But economies of size lead to a lower cost per pound of product. This result is consistent with the Mesa-Dishington et al. Cheddar cheese study[19].

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[19] Ibid.

Property Tax and Insurance Costs. Property taxes and insurance costs behave much like capital costs since they are a function of initial capital investment. Thus, alternate-day manufacturing, with a higher initial investment, has a higher tax and insurance cost per pound of cheese than concurrent manufacturing. Since this is an annual fixed cost similar to annual capital costs, reducing the annual quantity of cheese produced leads to a direct and large increase in the cost per pound of cheese for these cost items.

Other Expenses. The cost of other expenses is zero because there were no added costs to the Cheddar plant due to specialty cheese manufacturing being added to the plant. Other expenses include accounting and office supplies, communication and travel, laundry, telephone, and other services. The consulting engineers who estimated these annual costs concluded there would be little or no increase in these other expenses due to incorporating specialty cheese production into the existing Cheddar plant.

Conclusion

The costs of producing both Jarlsberg-type and Havarti cheese in a Cheddar plant with the alternate-day manufacturing scenario are significantly lower than concurrent manufacturing in a Cheddar plant. The lower initial capital cost for concurrent production is far outweighed by higher labor and utility requirements and by inefficiencies induced into Cheddar cheese production by specialty cheese.

SPECIALTY-ONLY PLANTS

Objective Overview

Another objective of the study was to measure the economies of scale and behavior of production costs over a range of production in two different size plants designed to produce only specialty cheese. Production costs for large, 960,000 pounds of milk per day specialty-only plants were compared to production costs for small, 385,000 pounds of milk per day specialty-only cheese plants. This analysis provides insight into differences in the cost per pound of specialty cheese produced in two size plants, and into the behavior of the short run cost curves. Moreover, it provides a basis to determine whether specialty cheese can be produced at a lower cost in a Cheddar plant than in a plant designed to produce only specialty cheese.

Thus far, analysis of specialty cheese in a Cheddar plant involved a production range from about 1.8 to 9.5 million pounds annually for Jarlsberg-type production and from about 2.7 to 14.1 million pounds annually of Havarti cheese. The production ranges for the large and small specialty cheese plants are wider. The annual production ranges for the small plant are from about 2.5 to 13.3 million pounds for Jarlsberg-type and from 3.8 to 19.7 million pounds for Havarti cheese (Table 25). The annual production ranges for the large plant are from 6.3 to 33.1 million pounds for Jarlsberg-type and from 9.4 to 49.2 million pounds for Havarti cheese.

The range of production for the large plants is huge compared to the estimated current domestic market, but these model plants can be thought of as supplying international markets, such as the very large plants found in Europe. Since this study addresses the cost of European-style specialty cheese production, United States producers will have to compete with their European counterparts. Estimates of production costs for the large specialty-only plants may be useful in

Table 25 Production Schedules and Annual Production For Large and Small Plants Producing Only Specialty Cheese, High Automation

Weekly Schedule Days	Weekly Schedule Hours	Annual Cheese Production: Jarlsberg-Type Large Plant	Jarlsberg-Type Small Plant	Havarti Large Plant	Havarti Small Plant
		(Thousands of Pounds)			
7	24[1]	33,092	13,269	49,201	19,717
6	24	28,365	11,373	42,172	16,900
5	24	23,637	9,478	35,144	14,083
4	24	18,910	7,582	28,115	11,267
3	21	11,819	4,739	17,572	7,042
2	18	6,303	2,527	9,372	3,756

[1]Production capacity of the large specialty cheese plant is 960,000 pounds of standardized milk per day. Production capacity of the small specialty cheese plant is 385,000 pounds of standardized milk per day.

evaluating the relative competitiveness of domestic and foreign specialty cheese production. Moreover, the large specialty-only plants may provide some insights as to the level of production costs that might be achieved in a multi-product plant producing two or more related specialty cheeses.

Production Cost Estimates

It is not surprising that the large specialty-only plants have significant economies of size over the small specialty-only plants. But over much of the production range of the small plant, the large plant has a lower production cost at equivalent quantities of production, even though it would be operating far below capacity.

Costs of producing Jarlsberg-type cheese ranged from 33.9 to 71.5 cents per pound in the small plant and from from 19.1 to 39.1 cents in the large plant (Table 26). Production costs for Havarti cheese ranged from 25.7 to 54.9 cents per pound in the small plant and from 15.3 to 31.9 cents per pound in the large plant (Table 27).

Economies of Size. Significant economies of size were found in the large specialty-only plants over the small specialty-only plants. When both large and small plants are operating at full capacity (seven days per week, 24 hours per day), the large plant has a large production cost advantage, 14.8 cents per pound for Jarlsberg-type and 10.5 cents per pound for Havarti.

Table 26 Jarlsberg-Type Cheese: Cheese Production Cost Range of Large and Small Specialty-Only Plants, High Automation

Cost Item	--Large Plant-- Cost Range Over Production Schedules[1]	--Small Plant-- Cost Range Over Production Schedules[2]
	----------(Cents per Pound)----------	
Labor		
Supervisory	(0.5 - 0.7)	(1.1 - 1.7)
Direct Fixed	(0.6 - 0.9)	(1.5 - 2.3)
Direct Variable	(4.0 - 4.0)	(10.3 - 10.3)
Total Labor	(5.0 - 5.6)	(12.9 - 14.3)
Capital Costs		
Deprec. & Interest	(3.8 - 18.2)	(6.8 - 32.0)
Utilities		
Electricity	(0.2 - 0.2)	(0.4 - 0.4)
Fuel	(0.4 - 0.4)	(1.4 - 1.6)
Water & Sewage	(0.1 - 0.2)	(0.3 - 0.4)
Total Utilities	(0.7 - 0.8)	(2.1 - 2.4)
Materials		
Laboratory	(0.1 - 0.1)	(0.1 - 0.1)
Production	(2.9 - 2.9)	(2.9 - 2.9)
Packaging	(1.5 - 1.5)	(1.5 - 1.5)
Cleaning	(0.2 - 0.3)	(0.7 - 1.1)
Total Materials	(4.7 - 4.8)	(5.2 - 5.5)
Repair & Maintenance	(0.6 - 0.8)	(1.2 - 1.5)
Property Tax & Insurance	(0.9 - 5.0)	(2.1 - 11.2)
Production Inventory	(3.0 - 3.1)	(3.3 - 3.3)
Other Expenses	(0.2 - 1.0)	(0.2 - 1.3)
TOTAL	(19.1 - 39.1)	(33.9 - 71.5)

[1]Cost range is reported for large plant producing between 33,091,968 and 6,303,232 pounds of Jarlsberg-type cheese annually.
[2]Cost range is reported for small plant producing between 13,268,895 and 2,527,409 pounds of Jarlsberg-type cheese annually.

The large plants have significantly lower labor and utility costs per pound of product. The large plants have significantly higher initial investment costs, but lower capital costs per pound of specialty cheese.

Cost Behavior Over Production Ranges. Production costs for the large plant are less than for the small plant across the entire production range of the large plant (Figures 5 and 6). The large plant has a production cost advantage even when both plants are manufacturing the same annual quantity of cheese (from 6.3 to 13.3 million pounds annually for Jarlsberg-type, and from 9.4 to 19.7 million pounds annually for Havarti). Thus, the large specialty-only plants have a production cost advantage even when operating at extremely low levels of capacity

Table 27 Havarti Cheese: Cheese Production Cost Range of Large and Small Plant, Specialty-Only Plants, High Automation

Cost Item	--Large Plant-- Cost Range Over Production Schedules[1]	--Small Plant-- Cost Range Over Production Schedules[2]
	-----------(Cents per Pound)-----------	
Labor		
Supervisory	(0.3 - 0.5)	(0.7 - 1.1)
Direct Fixed	(0.5 - 0.7)	(1.1 - 1.7)
Direct Variable	(3.3 - 3.3)	(7.9 - 7.9)
Total Labor	(4.1 - 4.5)	(9.7 - 10.7)
Capital Costs		
Deprec. & Interest	(3.2 - 14.9)	(5.3 - 24.9)
Utilities		
Electricity	(0.2 - 0.2)	(0.3 - 0.3)
Fuel	(0.3 - 0.3)	(1.0 - 1.1)
Water & Sewage	(0.1 - 0.1)	(0.2 - 0.3)
Total Utilities	(0.6 - 0.6)	(1.5 - 1.7)
Materials		
Laboratory	(0.04 - 0.04)	(0.04 - 0.04)
Production	(1.6 - 1.6)	(1.6 - 1.6)
Packaging	(2.6 - 2.6)	(2.6 - 2.6)
Cleaning	(0.1 - 0.2)	(0.5 - 0.7)
Total Materials	(4.3 - 4.4)	(4.7 - 4.9)
Repair & Maintenance	(0.5 - 0.6)	(0.9 - 1.1)
Property Tax & Insurance	(0.9 - 4.6)	(1.7 - 9.1)
Production Inventory	(1.5 - 1.5)	(1.7 - 1.7)
Other Expenses	(0.1 - 0.7)	(0.2 - 0.8)
TOTAL	(15.2 - 31.8)	(25.7 - 54.9)

[1]Cost range is reported for large plant producing between 49,201,152 and 9,371,648 pounds of Havarti cheese annually.
[2]Cost range is reported for small plant producing between 19,716,812 and 3,755,583 pounds of Havarti cheese annually.

utilization due to more efficient labor and utility use, as well as a lower capital cost per pound.

Whey Handling Costs. When the cost of whey handling is brought into the picture, the small specialty-only plant becomes an even less advantageous alternative. A small, 385,000 pounds of milk per day specialty plant (or Cheddar plant for that matter) would find grade A whey powder handling costs high, because of the large economies of size in whey processing.[20] Such a small cheese plant would probably dispose of liquid whey at a nearby whey processing facility. Whey handling in the small plants would probably break even at best.

The cost of whey handling is much lower for a large 960,000 pounds of milk per day specialty-only plant. Whey handling costs for this size plant are between 5.9 and 14.6 cents per pound of Jarlsberg-type (9.0 and 22.2 cents per pound of powder) and between 3.9 and 9.7 cents per pound of Havarti (9.9 and 24.3 cents per pound of powder), over the production ranges studied (Appendices K and L). Whey handling costs for small, specialty-only whey plants range from 11.0 to 27.2 cents per pound of Jarlsberg-type cheese (from 16.8 to 41.4 cents per pound of powder) and from 7.3 to 18.3 cents per pound of Havarti cheese (from 18.4 to 45.3 cents per pound of powder) (Appendices M and N). The cost advantage of specialty cheese production in large plants is very large when both cheesemaking and whey handling costs are considered.

Conclusion

For manufacturers interested in breaking into specialty cheese markets, these results may indicate the advantage of a large plant producing well below capacity while market position is being established, then slowly increasing production as sales grow. However, as discussed later, producing specialty cheese in a Cheddar plant may be a more attractive alternative than producing it in a large specialty-only plant. Two major disadvantages of a small specialty-only plant as compared to a large specialty-only plant are diseconomies of size in cheesemaking and the problem of whey disposal.

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[20]Economies of size in whey processing will be discussed in a forthcoming report by D. M. Barbano, R. D. Aplin, and Susan Hurst.

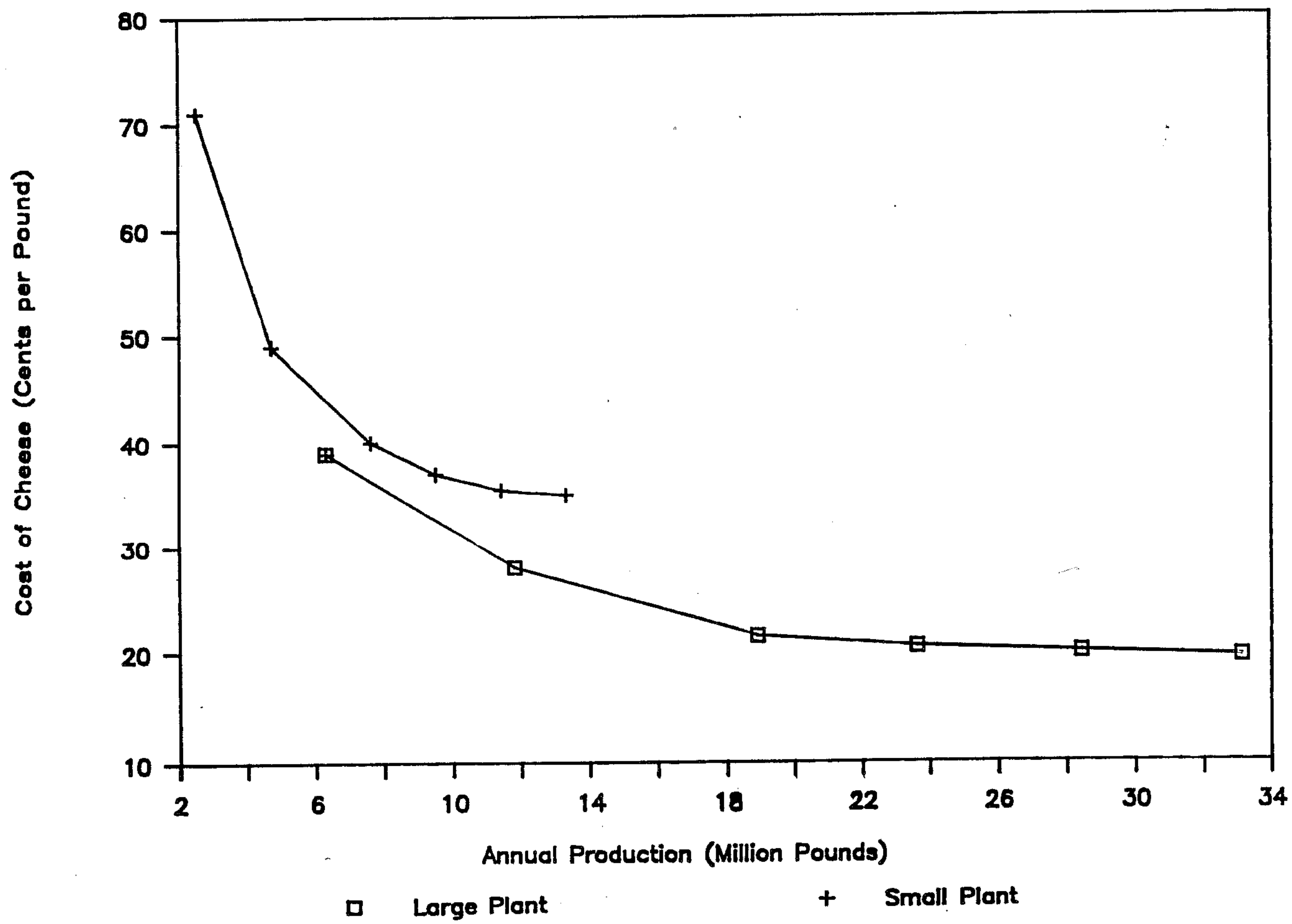

Figure 5 Jarlsberg-Type Cheese: Production Costs for Large and Small Specialty-Only Plants Over Their Production Ranges, High Automation

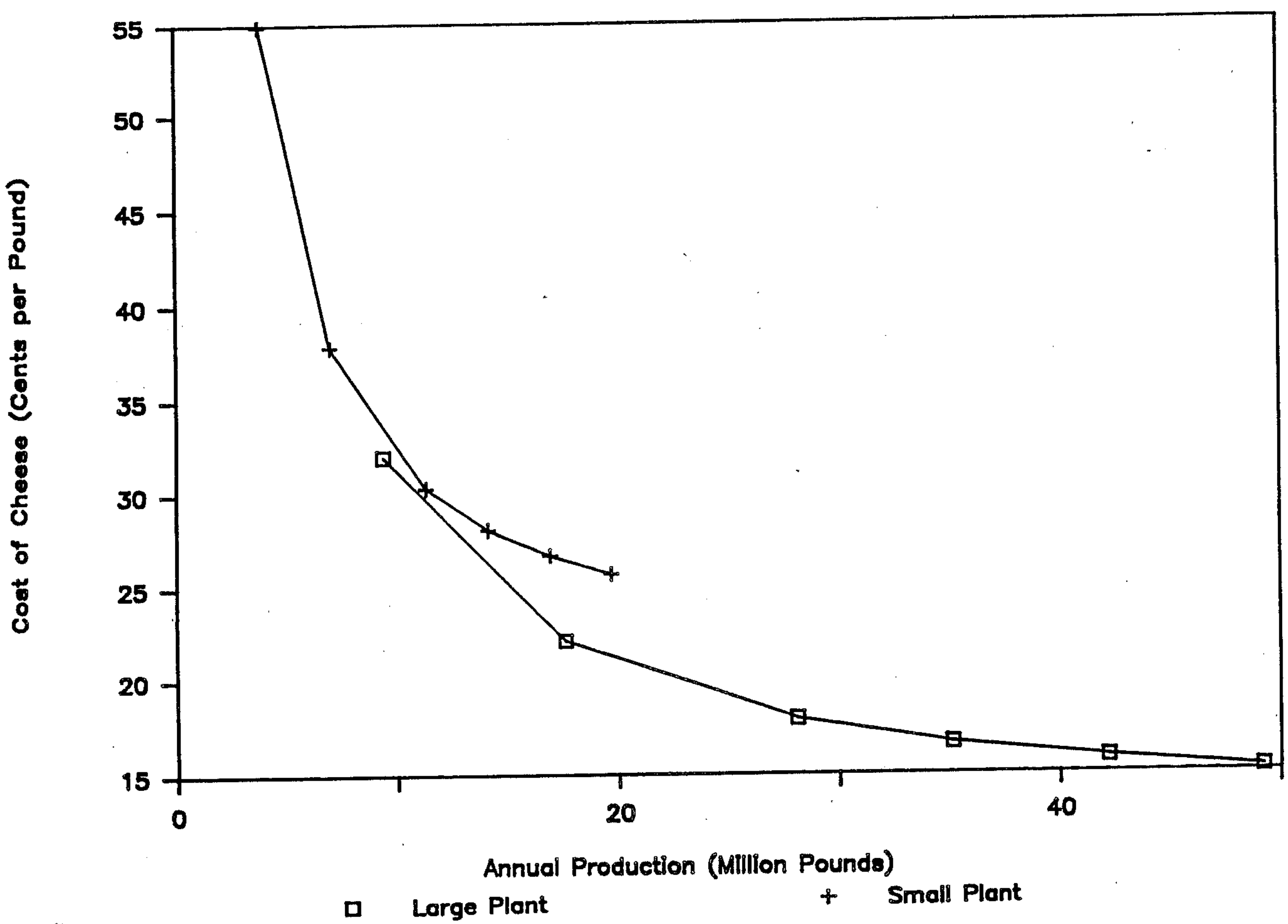

Figure 6 Havarti Cheese: Production Costs for Large and Small Specialty-Only Plants Over Their Production Ranges, High Automation

SPECIALTY CHEESE IN CHEDDAR PLANT VERSUS SPECIALTY-ONLY PLANT

Objective Overview

A third objective of this study was to compare specialty cheese production costs in a Cheddar cheese plant with the costs of producing specialty cheese in a specialty-only plant. By comparing the production costs, the cost advantage of using some common support centers to produce specialty cheese in conjunction with Cheddar are determined.

Alternate-day manufacturing in a Cheddar cheese plant and in large specialty-only plants were compared for this analysis since they were determined to be least-cost manufacturing scenarios. Cost comparisons were made using the high automation plants, which lead to lower production costs in all but one manufacturing scenarios.

The production ranges studied in this section are the same ranges used earlier for the alternate-day manufacturing (Table 20) and for the large specialty-only plant (Table 25).

Production Cost Estimates

The large, 960,000 pounds of milk per day specialty-only plant has lower production costs per pound of product than alternate-day manufacturing, when both plants are operating at full capacity. But at full capacity, the large plant produces a huge quantity of specialty cheese compared to alternate-day manufacturing and compared to the estimated current United States market. When considering a range of production closer to an achievable share of the estimated domestic market, alternate-day manufacturing in a Cheddar plant has lower production costs.

When producing specialty cheese at their respective capacities (two days per week, 24 hours per day for the alternate-day scenario, and seven days per week, 24 hours per day for the large specialty-only plant), the large specialty-only plants have a lower cost of production than alternate-day manufacturing. Production costs for the large specialty-only plants are lower than the alternate-day plant by 3.5 cents per pound for Jarlsberg-type and by 2.8 cents per pound for Havarti production (Tables 23, 24, 26, and 27). Most of this cost advantage for the large specialty-only plants comes from the annual capital depreciation and interest charge being spread over a huge quantity of cheese. But the cost of labor, utilities, and materials per pound of cheese are essentially the same in large specialty-only and alternate-day plants.

The production quantities for the alternate-day and large specialty-only plants corresponding with these costs are quite different. At full capacity, the annual production for alternate-day manufacturing of Jarlsberg-type cheese is 9.5 million pounds while Havarti is 14.1 million pounds. In contrast, the associated annual production quantity of the large specialty-only plant is 33.1 million pounds for Jarlsberg-type and 49.2 million pounds for Havarti cheese. At production capacity, the large specialty-only plants have a production cost advantage over alternate-day manufacturing, but the associated huge production quantity of the large specialty-only plant probably would be difficult, if not impossible, to market in the current domestic specialty cheese market.

However, when one considers the range of production for alternate-day manufacturing (i.e., 1.8 to 9.5 million pounds of Jarlsberg-type annually and 2.7

to 14.1 million pounds of Havarti annually), the large specialty-only plant has a higher production cost (Figures 7 and 8). Depending on the quantity of production, the market share represented by the alternate-day manufacturing is estimated to be from about 9 to 63 percent of the Jarlsberg-type market and from about 10 to 56 percent of the Havarti market. Marketing these quantities of specialty cheese, as challenging as it would be, would be more achievable than marketing the quantities produced in large specialty-only plants operating at levels that would lead to lower costs than producing specialty cheeses in a Cheddar plant.

The cost saving for the alternate-day manufacturing over this range of production is a bit difficult to quantify since production schedule differences make comparing equivalent annual production levels difficult. But the extrapolated production cost savings for alternate-day manufacturing over large specialty-only plants is from 8.7 to 41.4 cents per pound of Jarlsberg-type and from 7.8 to 35.3 cents per pound of Havarti (Tables 28 and 29).

These cost saving estimates are conservative because whey handling costs are not included. Even at low production levels of specialty cheese, alternate-day manufacturing utilizes most of the cheese and whey plant capacity for Cheddar cheese production. But the large specialty-only plant would utilize the whey plant, as well as the cheese plant, far below capacity. Thus a very high fixed annual capital cost is spread over relatively small quantities of cheese (and whey powder).

Table 28 Jarlsberg-Type Cheese: Cost Advantage of Alternate-Day Manufacturing in Cheddar Plant Over a Large Plant Producing Only Jarlsberg-Type Cheese, High Automation

Approximate Jarlsberg-type Production[1]	Alternate-Day Manufacturing Cost Advantage
(1000/Lbs/Year)	(Cents per Pound)
9,455	8.7
7,879	10.3
6,303	12.7
4,727	16.5
3,940	19.7
3,152	24.5
1,838	41.4

[1]Production schedules are adjusted so that equivalent quantities of Jarlsberg-type cheese are manufactured with alternate-day manufacturing and the large plant.

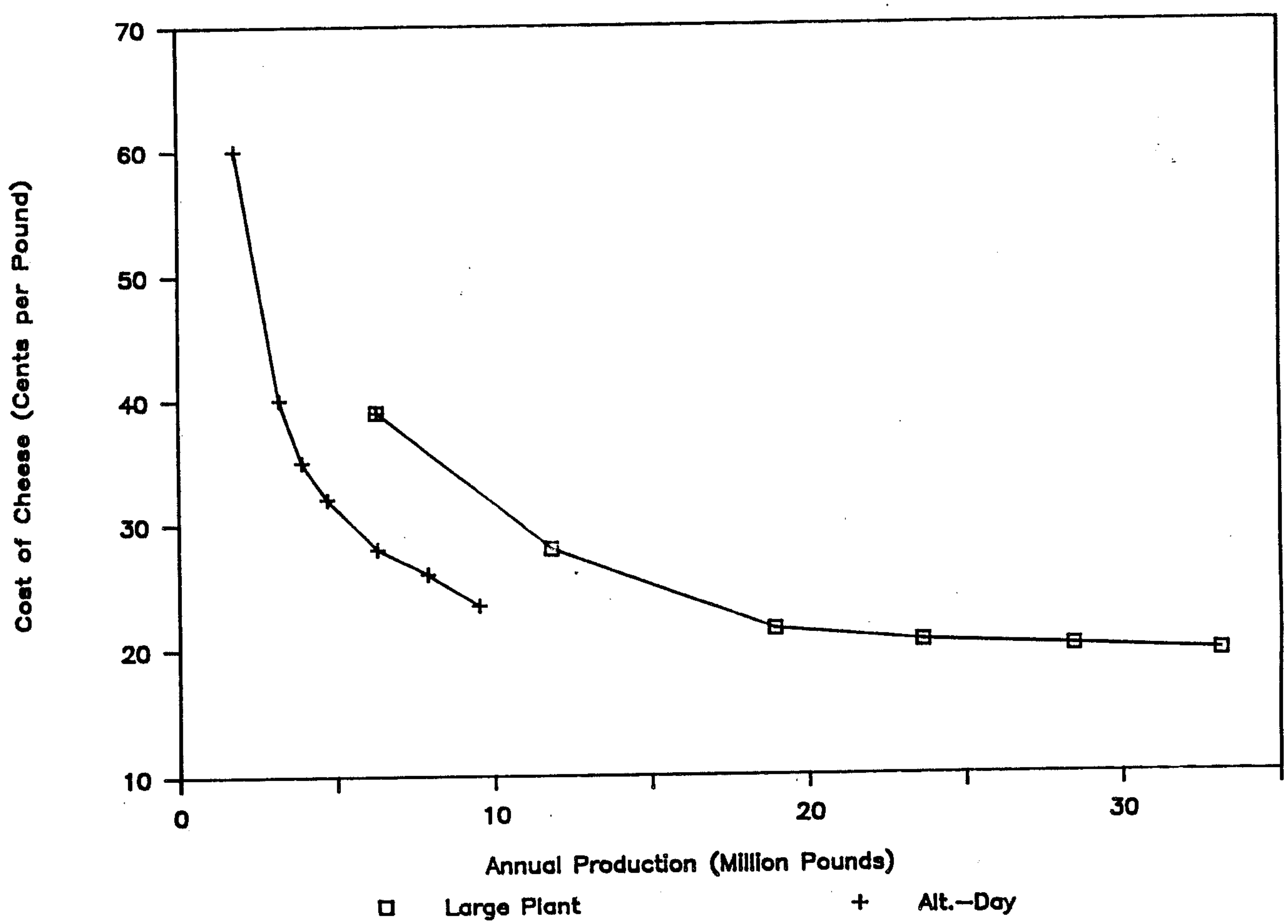

Figure 7 Jarlsberg-Type Cheese: Production Costs for Alternate-Day Manufacturing in Cheddar Plant and Large Specialty-Only Plants Over Their Production Ranges, High Automation

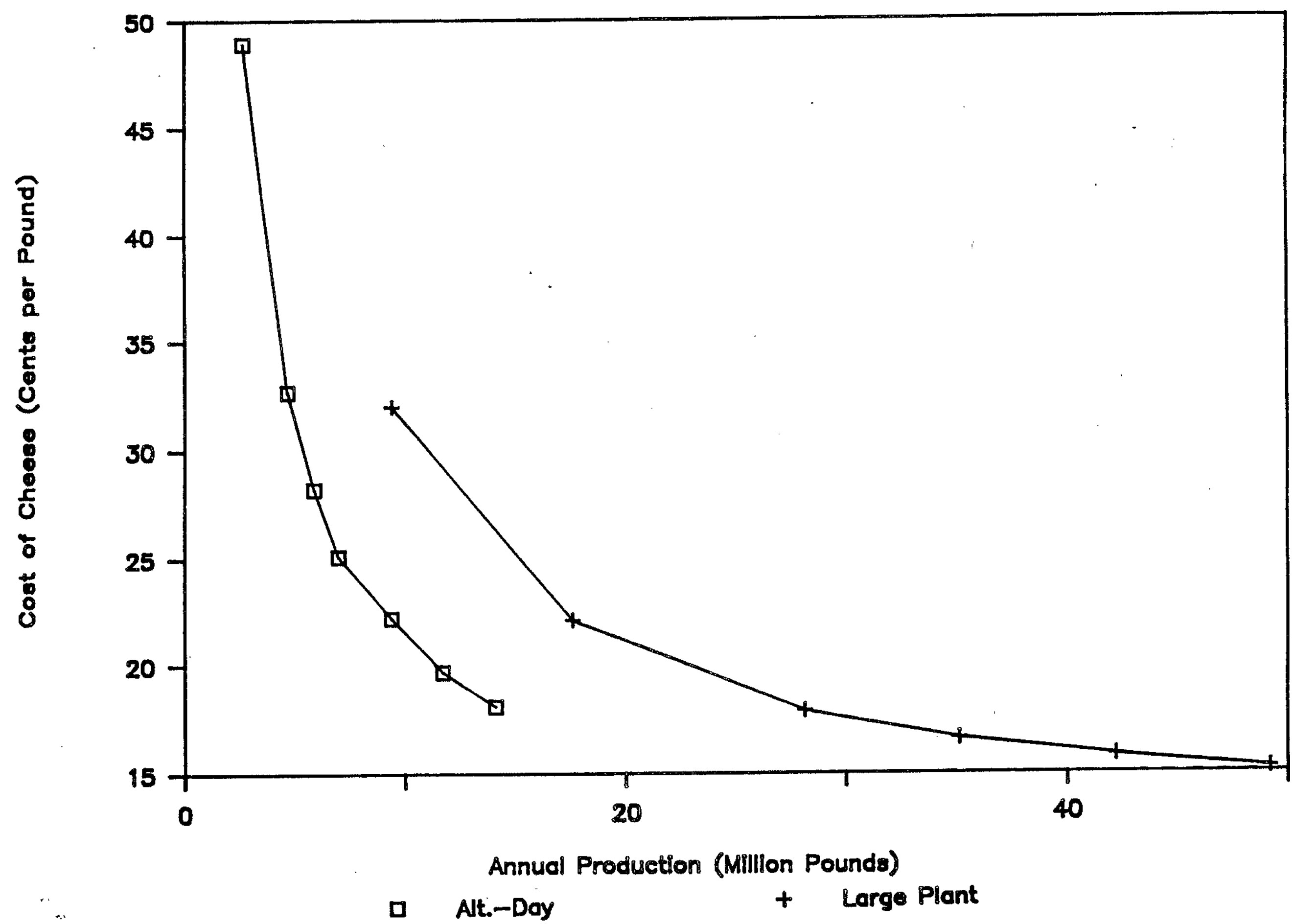

Figure 8 Havarti Cheese: Production Costs for Alternate-Day Manufacturing in Cheddar Plant and Large Specialty-Only Plants Over Their Production Ranges, High Automation

Table 29 Havarti Cheese: Cost Advantage of Alternate-Day Manufacturing In Cheddar Plant Over a Large Plant Producing Only Havarti Cheese, High Automation

Approximate Havarti Production[1]	Alternate-Day Manufacturing Cost Advantage
(1000/Lbs/Year)	(Cents per Pound)
14,057	7.8
11,715	9.2
9,372	11.2
7,029	14.4
5,857	17.1
4,686	21.1
2,733	35.3

[1]Production schedules are adjusted so that equivalent quantities of Havarti cheese are manufactured with alternate-day manufacturing and the large plant.

A major investment cost advantage of manufacturing specialty cheese in an existing Cheddar cheese plant is that existing support centers (e.g., receiving, treatment, laboratory, C.I.P, and lunch centers) can be used with little or no modification. The specialty-only plant must invest in these services to support only specialty cheese production. Specialty production in a Cheddar plant must pay for the added wear and tear on the existing support centers, but this is a rather insignificant capital cost.

Conclusions

Large specialty-only plants can produce specialty cheese at a lower cost than alternate-day manufacturing. But when achievable annual production quantities for domestic markets are considered, the alternate-day manufacturing method has a production cost advantage over the large specialty-only plants.

Cost Observations In All Model Plants

The following observations on cost behavior are consistent across all model plants. Production costs varied widely depending on the type of cheese produced, production schedule, manufacturing scenario, and automation level. Each factor has a distinct effect on absolute costs, as well as on the proportions of various cost items. Production costs for Havarti cheese are lower than Jarlsberg-type cheese mainly due to different cheese yields. The raw milk cheese yield for Havarti is 64 percent higher than for Jarlsberg-type. The much higher Havarti cheese yield is due to the higher fat content of the cheese. A higher cheese yield leads to a lower cost per pound of product mainly due to the fact that most production cost items are a function of quantity of milk processed, as opposed to quantity of cheese produced.

The influence of cheese yield is evident in capital costs. Initial investment is higher for Havarti than Jarlsberg-type (Table 19), because the higher yields require larger equipment and more space to handle the larger volumes of cheese downstream from the vats. But the cost per pound of cheese, for a given manufacturing scenario, automation level, and production range, is lower for Havarti than Jarlsberg. Higher cheese yields also make a substantial difference when revenues are considered, because for a given quantity of milk more cheese can be sold.

Capital costs, property tax and insurance are the most sensitive cost items with respect to changes in quantity of cheese produced. The volatility in these cost items stems from the fact that they are a fixed annual cost.[21] Reducing the annual quantities of cheese produced leads to a direct and large increase in the cost per pound of cheese for these fixed annual cost items.

On the other hand, direct variable labor, utilities and materials are less affected by production quantities since the majority of these costs vary with the quantity of milk processed or quantity of cheese produced. Direct variable labor is a function of operating hours per day which directly affects the quantity of cheese produced. Utilities like electricity and gas and materials such as packaging, laboratory supplies, and production ingredients (e.g., rennet, starter cultures, and media) are used in proportions relative to milk processed or cheeses produced. Thus, the cost per pound of cheese for these items is not greatly affected by changes in production.

AUTOMATION LEVELS

Objective Overview

Another objective of this study was to estimate the costs of producing specialty cheese with two different levels of automation. High and low automation levels were modeled, one representing a state-of-the-art specialty cheese production system and the other representing a more traditional specialty cheese production system. Equipment and processes for both automation levels were described earlier.

Production Cost Estimates

Specialty cheese production costs are consistently lower for high automation than low automation, for all production quantities in all manufacturing scenarios, except one. (Tables 30 and 31, and Appendices O and P). However, automation level has a smaller effect on production costs than manufacturing scenarios or production quantities.

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[21]Annual capital depreciation and interest charges are not an absolute fixed cost since a decrease in the annual quantity of cheese will increase equipment and building life, thus decreasing the annual capital costs. But the reduction in annual costs is minimal.

Table 30 Jarlsberg-Type Cheese: Cheese Production Cost Advantage of High Automation Over Low Automation Level, Three Manufacturing Scenarios

Approximate Jarlsberg-Type Production	Alternate-Day Manufacturing	Concurrent Manufacturing	Small Specialty-Only Plant
(1000/Lbs/Year)	-----------(Cents per Pound)-----------		
9,479	1.3	0.9	1.0
8,125	1.3	0.9	1.0
6,771	1.5	0.9	1.0
5,643	1.7	0.9	1.1
3,611	2.1	0.9	1.2
1,806	3.3	0.8	1.5

Alternate-day manufacturing has the largest cost advantage from high automation over low automation, from 1.3 to 3.3 cents per pound for Jarlsberg-type and from 1.0 to 2.8 cents per pound for Havarti cheese (Tables 30 and 31). Concurrent manufacturing has the least cost savings from high automation, from 0.8 to 0.9 cents per pound for Jarlsberg-type and from a 0.1 cents per pound cost disadvantage at low levels of Havarti production to a cost advantage of 0.3.

The lower costs of producing specialty cheese with high automation are principally due to lower labor costs (data not shown).

Assumed cheese yields for low automation were reduced because of technical factors. Cheese fines and floor losses are common with the low automation DBS strainer vats and associated cheese handling systems. These losses were estimated at approximately 300 pounds of cheese per million pounds of milk processed. Losses would vary with the equipment condition and the cheese plant management skill.

The assumed cheese yield in low automation production for raw milk is reduced from 9.26 to 9.23 lbs/cwt of raw milk for Jarlsberg-type and from 15.22 to 15.19 lbs/cwt of raw milk for Havarti cheese. The direct effect on production costs of this reduction in cheese yields is 0.1 cent per pound of specialty cheese or less. An indirect, but important, effect of lower potential revenues would result from the reduced quantity of cheese produced with low automation.

The total capital investment cost for high automation, concurrent manufacturing is more than for low automation. But for alternate-day and specialty-only plants the total capital investment for high automation is less than for low automation (Table 19).

Table 31 Havarti Cheese: Cheese Production Cost Advantage of High Automation Over Low Automation Level, Three Manufacturing Scenarios

Approximate Havarti Production	Alternate-Day Manufacturing	Concurrent Manufacturing	Small Specialty-Only Plant
(1000/Lbs/Year)	-----------(Cents per Pound)-----------		
14,094	1.0	0.3	0.6
12,081	1.0	0.3	0.7
10,067	1.2	0.2	0.8
8,389	1.3	0.2	0.9
5,369	1.7	0.1	1.1
2,685	2.8	-0.1	2.0

It might be expected that the investment cost for high automation would be more than for low automation in all the manufacturing scenarios. But the low automation production system requires more building space and associated land than high automation (Table 10). Consequently, in the larger size, alternate-day manufacturing and specialty-only plants, relatively high land and building costs for low automation lead to a greater total capital investment cost than for high automation. This investment cost relationship helps explain the narrowing cost advantage of high over low automation for concurrent manufacturing and the widening cost advantage for alternate-day and specialty-only plants, as production quantities decrease (Tables 30 and 31). As the production volume decreases, the capital depreciation and interest costs on the added capital required for low automation drives the production cost even higher relative to high automation.

For concurrent manufacturing the opposite is true: total investment cost for high automation is more than for low automation. So as production volume decreases, depreciation and interest costs for high automation increases relative to low automation costs. Therefore, the cost advantage of high over low automation production narrows and, in the case of producing Havarti at low volumes, disappears as concurrent manufacturing production volume decreases.

Conclusions

Although the absolute cost difference is not that large, high automation has a consistently lower production cost than low automation except for one case. The savings are principally due to a lower variable labor cost for high automation.

CHEESE YIELDS AND WAGE RATES SENSITIVITY ANALYSIS

Objective Overview

A fifth objective of this study was to measure the effects of different specialty cheese yields and labor wage rates on the cost of specialty cheese production. Up to this point, the production costs estimates for specialty cheese have been made with certain assumptions regarding production characteristics and input costs. Because quantity of production has such a large influence on production costs in all model plants, and because labor costs represent a large proportion of total cheese production costs, sensitivity analyses on cheese yields and wage rates were performed. Because interest rate and investment cost sensitivity by Mesa-Dishington et al.[22] revealed little effect on Cheddar production costs, sensitivity analysis was performed only on yields and wage rates.

Cheese Yield Sensitivity

Cheese yields for raw milk were reduced five percent from 9.26 to 8.80 for Jarlsberg-type cheese, and from 15.22 to 14.46 for Havarti cheese. It is assumed that raw milk composition is constant at 3.7 percent fat and 3.2 percent protein. The reduction in actual cheese yield is assumed to represent inefficient recovery of cheese solids (i.e., fat and cheese fines losses) due to poor cheesemaking practices, as opposed to different milk compositions.

In the sensitivity analysis performed, changing cheese yields did not affect the basic cost relationships, although cost levels were slightly affected. Most production costs are based on quantity of milk processed rather than quantity of cheese produced (packaging is the only cost directly related to pounds of cheese produced). Since the quantities of cheese produced have been reduced with lower cheese yields, the total production costs are spread over smaller quantities of cheese, thus driving up costs per pound of cheese.

Reducing Jarlsberg-type cheese yield from 9.26 to 8.80 pounds of cheese per cwt of raw milk increases the cost per pound of cheese substantially. Depending on the manufacturing scenario and production quantity, the cost per pound of Jarlsberg-type cheese increases by 1.1 to 4.5 cents per pound. A reduction in the Havarti cheese yield from 15.22 to 14.46 pounds of cheese per cwt of raw milk, increases the cost per pound of Havarti by 0.8 to 3.4 cents per pound (Tables 32 and 33). The effect of reducing cheese yields is greatest at lower annual production levels.

An indirect, but large, effect of a lower cheese yield is the opportunity cost of lost profits by not achieving the cheese yield potential. A lower cheese yield means fewer pounds of cheese to sell. If this foregone revenue is considered, lower cheese yields have a substantial effect on production costs. This indirect effect of lost revenues is illustrated in the next section under Specialty Cheese Profitability.

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[22]Mesa-Dishington, J.K.; Barbano, D.M.; & Aplin, R.D. Cheddar Cheese Manufacturing Costs Economies of Size and Effects of Different Current Technologies A.E. Res. 87-3. Ithaca, NY: Cornell University, Department of Agricultural Economics.

Table 32 Jarlsberg-Type Cheese: Production Costs for Three Manufacturing Scenarios with Different Cheese Yields, Direct Cost Effect Only, High Automation

Approximate Jarlsberg-Type Production	Cheese Yield	Manufacturing Scenario: Alternate-Day Production	Concurrent Production	Small Specialty-Only Plant
(1000/Lbs/Yr.)	(#/Cwt)	(Cents per Pound)		
9,479	9.26	22.6	35.3	36.9
9,005	8.80	23.7	37.1	38.8
8,125	9.26	24.2	36.6	39.4
7,719	8.80	25.4	38.4	41.3
6,771	9.26	26.5	38.5	42.0
6,432	8.80	27.8	40.5	44.2
5,643	9.26	29.3	40.6	46.0
5,360	8.80	30.7	42.7	48.3
3,611	9.26	38.5	49.1	55.5
3,431	8.80	40.4	51.6	58.4
1,806	9.26	59.8	66.0	88.2
1,715	8.80	62.9	69.4	92.7

Wage Rate Sensitivity

The average hourly wage rate used in this study is $9.30. This wage rate represents the average rate for all part-time, full-time, and overtime employees. Wage rate sensitivity analysis allowed the rate to range between $7.30 and $11.30 per hour. Total hourly cost for all employees includes, besides the wage rate, fringe benefits amounting to 32 percent of the wage rate.

Changes in wage rates did not change the cheese production cost relationships for this study, although cost levels were affected. Since concurrent manufacture of specialty cheese has the highest labor cost, changes in wage rate had the greatest effect on this manufacturing scenario. Changing the wage rate by $2.00 an hour causes concurrent cheese manufacturing costs to change by 3.6 to 4.1 cents per pound of Jarlsberg-type or by 2.7 to 3.0 cents per pound of Havarti, over the production range (Tables 34 and 35).

Alternate-day manufacturing was least affected by wage rate changes. A $2.00 change in the hourly wage rate leads to a 1.1 to 1.5 cent per pound change in Jarlsberg-type cheese production costs or a 0.9 to 1.2 cent change in Havarti production costs. Changes in specialty-only plant production costs due to wage rate changes are in between those of alternate-day and concurrent manufacturing, because labor costs for this scenario fall between alternate-day and concurrent manufacturing in a Cheddar plant.

Table 33 Havarti Cheese: Production Costs for Three Manufacturing Scenarios with Different Cheese Yields, Direct Cost Effect Only, High Automation

Approximate Havarti Production	Cheese Yield	Manufacturing Scenario: Alternate-Day Production	Concurrent Production	Small Specialty-Only Plant
(1000/Lbs/Yr.)	(#/Cwt)	(Cents per Pound)		
14,094	15.22	18.1	26.3	28.6
13,396	14.46	18.9	27.6	30.0
12,081	15.22	19.5	27.3	29.9
11,481	14.46	20.3	28.6	31.4
10,067	15.22	21.3	28.8	31.9
9,566	14.46	22.3	30.1	33.5
8,389	15.22	23.6	30.4	34.2
7,972	14.46	24.7	31.8	35.9
5,369	15.22	29.8	36.8	43.2
5,102	14.46	31.2	38.5	45.3
2,685	15.22	49.6	50.0	67.7
2,551	14.46	52.1	52.4	71.1

Table 34 Jarlsberg-Type Cheese: Cheese Production Costs for Three Manufacturing Scenarios with Different Wage Rates, High Automation

Approximate Jarlsberg-Type Production	Wage Rate	Manufacturing Scenario: Alternate-Day Production	Concurrent Production	Specialty-Only Plant
(1000/Lbs/Yr.)	($/Hr.)	(Cents per Pound)		
9,479	7.30	21.5	31.7	34.1
	9.30	22.6	35.3	36.9
	11.30	23.7	38.9	39.8
8,125	7.30	23.1	32.9	36.4
	9.30	24.2	36.6	39.4
	11.30	25.3	40.2	42.3
6,771	7.30	25.3	34.8	39.1
	9.30	26.5	38.5	42.0
	11.30	27.1	42.2	44.9
5,643	7.30	28.0	36.9	42.9
	9.30	29.3	40.6	46.0
	11.30	30.5	44.4	49.0
3,611	7.30	37.0	45.1	52.7
	9.30	38.5	49.1	55.5
	11.30	39.9	53.2	58.4
1,806	7.30	58.3	62.0	85.3
	9.30	59.8	66.0	88.2
	11.30	61.2	70.1	91.0

Table 35 Havarti Cheese: Cheese Production Costs for Three Manufacturing Scenarios with Different Wage Rates, High Automation

		Manufacturing Scenario		
Approximate Havarti Production	Wage Rate	Alternate-Day Production	Concurrent Production	Specialty-Only Plant
(1000/Lbs/Yr.)	($/Hr.)	(Cents per Pound)		
	7.30	17.2	23.6	26.4
14,094	9.30	18.1	26.3	28.6
	11.30	19.0	29.0	30.8
	7.30	18.5	24.6	27.8
12,081	9.30	19.5	27.3	29.9
	11.30	20.4	30.0	30.8
	7.30	20.4	26.0	29.8
10,067	9.30	21.3	28.8	31.9
	11.30	22.3	31.5	34.1
	7.30	22.6	27.6	32.1
8,389	9.30	23.6	30.4	34.2
	11.30	24.6	33.2	36.3
	7.30	28.9	33.8	41.0
5,369	9.30	29.8	36.8	43.2
	11.30	30.7	39.8	45.3
	7.30	48.5	47.0	65.6
2,685	9.30	49.6	50.0	67.7
	11.30	50.8	52.9	69.8

ASSESSMENT OF POTENTIAL PROFITABILITY

Objective Overview

The final objective provides an assessment of the potential profitability of European-style specialty cheese production in the United States, assuming market relationships can be established. So far, specialty cheese production cost behavior has been observed over a wide range of production situations (i.e. various manufacturing scenarios, automation levels, and plant sizes, over a range of production). This section analyzes the profitability of Jarlsberg-type, Havarti, and Cheddar cheese. The profitability of Cheddar cheese production is included to provide a perspective on the relative profitability of specialty cheese.

Profitability is analyzed for two milk supply situations under which United States manufacturers may operate. One situation assumes an unlimited milk supply, the other assumes a limited milk supply.

Finally, the potential profitabilities of manufacturing each cheese in New York and in Wisconsin are compared. In this between-state profitability comparison, actual milk compositions for the year 1984, yields and prices in the two states during the 12 months ending December 1988 are used instead of the assumed, although realistic, yields and prices used in the rest of the analyses in other parts of this publication.

The profitability analyses center on the total costs and total returns to cheesemaking. All costs, including cheese production costs, whey handling costs, and raw ingredient costs (i.e., milk and cream), are compared to all revenues from cheese, whey powder, and other by-products (i.e., whey cream and fresh cream).

Assumptions

Input and output costs and projected price estimates are very important in evaluating the profitability of various production opportunities for a cheese plant. The products involved are raw milk, fresh cream (either removed from raw milk for Jarlsberg-type, or added to raw milk for Havarti), whey cream, powdered whey, and the cheeses themselves. Production and whey handling costs are also important and are well developed from the research presented earlier.

Costs and prices for the inputs and outputs differ from region to region and over time. Hauling and handling costs are factors affecting inter-regional price differences. Milk and Cheddar cheese prices are dominated by price regulations and market forces. Domestically produced European style Jarlsberg-type and Havarti cheese prices are influenced by consumer tastes and preferences, market sizes, size of domestic production, size of quotas for foreign imports, and, of course, the quality of the product. Cream and whey powder prices are affected by the total milk supply and demand for the products.

Two sets of assumptions regarding milk composition, yields, raw product prices, whey and cheese prices are used in the profitability analyses. For most of the profitability analyses, yields and prices are assumed that were thought to be reasonably representative of the Northeast and North Central regions in 1988. For the last part of this profitability analysis, where the potential profitability of Cheddar, Jarlsberg, and Havarti manufactured in New York is compared to the profitability of manufacturing the cheeses in Wisconsin, actual milk composition (from 1984), yields, raw product prices, whey and cheese prices in New York and Wisconsin from January through December 1988 are used.

All cheese prices are assumed to be realized at the cheese plant loading dock and do not include any costs associated with product marketing.

Prices Assumed in General Profitability Analyses. The raw milk price used is $11.85 per cwt for 3.70 percent fat test milk. Cheddar cheese prices used range from $1.20 to $1.30 per pound. The assumed base price for Jarlsberg-type cheese is $1.80 per pound, and for Havarti cheese $1.65 per pound, although ranges of lower prices are used to further assess profitability. Whey powder is valued at $0.20 per pound. Whey cream and fresh cream are valued at $1.40 and $1.60 per pound of fat, respectively.

Net returns to cheese production are quoted in dollars per cwt of raw milk because raw milk is commonly the most limiting resource for cheese production and because of different yields for different cheeses a common denominator is needed. Returns per cwt of raw milk is a standard used by many people in the industry, as well. Net returns per cwt of raw milk are a function of production costs, price levels and yields for cheese, cream, and whey powder.

Example Calculations of Cheddar and Specialty Cheese Profitabilities

The profitability of Cheddar, Jarlsberg and Havarti cheese production were estimated using the approach illustrated in Tables 36, 37 and 38. These calculations serve as a basis for the general assessment of the potential profitability of specialty cheese production in the United States.

Several things should be kept in mind regarding the profitability calculations:

1. General assumptions are made regarding milk composition, yields, raw milk and cream prices and cheese prices (see assumptions above). In a later section, observed 1984 theoretical yields and actual 1988 prices in New York and Wisconsin are used to compare the potential profitability of manufacturing Cheddar and the specialty cheeses in the two states.

2. The Cheddar cheese manufacturing cost estimates are based on the earlier modeled plant using 960,000 pounds of milk per day, operating five days a week, 24 hours per day.[23]

3. Whey manufacturing costs are estimates of the costs of producing powdered whey in a plant attached to the cheese plant and operating on the same schedule. These estimates are from a soon-to-be published economic-engineering study of whey plants by the authors.

4. Both the Jarlsberg and Havarti are assumed to be manufactured in a Cheddar cheese plant, producing Cheddar and the specialty cheese on alternate days. Cheese and whey production costs for both Jarlsberg and Havarti are assumed to be incremental costs. Thus, only the additional costs generated by manufacturing specialty cheese in the Cheddar plant and from handling the additional whey produced by the specialty cheese are charged on these worksheets, with all other costs being attributed to the Cheddar manufacture. See page 40 for a more complete explanation.

5. In the profitability worksheets, no charge for raw whey is made to the whey operation because such a charge, or transfer price, would be arbitrary. Thus, to the extent the raw whey has value, the "operating profit from cheese" reported understates the profitability of cheese and the "operating profit from whey" reported overstates the profitability of the whey operation. The combined profit from cheese and whey is the important number.

Profitability of Each Cheese

Although the profitability calculations for each cheese are based on general assumptions, and thus should be used with care, the comparison of profitability

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[23]Ibid.

for each of the cheeses involved in this study reveals considerable profit potential for specialty cheese compared to Cheddar cheese, assuming marketing can be successfully achieved. Havarti cheese is the most profitable cheese studied. Relatively high profits for Havarti are due mainly to a high cheese yield and a favorable wholesale price compared to Cheddar cheese. The profits from Jarlsberg-type, while not as high as Havarti, are also considerably higher than for Cheddar cheese.

Cheddar Cheese Profitability. Under the basic assumptions, Cheddar cheese production, including profit from whey, results in a profit of $0.54 per cwt milk in the model Cheddar cheese plant (Table 36). This situation is probably not unlike the current condition of many Cheddar plants operating at this production capacity (five days, 24 hours per day; 960,000 pounds of milk per day). A large plant would achieve significant economies of size and resulting lower cheese and whey manufacturing costs.

This result reflects an assumed premium price for high quality, current Cheddar cheese in 40-pound blocks suitable for aging, thus commanding a higher price than commodity grade barrel Cheddar.

Specialty Cheese Profitability. Production costs used for specialty cheese profitability in Tables 37 and 38 are based on alternate-day manufacturing of 3.9 and 5.9 million pounds annually of Jarlsberg-type and Havarti cheese, respectively. This production level represents approximately 22 percent of the current Jarlsberg-type market and 23 percent of the Havarti market. As with Cheddar cheese profitability estimates, although the production level affects the unit production costs of product, the yields and values for all products will not be affected on a per cwt of milk basis.

Profits for specialty cheese are much higher than for Cheddar cheese. For Jarlsberg-type cheese, the profit from cheese and whey powder is $4.24 per cwt raw milk (Table 37). Jarlsberg-type profitability is highlighted by a relatively high wholesale cheese price of $1.80 per pound of cheese. Revenues from Jarlsberg-type cheese alone ($16.67 per cwt raw milk) more than offset total cheese production costs ($15.07 per cwt raw milk), without taking into account revenues from cream and profits from whey powder. Fresh cream removed from the raw milk during standardization and whey cream contribute $1.84 per cwt of milk to over-all profits.

Havarti cheese profitability is highlighted by revenues from the cheese, $25.11 per cwt raw milk (Table 38). This is due to a relatively high cheese yield of 14.08 pounds of cheese per cwt of standardized milk or 15.22 pounds per cwt of raw milk. Total costs for Havarti cheese include the cost of fresh cream added to the raw milk during standardization. This cream cost amounts to $5.16 per cwt of raw milk. Nevertheless, Havarti has the highest profits for cheese and whey powder ($5.89 per cwt raw milk) of all three cheeses studied.

Specialty Cheese Profitability With Lower Cheese Yields. Potential profits from specialty cheese are quite dramatic, as illustrated in the previous section. The effects on profits of a lower cheese yield also were analyzed. As with the cheese yield sensitivity presented earlier, which highlighted the production cost effects of lower actual cheese yields, this analysis assumes cheese yields are reduced due to inefficient recovery of cheese solids.

For this example the actual cheese yield was reduced five percent, which is assumed to be caused by fat and fines loss in the whey. In the original profitability calculations (Tables 37 and 38), the loss of fines was assumed to be

Table 36 Sample Worksheet to Calculate the Profitability of Cheddar Cheese Production in a Cheddar Plant That Can Receive 960,000 Pounds of Milk Per Day

Item		Cheddar Cheese
		($/Cwt Milk)
REVENUES		
Cheddar Cheese		
Yield (Lbs/Cwt Raw Milk)	10.00	
Price ($/Lb Cheese)	1.30	
Revenue		13.00
Whey Cream		
Yield (Lbs/Cwt Raw Milk)[1]	0.70	
Price ($/Lb Whey Cream)[2]	0.56	
Revenue		0.39
Total Revenues		13.39
COSTS		
Cheese Manufacturing Cost[3]		1.58
Raw Milk Cost		11.85
Total Costs		13.43
OPERATING PROFIT FROM CHEESE		-0.04
REVENUES		
Whey Powder Yield (Lbs/Cwt Raw Milk)	5.80	
Whey Powder Price ($/Lb Powder)	.20	
Total Revenue		1.16
COSTS		
Whey Powder Yield (Lbs/Cwt Raw Milk)	5.80	
Whey Manufacturing Costs ($/Lb Powder)[4]	.10	
Total Cost		.58
OPERATING PROFIT FROM WHEY ($/Lb Powder)	.10	
		.58
PROFIT FROM CHEESE & WHEY		$ 0.54

[1]Assumes 90% recovery of theoretical whey cream yield.
[2]Whey cream price $1.40 per lb fat.
[3]Cheesemaking costs for Cheddar plant, operating five days per week, 24 hours per day, see Appendix J.
[4]Source, unpublished data.

Table 37 Sample Worksheet to Calculate Profitability of Jarlsberg-Type Cheese Production per Cwt of Raw Milk

Item		Jarlsberg-Type Cheese
		($/cwt Milk)
REVENUES		
Jarlsberg-type Cheese		
Yield (Lbs/Cwt Raw Milk)	9.26	
Price ($/Lb Cheese)	1.80	
Revenue		16.67
Fresh Cream		
Yield (Lbs/Cwt Raw Milk)	2.20	
Price ($/Lb Fresh Cream)[1]	0.64	
Revenue		1.41
Whey Cream		
Yield (Lbs/Cwt Raw Milk)[2]	0.77	
Price ($/Lb Whey Cream)[1]	0.56	
Revenue		0.43
Total Revenues		18.51
COSTS		
Cheese Manufacturing Cost[3]		3.22
Raw Milk Cost		11.85
Total Costs		15.07
OPERATING PROFIT FROM CHEESE		3.44
REVENUES		
Whey Powder Yield (Lbs/Cwt Raw Milk)	5.72	
Whey Powder Price ($/Lb Powder)	.20	
Total Revenue		1.14
COSTS		
Whey Powder Yield (Lbs/Cwt Raw Milk)	5.72	
Whey Manufacturing Costs ($/Lb Powder)[4]	.06	
Total Cost		.34
OPERATING PROFIT FROM WHEY ($/Lb Powder)	.14	.80
PROFIT FROM CHEESE & WHEY		$ 4.24

[1]Fresh cream $1.60 per lb fat, whey cream $1.40 per lb fat.
[2]Assumes 90% recovery of theoretical whey cream yield.
[3]Incremental cheese-making cost for high-automation alternate-day manufacturing in a Cheddar plant producing 3.94 million pounds of Jarlsberg-type cheese annually.
[4]Incremental whey processing cost adapted from unpublished data.

Table 38 Sample Worksheet to Calculate Profitability of Havarti Cheese Production Per Cwt of Raw Milk

Item		Havarti Cheese
		($/Cwt Milk)
REVENUES		
Havarti Cheese		
Yield (Lbs/Cwt Raw Milk)	15.22	
Price ($/Lb Cheese)	1.65	
Revenue		25.11
Whey Cream		
Yield (Lbs/Cwt Raw Milk)[1]	2.34	
Price ($/Lb Whey Cream)[2]	.56	
Revenue		1.31
Total Revenues		26.42
COSTS		
Cheese Manufacturing Cost[3]		4.29
Raw Milk Cost		11.85
Fresh Cream		
Amount Used (Lbs/Cwt Raw Milk)	8.07	
Cost ($/Lb Fresh Cream)[2]	.64	
Cost of Cream Used		5.16
Total Costs		21.30
OPERATING PROFIT FROM CHEESE		5.12
REVENUES		
Whey Powder Yield (Lbs/Cwt Raw Milk)	5.93	
Whey Powder Price ($/Lb Powder)	.20	
Total Revenue		1.19
COSTS		
Whey Powder Yield (Lbs/Cwt Raw Milk)	5.93	
Whey Manufacturing Costs ($/Lb Powder)[4]	.07	
Total Costs		.42
OPERATING PROFIT FROM WHEY ($/Lb Powder)	.13	.77
PROFIT FROM CHEESE AND WHEY		$ 5.89

[1]Assumes 90% recovery of theoretical whey cream yield.
[2]Fresh cream $1.60 per lb fat, whey cream $1.40 per lb fat.
[3]Incremental cheesemaking cost for high-automation alternate-day manufacturing in a Cheddar plant producing 5.9 million pounds of Havarti cheese annually.
[4]Incremental whey processing cost adapted from unpublished data.

negligible. Half of the fat loss is assumed to be recovered in the whey fines (43 percent moisture and 31 percent FDB for Jarlsberg-type, and 42 percent moisture and 45 percent FDB Havarti cheese). The whey fines are pressed into blocks and sold as a processed cheese ingredient. Only 90 percent of the remaining fat is assumed to be recovered as whey cream (40 percent fat).

For Jarlsberg-type cheese, reducing cheese yields by 5 percent reduced profits by 47 cents per cwt of raw milk (5.2 cents per pound of Jarlsberg-type cheese) (Tables 37 and 39). The total profits are reduced mainly because revenue from the cheese is 83 cents per cwt of milk less. But recovery of fat as whey cream and whey solids leads to added revenues of 34 cents per cwt milk. Cheese production costs are reduced (due to reduced cheese packaging cost) per cwt of raw milk (but increase on a pound of cheese basis) since less packaging material is required with a lower cheese yield.

For Havarti cheese, reducing cheese yields reduced total profits per cwt of raw milk by 30 cents (2.1 cents per pound of Havarti cheese) (Tables 38 and 40). Profits per cwt are reduced to a lesser extent than for Jarlsberg-type cheese because the higher fat content of the losses leads to more added revenues to offset lost cheese revenues. Lost cheese revenues total $1.25 per cwt of milk. Added revenues from whey cream and whey fines amounted to 93 cents per cwt milk, and the remaining 2 cent difference is due to lower cheese production costs per cwt of milk due to less packaging required.

This analysis and the cheese yield sensitivity analysis show that cheese yields may not affect production costs to a great extent (Tables 32 and 33), but when profitability is considered, the opportunity cost of lower cheese yields are substantial. Cheese solids have the greatest value when sold as cheese, not when sold as whey cream or whey fines.

Comparison of Profitability of Three Cheeses

In the example calculations, net profits from cheese and whey for Jarlsberg-type cheese are $3.70 higher than Cheddar per cwt of raw milk. Net profits for Havarti are $5.35 higher than Cheddar, almost 10 times greater (Tables 36-38). This is despite the assumed premium price for Cheddar cheese and relatively high Cheddar cheese yield.

Raw milk is the largest portion of total costs for all cheeses. Cheese production costs constitute only a small proportion of total cheese costs. It accounts for only 21 percent of total cheese costs in Jarlsberg-type manufacturing and 20 percent for Havarti cheese. The base Cheddar cheese production cost represents less than 12 percent of total Cheddar costs.

The impact of cheese yields on total revenues is very significant. Havarti cheese provides greater revenue from a cwt of milk than Jarlsberg-type. Although the price per pound for Havarti is assumed to be 15 cents lower than Jarlsberg-type, the extra 5.96 pounds of cheese per cwt of raw milk leads to $8.44 more revenue per cwt milk (Tables 37 & 38). Cheese revenues for Cheddar are $3.67 less than Jarlsberg-type and $12.11 less than Havarti per cwt of raw milk.

Whey powder profit is lower for Cheddar cheese than for the specialty cheeses because the assumed manufacturing cost per pound is higher. The cost of whey handling per cwt milk to produce 24.9 million pounds of Cheddar cheese a year is more than the incremental whey handling cost per cwt of milk to manufacture specialty cheese. The incremental costs are those costs above the costs

Table 39 Profitability of Jarlsberg-Type Cheese Production Assuming a Lower Actual Cheese Yield (8.8 Lbs. per Cwt of Raw Milk)

Item		Jarlsberg-Type Cheese
		($/Cwt Milk)
REVENUES		
Jarlsberg-type Cheese		
Yield (Lbs/Cwt Raw Milk)	8.80	
Price ($/Lb Cheese)	1.80	
Revenue		15.84
Fresh Cream		
Yield (Lbs/Cwt Raw Milk)	2.20	
Price ($/Lb Fresh Cream)[1]	.64	
Revenue		1.41
Whey Cream		
Yield (Lbs/Cwt Raw Milk)[2]	.91	
Price ($/Lb Whey Cream)[1]	.56	
Revenue		.51
Whey Fines		
Yield (Lbs/Cwt Raw Milk)[3]	.35	
Price ($/Lb Whey Fines)	.75	
Revenue		.26
Total Revenue		18.02
COSTS		
Cheese Manufacturing Cost[4]		3.20
Raw Milk Cost		11.85
Total Cost		15.05
OPERATING PROFIT FROM CHEESE		2.97
REVENUES		
Whey Powder Yield (Lbs/Cwt Raw Milk)	5.72	
Whey Powder Price ($/Lb Powder)	.20	
Total Revenue		1.14
COSTS		
Whey Powder Yield (Lbs/Cwt Raw Milk)	5.72	
Whey Manufacturing Costs ($/Lb Powder)[5]	.06	
Total Cost		.34
OPERATING PROFIT FROM WHEY ($/Lb Powder)	.14	
		.80
PROFIT FROM CHEESE AND WHEY		$ 3.77

[1]Fresh cream $1.60 per lb fat, whey cream $1.40 per lb fat.
[2]Assumes 90% recovery of theoretical whey cream yield.
[3]Represents increased whey fines due to poor cheesemaking practice.
[4]<u>Incremental</u> cheese-making cost for high-automation alternate-day manufacturing in a Cheddar plant, producing 3.74 million pounds of Jarlsberg-type cheese annually.
[5]<u>Incremental</u> whey processing cost adapted from unpublished data.

Table 40 Profitability of Havarti Cheese Production Assuming a Lower Actual Cheese Yield (14.46 Lbs per Cwt of Raw Milk)

Item		Havarti Cheese
		($/Cwt Milk)
REVENUES		
Havarti Cheese		
Yield (Lbs/Cwt Raw Milk)	14.46	
Price ($/Lb Cheese)	1.65	
Revenue		23.86
Whey Cream		
Yield (Lbs/Cwt Raw Milk)[1]	3.26	
Price ($/Lb Whey Cream)[2]	.56	
Revenue		1.83
Whey Fines		
Yield (Lbs/Cwt Raw Milk)[3]	.55	
Price ($/Lb Whey Fines)	.75	
Revenue		.41
Total Revenues		26.10
COSTS		
Cheese Manufacturing Cost[4]		4.27
Raw Milk Cost (3.7% butter fat)		11.85
Fresh Cream		
Amount Used (Lbs/Cwt Raw Milk)	8.07	
Cost ($/Lb Fresh Cream)[2]	.64	
Cost of Cream Used		5.16
Total Costs		21.28
OPERATING PROFIT FROM CHEESE		4.82
REVENUES		
Whey Powder Yield (Lbs/Cwt Raw Milk)	5.93	
Whey Powder Price ($/Lb Powder)	.20	
Total Revenue		1.19
COSTS		
Whey Powder Yield (Lbs/Cwt Raw Milk)	5.93	
Whey Manufacturing Costs ($/Lb Powder)[5]	.07	
Total Costs		.42
OPERATING PROFIT FROM WHEY ($/Lb Powder)	.13	.77
PROFIT FROM CHEESE AND WHEY		$ 5.59

[1]Assumes 90% recovery of theoretical whey cream yield.
[2]Fresh cream $1.60 per lb fat, whey cream $1.40 per lb fat.
[3]Represents increased whey fines due to poor cheesemaking practice.
[4]Incremental cheese-making cost for high-automation alternate-day manufacturing in a Cheddar plant producing 5.6 million pounds of Havarti cheese annually.
[5]Incremental whey processing cost adapted from unpublished data.

associated with processing the whey from 24.9 million pounds of Cheddar cheese that are assumed to be manufactured in the existing Cheddar plant before modification to include specialty cheese.

Potential Profitability of Producing Specialty Cheese in a Cheddar Plant Considering Availability of Milk Supplies

Because alternate-day manufacturing of specialty cheese in a Cheddar plant is the least-costly manufacturing scenario when considering the size of the domestic specialty cheese market, a more in-depth profitability evaluation was performed on these modified Cheddar cheese plants. Profitability analysis was carried out under two assumed milk supply situations for the 960,000 pounds of milk per day Cheddar plant operating five days per week, 24 hours per day.

The first milk supply situation assumes a sufficient supply of raw milk to increase production. Available supplies of milk would enable the cheese plant to expand production, either by producing more Cheddar or by modifying the plant and producing specialty cheese while maintaining Cheddar production.

The second milk supply situation assumes a limited milk supply. The cheese plant cannot increase its milk use beyond current levels (about 4.8 million pounds of milk a week). If the plant wishes to produce specialty cheese, Cheddar cheese production would have to be reduced to accommodate specialty cheese production.

With An Unlimited Milk Supply. If a Cheddar cheese plant operates with an unlimited milk supply, the plant would expand production until marginal revenue equals marginal cost or until some other input or technical production constraint, or marketing consideration becomes a limiting factor. The model Cheddar plant considered in this study is assumed to operate at 71 percent of capacity (five days per week, 24 hours per day; 24.96 million pounds of Cheddar annually).

The profits associated with specialty cheese production in a Cheddar plant modified for alternate-day manufacture are compared to the profits the Cheddar plant could realize by expanding Cheddar production beyond the base production level of 71 percent capacity (five days per week, 24 hours per day).

The profits compared are the average profits received per cwt of milk used above the milk required for the base Cheddar cheese production. Since adding specialty cheese production or expanding Cheddar production both assume a base Cheddar production of 24.96 million pounds annually, profits associated with this base Cheddar production are ignored.

If the Cheddar cheese plant invests in alternate-day manufacturing of specialty cheese, profit from the added milk used to make specialty cheese would be higher than profits from increasing Cheddar cheese production in all but two scenarios (Tables 41 and 42). This comparison illustrates the dramatic profit potential of specialty cheese compared to Cheddar.

Cheddar production has an advantage over investing in specialty cheese production at only the lowest added production level. This occurs when the Cheddar price is high ($1.30 per pound), Jarlsberg-type and Havarti prices are low ($1.60 & $1.45 per pound, respectively), and the added production is at the lowest level (producing 1.84 million pounds of Jarlsberg-type cheese and 2.73 million pounds of Havarti annually, versus expanding Cheddar production by 1.94 million pounds per year). In all other price and production situations, adding specialty cheese production leads to greater profits than expanding Cheddar production.

Table 41 Jarlsberg-Type Cheese: Profits per Cwt of <u>Added</u> Raw Milk by Expanding Production Beyond 24.96 Million Pounds of Cheddar Annually[1]

Approximate Increase In Cheddar Production[2]	Profits By Increasing Cheddar Cheese Production: Cheddar Price 1.20	Profits By Increasing Cheddar Cheese Production: Cheddar Price 1.30	Approximate Jarlsberg-Type Production[3]	Profits By Adding Alternate-day Jarlsberg-type Cheese Production: Jarlsberg-type Price 1.60	Jarlsberg-type Price 1.70	Jarlsberg-type Price 1.80
(Lbs/Year)	($/cwt Milk[4])		(Lbs/Year)	---($/cwt Milk[4])----		
9,984,000	0.07	1.07	9,455,000	3.51	4.44	5.37
8,320,000	0.03	1.04	7,879,000	3.33	4.25	5.18
6,655,000	-0.06	0.98	6,303,000	3.04	3.97	4.89
4,992,000	0.08	1.08	4,727,000	2.74	3.67	4.59
4,160,000	0.04	1.04	3,940,000	2.39	3.32	4.24
3,328,000	-0.02	0.98	3,152,000	1.87	2.80	3.72
1,941,000	-0.23	0.77	1,838,000	0.01	0.94	1.86

[1]Assumed base production for 960,000 pounds per day Cheddar plant operating 5 days per week, 24 hours per day.
[2]Approximate annual production of Cheddar cheese beyond the base production of 24.96 million pounds per year.
[3]Approximate annual production of Jarlsberg-type cheese beyond the base Cheddar production of 24.96 million pounds per year, if Cheddar plant adds alternate-day Jarlsberg-type cheese production.
[4]Average Profits per cwt of raw milk <u>added</u> to expand production.
Assumptions: milk cost $11.85 cwt, fresh cream price $1.60 lb fat, whey cream price $1.40 per lb fat, and whey powder price $0.20 lb.

For all but these two cases, specialty cheese production appears advantageous over increasing Cheddar production. The increase in profits per cwt of <u>additional</u> milk range from $0.24 to $5.30 for Jarlsberg-type production and from $1.36 to $7.33 for Havarti production. The advantage specialty cheese production has over increasing Cheddar production is a function of the amount of production (or milk) added to the base Cheddar production and the price differential between the two cheeses. The more production increases, the greater the advantage of specialty cheese, because specialty cheese production costs are spread over more cheese and specialty profits are greater than Cheddar.

Table 42 Havarti Cheese: Profits per Cwt of Added Raw Milk by Expanding Production Beyond 24.96 Million Pounds of Cheddar Annually

Approximate Increase In Cheddar Production[2]	Profits By Increasing Cheddar Cheese Production: Cheddar Price 1.20	1.30	Approximate Havarti Cheese Production[3]	Profits By Adding Alternate-day Havarti Cheese Production: Havarti Cheese Price 1.45	1.55	1.65
(Lbs/Year)	($/cwt Milk[4])		(Lbs/Year)	--($/cwt Milk[4])---		
9,984,000	0.07	1.07	14,057,000	4.36	5.88	7.40
8,320,000	0.03	1.04	11,715,000	4.10	5.64	7.15
6,655,000	-0.06	0.98	9,372,000	3.72	5.24	6.77
4,992,000	0.08	1.08	7,029,000	3.29	4.81	6.34
4,160,000	0.04	1.04	5,857,000	2.84	4.34	5.87
3,328,000	-0.02	0.98	4,686,000	2.12	3.64	5.16
1,941,000	-0.23	0.77	2,733,000	-0.39	1.13	2.65

[1]Assumed base production for 960,000 pounds per day Cheddar plant operating 5 days per week, 24 hours per day.
[2]Approximate annual production of Cheddar cheese beyond the base production of 24.96 million pounds per year.
[3]Approximate annual production of Havarti cheese beyond the base Cheddar production of 24.96 million pounds per year, if Cheddar plant adds alternate-day Havarti-type cheese production.
[4]Average profits per cwt of raw milk added to expand production.
Assumptions: milk cost \$11.85 cwt, fresh cream cost \$1.60 Lb fat, whey cream price \$1.40 per Lb fat, and whey powder price \$0.20 Lb.

With A Limited Milk Supply. Many Cheddar cheese plants face a situation where production cannot be increased due to a limited milk supply. In this situation a Cheddar plant considering specialty cheese manufacturing would need to reduce Cheddar production to accommodate specialty manufacturing. To evaluate the potential advantages of specialty cheese replacing some Cheddar production, management must assess whether investing in specialty cheese manufacturing and replacing some Cheddar production with specialty cheese will increase the profits from available milk.

Average profits per cwt of all milk received at the plant were compared between the existing Cheddar plant and the same plant modified for alternate-day manufacturing of both Cheddar and specialty cheese. As contrasted to the previously reported profitability analyses under unlimited milk supplies for the plant where profit estimates were analyzed on the additional milk, in this analysis profits are figured on the total milk receipts of the plant because the

Cheddar production volume varies. Also, internal rates of return (IRR) on the investment in alternate-day specialty cheese production were calculated.

For this analysis, no matter the production configuration of the plant (either existing Cheddar plant or alternate-day manufacturing), the cheese plant operates five days per week, 24 hours per day. The weekly quantity of milk received at the plant is nearly the same for both configurations, regardless of the operating schedules and corresponding production mix of cheeses.

Two operating schedules were examined for the existing plant investing in alternate-day specialty cheese manufacturing. The first schedule is one day specialty and four days Cheddar cheese. The other schedule is two days specialty and three days Cheddar cheese.

Average profit per cwt of total raw milk received was calculated by subtracting total costs from total revenue and dividing by total hundredweight of milk received. The average profits for alternate-day manufacturing include the revenues and costs for both Cheddar and specialty cheese production. Since this analysis maintains weekly raw milk receipts at nearly a constant level for both plant configurations, average profits per cwt of raw milk provide a gauge to measure the total profitability of both plant configurations.

Given a limited milk supply, replacing one day of Cheddar production with one day of specialty production will increase average profits per cwt of total raw milk received at the plant (Tables 43 and 44). Replacing two days of Cheddar production increases profits even more. This relationship is true for all Cheddar and specialty cheese price relationships studied.

Investing in Jarlsberg-type specialty cheese production and replacing five days per week of Cheddar with four days Cheddar and one day specialty cheese leads to an increase in the average profits by \$0.30 to \$0.89 per cwt of raw milk. For Havarti cheese, replacing one day of Cheddar production leads to an increase in average profits by \$0.37 to \$1.13 per cwt raw milk. The increase in profits are dependent on the assumed Cheddar and specialty cheese prices.

Replacing two of the five days per week of Cheddar production with specialty cheese leads to an even greater increase in average profits per cwt of milk. This indicates there is a potential to improve the financial position of the cheese plant by replacing even more than two days of Cheddar production with specialty cheese production. But alternate-day manufacturing is limited to only two days per week specialty cheese production because of the limited ripening and aging center space, as well as by a probable limited market demand.

Investing in specialty cheese production and replacing two of the five days of Cheddar production with Jarlsberg-type production increases average profits by \$0.96 to \$2.11 per cwt of raw milk. Havarti production increases average profits by \$1.21 to \$2.74 per cwt of raw milk.

Besides looking at increases in profits, another way to view the potential profitability of producing specialty cheese over Cheddar is the internal rate of return (IRR). IRR is determined by calculating the interest rate that equates an investment's initial capital outlay with the present value of the cash income stream provided by the investment. The estimated IRR's can be compared with the plant's cost of capital to determine not only if the investment would be wise, but also to show how much margin there is to allow for risk and uncertainty.

Table 43 Profit Per Cwt on All Milk Received for Various Product Mixes, Producing Only Cheddar 5 Days Per Week vs. Producing Jarlsberg-Type Cheese 1 or 2 Days Per Week, 24-Hour Day Operation, Alternate-Day Manufacturing of Jarlsberg

		Existing Ched. Plant	Cheddar Plant Modified For Alternate-Day Production	
Cheddar Cheese Price	Jarlsberg -Type Price	Days Per --Week-- Cheddar 5	Days Per ----Week---- Ched. 4 Jarls. 1	Days Per ----Week---- Ched. 3 Jarls. 2
($/Lb. Cheese)		Average Profit Per CWT of Raw Milk ($)		
1.20	1.60	-0.46	0.05	0.90
1.20	1.70	-0.46	0.24	1.28
1.20	1.80	-0.46	0.43	1.65
1.30	1.60	0.54	0.84	1.50
1.30	1.70	0.54	1.03	1.87
1.30	1.80	0.54	1.22	2.25

The IRR's were determined for the investment in alternate-day specialty cheese production. The IRR is the discount or interest rate that equates the total capital investment needed to modify the existing Cheddar plant to produce specialty cheese with the present value of the increase in profits (expressed in cash flow terms) due to producing specialty cheese on one or two days of the week instead of Cheddar all five days of the week.[24] The plant is assumed to operate for 30 years, taking into account equipment replacement. Specialty cheese equipment is assumed to be replaced at five, ten, and 15 year intervals according to the equipment minimum useful life categories. At the end of the 30 year period the added building and equipment are assumed to have a zero salvage value and the added land is valued at its initial cost.

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[24]The added annual income streams or profits were calculated by determining the increase in net cash flows for the modified plant operating five days a week, with one or two days of specialty cheese production over five days per week of strictly Cheddar production in the existing Cheddar plant. Production costs used for Cheddar excluded capital depreciation and interest charges because the Cheddar plant is assumed to already be in production.

Table 44 Profit Per Cwt on All Milk Received For Various Product Mixes, Producing Only Cheddar 5 Days Per Week vs. Producing Havarti 1 or 2 Days Per Week, 24-Hour Day Operation, Alternate-Day Manufacturing of Havarti

Cheddar Cheese Price	Havarti Price	Existing Ched. Plant Days Per --Week-- Cheddar 5	Cheddar Plant Modified For Alternate-Day Production Days Per ----Week---- Ched. 4 Havti. 1	 Days Per ----Week---- Ched. 3 Havti. 2
($/Lb. Cheese)		Average Profit Per CWT of Raw Milk ($)		
1.20	1.45	-0.46	0.11	1.12
1.20	1.55	-0.46	0.38	1.70
1.20	1.65	-0.46	0.67	2.28
1.30	1.45	0.54	.91	1.75
1.30	1.55	0.54	1.20	2.33
1.30	1.65	0.54	1.48	2.91

If the IRR exceeds the real or inflation free cost of capital, then the value of the plant would be increased by making the investment.

The internal rates of return on the added specialty investment for both Jarlsberg-type and Havarti cheese are very favorable (Tables 45 and 46). The IRR for the investment in alternate-day manufacturing and replacing one of the five days per week of Cheddar production with Jarlsberg-type cheese ranges from 23 percent to 72 percent (Table 45). The IRR for replacing one of the five days per week with Havarti cheese ranges from 23 percent to 74 percent (Table 46).

The IRRs on the specialty investment and for replacing two of the five days per week with specialty cheese are very high. Replacing two days per week with Jarlsberg-type leads to an IRR of 82 percent or higher. If Cheddar cheese is replaced with two days per week of Havarti, the IRR ranges from 79 percent to points where the added profit due to specialty cheese pays for the initial investment in a very short period.

Table 45 Jarlsberg-Type Cheese: Internal Rate of Return on Added Investment for Alternate-Day Manufacturing in Cheddar Plant Operating 5 Days Per Week, 24 Hours Per Day

Cheddar Cheese Price	Jarlsberg -Type Price	Cheddar Plant Modified For Alternate-Day Production: Days Per Week, Ched. 4, Jarls. 1	Cheddar Plant Modified For Alternate-Day Production: Days Per Week, Ched. 3, Jarls. 2
($/Lb. Cheese)		(Internal Rate of Return, Percent[1])	
1.20	1.60	38	149
1.20	1.70	53	288
1.20	1.80	72	747
1.30	1.60	23	82
1.30	1.70	36	144
1.30	1.80	52	276

[1]Internal rate of return is the percentage rate equating the total capital investment added to the existing Cheddar plant with the present value of the increase in profits (expressed in cash flow terms) due to producing some specialty cheese, as well as Cheddar.

The actual percentage rate for the IRR is very dependent on the days per week of specialty production, as well as the specialty and Cheddar cheese prices. Because specialty cheese was found to be consistently more profitable than Cheddar in this limited milk supply situation (Tables 43 and 44), an increase in specialty production increases the added returns to the modified plant and the IRR.

Increasing the price of specialty cheese has the same effect, making specialty production more favorable and increasing the IRR. Increasing the Cheddar cheese price has the opposite effect: Cheddar becomes relatively more profitable so the added returns due to specialty cheese are less. Thus, the investment in specialty cheese production becomes more attractive as the price of Cheddar cheese declines relative to specialty cheese.

Table 46 Havarti Cheese: Internal Rate of Return on Added Investment for Alternate-Day Manufacturing in Cheddar Plant Operating 5 Days Per Week, 24 Hours Per Day

Cheddar Cheese Price	Havarti Price	Cheddar Plant Modified For Alternate-Day Production: Days Per Week, Ched. 4, Havti. 1	Days Per Week, Ched. 3, Havti. 2
($/Lb. Cheese)		(Internal Rate of Return, Percent[1])	
1.20	1.45	34	126
1.20	1.55	51	266
1.20	1.65	74	859
1.30	1.45	23	79
1.30	1.55	45	156
1.30	1.65	57	352

[1]Internal rate of return is the percentage rate equating the total capital investment added to the existing Cheddar plant with the present value of the increase in profits due to producing some specialty cheese, as well as Cheddar.

Comparison of Potential Profitability of Each Cheese in New York and Wisconsin

The analyses reported in the previous section of this publication of the potential profitability of producing specialty cheese in a modified Cheddar cheese plant were based on realistic, but general, assumptions regarding milk composition and yields and raw milk, cream, whey cream, whey powder and cheese prices. To shed further light on the potential profitability of producing Jarlsberg or Havarti cheese in a Cheddar plant, the profitability of producing the cheeses in New York and Wisconsin were estimated based on the theoretical yields from an extensive milk composition study in 1984 and prices that were realized in these two states during the period January through December 1988.

Methodology and Data Collection. Monthly data were collected from a variety of sources for 1988, with an annual average calculated for each category. Twelve months of data were used to obtain a realistic average, not to imply seasonality. Price changes (particularly whey prices) are often in no way connected to seasonality and should not be viewed in this light.

The data categories included milk composition (fat and protein), theoretical cheese yields, whey powder and whey cream yields, and fresh cream added or removed (depending on the cheese being manufactured). Price data were also collected on raw milk, whey powder, fresh and whey creams, and on Cheddar, Jarlsberg, and Havarti cheeses.

Each item of data was collected for New York and Wisconsin (Tables 47 and 48). These figures were then used to calculate the profitability for each of the cheeses (Table 49). The procedures used to calculate the values in Table 49 are shown in Tables 36-38. Tables showing data for each month are in Appendices Q-T.

Data Sources. Milk composition information (fat, protein and total solids) for each region were from a 1984 survey. Details of the survey and its methodology can be found in the Journal of Dairy Science.[25]

A computer program was used to determine theoretical yield information for cheese, whey cream, whey, and fresh cream added or removed. This was done using the milk composition data and assumed characteristics for each type of cheese, (moisture, protein, and fat levels). Whey powder yields were determined by calculating the amount of whey produced (subtracting cheese yield from amount of milk used) and the total solids content of the whey (using the milk composition data) and assuming a 97% solids content for the whey powder.

Raw milk price data were based on the Minnesota-Wisconsin Manufacturing Milk (M&W) price for Wisconsin and on the Class 2, Federal Order 2 price for New York. The prices in each of these series were increased to allow for quality and competitive premiums, hauling subsidies and other raw milk procurement costs incurred by plants, marketing order assessments, etc. The monthly M&W prices were each increased $0.70 to reflect such added costs, and the New York prices were increased by $0.55. Also, each price was adjusted to the actual butterfat of the corresponding month in each region (from the milk composition survey) by the appropriate butterfat differential.

Whey powder prices for each month were averaged from "Dairy Market News" weekly reports.[26] The Wisconsin prices were taken from the "Dry Whey - Central, Mostly" ranges (the average of each range was used for each week, the weekly averages were averaged for each month), and the New York prices were from the "Dry Whey - FOB Eastern Area, Extra Grade," (also averaged for each week and month). Both price series were for spray-dried nonhygroscopic extra grade whey, for use in human food.

Fresh and whey cream prices ($/lb of cream) were assumed to be the same in both regions. Fresh cream prices were calculated by multiplying the butterfat differential by 4 (fresh cream and whey cream were both assumed to be 40% fat). A ratio of 1:.857 was assumed for the fresh and whey cream prices, so each whey cream price was calculated as 85.7% of the fresh cream price.

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[25]Barbano, D.M. and DelaValle, M.E. Seasonal Variations in Milk Solids Components in Various Regions of the U.S. (abstract). Journal of Dairy Science, Volume 68, Supplement 1, Pages 71-72, 1985.

[26]Dairy Market News (various issues), U.S. Department of Agriculture - Agricultural Marketing Service.

TABLE 47 Average Milk Composition and Selected Dairy Product Yield Data, New York and Wisconsin Averages, January - December 1988

	New York	Wisconsin
Milk Composition[1]		
Percent Fat	3.57%	3.68%
Percent Protein	3.22%	3.27%
Cheese Yields (Lbs/Cwt Raw Milk)		
Cheddar	9.92	10.16
Jarlsberg	9.33	9.51
Havarti	15.33	15.58
Whey Powder Yields (Lbs/Cwt Raw Milk)		
Cheddar	5.81	5.78
Jarlsberg	5.73	5.70
Havarti	5.94	5.91
Fresh Cream (Lbs Added or Removed/Cwt Raw Milk)		
Cheddar	0.00	0.00
Jarlsberg	-1.82	-1.98
Havarti	8.53	8.54
Whey Cream Yield (Lbs of Cream/Cwt Raw Milk)		
Cheddar	0.56	0.58
Jarlsberg	0.77	0.77
Havarti	2.36	2.39

[1]Milk composition based on 1984 survey.

Cheddar cheese prices for each region were based on the Green Bay Wisconsin National Cheese Exchange 40 lb. block prices. Cheese industry sources agreed that New York premium Cheddar, (10 days old, suitable for aging), would command approximately an $0.18 premium over the block price. For Wisconsin, it was determined that this same type and quality of cheese produced in Wisconsin would receive $0.05 over block. No transportation or aging costs are assumed in these prices.

The prices for Jarlsberg and Havarti ($1.82 and $1.67 per pound, respectively) were based on information supplied by importers and marketers of specialty cheeses. Jarlsberg and Havarti were determined to have no regional price differences based on where they are produced. It is assumed that the Havarti will have been aged for two months and the Jarlsberg for three, with each ready for immediate distribution and sale.

TABLE 48 Average Cheese and Whey Product Prices and Cost Data, Based on New York and Wisconsin Averages, January - December 1988

	New York	Wisconsin
Price Data		
Raw Milk ($/Cwt)	$11.68	$11.99
Whey Powder extra grade ($/Lb)	0.20	0.19
Fresh Cream 40% bf ($/Lb Cream)	0.61	0.61
Whey Cream 40% bf ($/Lb Cream)	0.54	0.54
Cheddar ($/Lb)	1.39	1.26
Jarlsberg ($/Lb)	1.82	1.82
Havarti ($/Lb)	1.67	1.67
Cheese Manufacturing Costs		
Cheddar ($/Cwt of milk)	1.58	1.58
Jarlsberg ($/Cwt of milk)	3.22	3.22
Havarti ($/Cwt of milk)	4.29	4.30
Whey Manufacturing Costs		
Cheddar ($/Lb of Whey Powder)	0.11	0.11
Jarlsberg ($/Lb of Whey Powder)	0.06	0.06
Havarti ($/Lb of whey Powder)	0.07	0.07

Cheese manufacturing costs were determined using the economic engineering method and assuming alternate-day, high automation production techniques in a Cheddar plant modified for the manufacture of specialty cheese. Plant capacity was assumed to be 960,000 cwt of milk per day, producing Cheddar five days per week, 24 hours per day and specialty cheese one day per week, 21 hours per day. Using the milk composition and yield data for each region, annual production of Cheddar was assumed to be 24,760,320 lbs for the New York plant and 25,359,360 lbs for the Wisconsin plant. The difference in total annual production from the same volume of milk is due to higher fat and protein content of the Wisconsin milk supply. New York specialty cheese production was calculated as 3,969,784 lbs of Jarlsberg annually or 5,878,080 lbs of Havarti, while Wisconsin Jarlsberg production was estimated as 4,046,371 or 5,969,600 lbs of Havarti.

The only component of manufacturing costs affected by the regional yield differences is packaging. All other manufacturing costs are dependent on the quantity of milk used and remain constant, regardless of the final quantity of cheese produced. Due to rounding and the small size of the yield differences, there was often no difference seen in manufacturing costs per cwt of milk despite the differences in yield and their effect on manufacturing costs.

Whey powder manufacturing costs were calculated in the same manner as cheese manufacturing costs, using the economic engineering approach and assuming the same plant size and operating schedule.[27] Total annual whey powder packaging costs were affected by the whey powder yield differences in the two regions. However,

[27]Based on authors' unpublished research.

the whey manufacturing costs per cwt of milk are the same, or only slightly different, in the two states due to rounding and the small size of the change.

Estimated Profitability of Three Cheeses in New York and Wisconsin. Using the foregoing assumptions and data, the profitability of Cheddar, Jarlsberg and Havarti cheese production were estimated for representative conditions existing in New York and Wisconsin during the 12 months ending December 31, 1988 (Table 49). In analyzing these profitability estimates, the focus should be on the relative profitability of the three cheeses in the two regions rather than on the absolute levels of profitability. Actual absolute levels of profitability will depend on a number of conditions including size of plant, plant efficiency, raw milk prices, cream prices, whey powder prices and the like that need to be assessed for a specific situation. Moreover, the estimated profitabilities of the specialty cheeses assumes that a very significant market, namely approximately 20% of the estimated current domestic market, has been established by the manufacturer.

Although both a cheese operating profit and a whey operating profit are estimated, the focus should be on the combined profit from cheese and whey. Whey powder production clearly is an important contributor to the profitability of the overall cheese operation. However, in these estimates no charge is made to the whey operation for the raw whey because such a charge in this important byproduct would have been arbitrary. Because the raw whey would probably have some value, the operating profit for cheese is understated and the operating profit for whey overstated.

Estimates indicate that the manufacture of Cheddar, Jarlsberg and Havarti cheeses would have been profitable in New York under the conditions assumed above and prevailing during 1988. As far as Wisconsin conditions in 1988, Jarlsberg and Havarti production would have been profitable but Cheddar production essentially breaks even in a 960,000 lbs. of milk per day plant operating 24 hours, 5 days per week. Despite the higher cheese yield in Wisconsin, Cheddar production was more profitable in New York than Wisconsin because a good quality, New York Cheddar suitable for aging commands a market premium of approximately $.13 per pound more than comparable quality Cheddar made in Wisconsin.

Although the manufacture of good quality aged Cheddar was profitable in New York and breakeven in Wisconsin under the assumed conditions, the manufacture of both Jarlsberg and Havarti in a plant modified to produce one of these cheeses as well as Cheddar was significantly more profitable than Cheddar production in both regions (Table 49). The higher profitability of the specialty cheeses was due to the higher wholesale prices for specialty cheese and in the case of Havarti, a much higher yield. Because Havarti has a much higher yield than Jarlsberg, Havarti was the more profitable of the two specialty cheeses studied, given the prevailing price of Havarti being only $.15 per pound lower than Jarlsberg.

Whereas the production of good quality, aged Cheddar was more profitable in New York than Wisconsin, estimated profits for both specialty cheeses were essentially the same in Wisconsin and New York.

TABLE 49 Comparison of Total Profitability for Three Cheeses Based on New York and Wisconsin Averages for January - December 1988[1]

	Cheddar		Jarlsberg		Havarti	
	NY	WI	NY	WI	NY	WI
	($/Cwt of Raw Milk)					
Total Cheese Revenues[2]	$14.09	$13.11	$18.50	$18.93	$26.88	$27.31
Total Cheese Costs	13.26	13.56	14.90	15.21	21.17	21.50
Cheese Operating Profit[3]	0.83	-0.45	3.60	3.72	5.70	5.81
Total Whey Revenues	1.16	1.10	1.15	1.08	1.19	1.12
Total Whey Cost[4]	0.64	0.64	0.34	0.34	0.42	0.41
Whey Operating Profit[5]	0.52	0.46	0.80	0.74	0.77	0.71
COMBINED PROFIT	$ 1.35	$ 0.01	$ 4.41	$ 4.46	$ 6.47	$ 6.52

[1]Based on regional averages in Tables 49 and 50, and calculated using the procedures demonstrated in Tables 38-40.
[2]Assuming annual Cheddar production of 24,760,320 lbs for the New York plant and 25,359,360 million for the Wisconsin plant, 3,969,784 lbs of Jarlsberg annually or 5,878,080 lbs of Havarti in New York, and 4,046,371 of Jarlsberg or 5,969,600 lbs of Havarti in Wisconsin.
[3]No revenue is credited to the cheese operation for the raw whey transferred to the whey plant.
[4]The whey production costs for the specialty cheeses are lower than for Cheddar because only the incremental costs of operating the whey plant are charged to the specialty cheeses.
[5]No charge is made to the whey operation for the raw whey.

Conclusions

Specialty cheese was found to be potentially very profitable in both New York and Wisconsin compared to Cheddar production, assuming a successful marketing program can be established. Alternate-day specialty cheese production was found to increase returns per cwt of milk for an existing Cheddar plant in all but two of the possible production situations considered. Havarti cheese appears to have the greatest profit potential per cwt of raw milk of all three cheeses studied.

Specialty cheese production could well be more profitable than Cheddar under many manufacturing scenarios since production costs would have to be very high, or specialty cheese price relative to Cheddar very low, to offset the potential revenues from specialty cheese. Our results suggest that a plant could have slightly less than 10% of the current domestic market for Jarlsberg-type cheese and still find it more profitable to produce the specialty cheese than more Cheddar, as long as Jarlsberg carried a premium of at least $.40 a pound at wholesale over fresh Cheddar ready for aging. The corresponding break point for Havarti at this level of production (the lowest one studied) would be a premium of approximately $.25 a pound over the Cheddar price.

FURTHER CONSIDERATIONS AND CAUTIONS

The optimistic economic potential for specialty cheese production suggested by this study must be tempered by some limitations. Many questions remain concerning the production and marketing of specialty cheese in the United States. Keys to success will be product quality and marketing. Moreover, technological disruptions in production due to implementing alternate-day specialty cheese manufacturing in a Cheddar plant needs to be assessed as well as specialty cheese quality and marketing.

This research is based on the assumption that domestically produced specialty cheese can be produced of the same quality as European specialty cheeses. Nitrates are commonly used as an additive in the manufacture of European specialty cheeses in some countries. This is done to prevent the growth of undesirable bacteria (Clostridia) that cause serious quality defects by producing gas and causing the blocks of cheese to crack. However, cheese produced in the U.S. and additives used in cheesemaking are regulated by the standards of identity for cheeses as described in Title 21, Subchapter B, Part 133, Subpart B - Requirements for Specific Standardized Cheese and Related Products. Cheese manufacturers in the U.S. are not permitted to use nitrates as an additive in cheeses. European cheese manufacturers who are allowed to use nitrates may have a competitive advantage in the production of high quality specialty cheeses due to differences in U.S. and European regulations. Domestic production of specialty cheeses without the use of nitrates might result in higher production costs for U.S. manufacturers due to higher incidences of cheese produced with quality defects. An alternative is the Bactofuge process where bacterial spores are removed from milk and heat inactivated. This process would increase capital and utility costs slightly.

Production of high quality specialty cheese will require very good management ability to prevent loses due to quality problems. Specialty cheese production requires unique skills not required by production of commodity grade products. Management's ability to solve and prevent quality problems will also influence consumers' perceptions of domestically produced European-style cheeses. Only premium products will command premium prices. Europeans have been producing high quality specialty cheeses for centuries; U.S. producers will have to work hard to match their level of quality.

Another consideration is the timing for management to make decisions concerning the marketing of specialty cheese. The sizes of these specialty markets are small, even with expected future growth. The few firms that enter the market first and manufacture these cheeses well will possess a distinct advantage over those entering the market later. Unless there is considerable growth, domestic markets for specialty cheese may well only allow room for a few producers who can manufacture a high quality product.

This study indicates substantial potential profits to be gained from the production of specialty cheese. One must consider the assumptions underlying these results. For new products to successfully enter the market, effective marketing will be necessary.

Profitability analysis was based on relatively high production levels, 10 percent or more of the estimated current Jarlsberg-type and Havarti markets. Initially, specialty cheese manufacturers will produce lower volumes of cheese while market shares are being established. At lower production levels production costs are much higher, leading to lower profits, or even losses. Our analyses do not take into account such risks and costs associated with establishing a market.

An important way to reduce losses at the beginning of specialty cheese production, as well as to increase profits and reduce risks over time, is by product line extensions -- producing several varieties or a family of specialty cheeses. The plants modeled in this study to produce Jarlsberg-type cheese, with rather little adaptation, would be capable of producing other round-eye cheeses such as Edam, Emmentaler, Gouda, Swiss and the like. Similarly, the granular cheese system modeled for Havarti cheese production could be rather easily adapted to produce Munster and Esiom. The production of several varieties of related specialty cheese would permit longer runs, lower costs, lower risks and profitable operations with smaller market shares.

Cheddar cheese plants facing limited or diminishing milk supplies may not be able to justify the expansion of production into specialty cheese. But as milk supplies tighten the only way plants may survive is by producing higher valued products. Diversified plants will be able to take advantage of changing consumer preferences and more easily adapt to an uncertain environment.

Results of this study identify alternate-day specialty cheese manufacturing in a Cheddar plant as the most cost effective method to produce specialty cheese given current market size. Management considering this manufacturing option will face several unique problems. The marketing channels for high quality specialty cheeses are very different than for commodity cheese types, indicating new challenges for the plant's marketing staff. Compared to a cheese plant producing only one specialty cheese or several related specialty cheeses, management expertise will have to be much higher in plants producing both Cheddar and specialty cheese because of more varied production requirements.

This study also does not address the impact on the Cheddar plant during the modification for alternate-day or concurrent specialty production. Cheddar production could be disrupted for several months, or longer, increasing operating costs. Another consideration is how long before the plant can produce specialty cheese with consistently high quality. Again, management's ability, expertise and knowledge will determine these issues.

FUTURE RESEARCH

This study addresses many questions concerning the possible diversification of the Cheddar industry through specialty cheese production, but some aspects of specialty cheese production feasibility, as well as diversification of the Cheddar industry, still need to be addressed. Future research should:

1. Survey the current domestic specialty cheese industry, including the marketing chain for specialty cheeses to identify cheese types and regions which could provide sales opportunities for domestic producers;

2. Determine consumer tastes, preferences, and perceptions of specialty cheeses in order to identify effective marketing strategies for cheeses with good market potential;

3. Estimate production costs of other specialty cheeses, including soft ripened cheeses such as brie and camembert;

4. Identify the impact of United States regulations preventing the use of nitrates in specialty cheese manufacturing, while imported cheeses contain nitrates which avert quality defects from developing during the cheeses' aging process; and

5. Identify cheesemaking systems and equipment flexible enough to manufacture a variety of specialty cheese types.

The results of this study indicate specialty cheese has the potential to be manufactured profitably in the United States, although marketing opportunities are limited and still need to be studied. Individuals and organizations that can develop and market a high quality product first will have an advantage over competitors. Innovation requires risk taking, but research can provide information for selecting appropriate alternatives to maximize the potential for success.

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APPENDIX A

CAPITAL INVESTMENT COST ESTIMATION[1]

Capital depreciation and interest costs were calculated on a cost per operating day basis. The total capital Investment less the discounted salvage value of the capital goods were annualized over the operating life of the corresponding asset. The annual cost were then converted to daily costs depending on the number of days per week the plant or equipment was operated per year. The number of days per week of operation for the equipment depended upon whether the equipment was designated as equipment used for just Cheddar, just specialty, or both Cheddar and specialty production and on the production schedule which determined the days per week just specialty cheese, just Cheddar cheese or both Cheddar and specialty was produced. The mathematical expression for this calculation was:

$$\text{Total Capital Investment Costs} = CCI_i \qquad i = 1,\ldots,n$$

$$CCI_i = \frac{ICI_i - DSV_i}{i \times OD_i}$$

Where:

$$DSV_i = SV_i \times i$$

$$i = \frac{(1 - i) \times 100}{DR}$$

$$i = (1 + \frac{DR}{100}) - OL_i$$

$$OL_i = EL_i \times [1 + (1 - \frac{PCU}{100})]$$

<u>Definition Of Variables</u>

CCI_i = Capital Investment Cost for capital good i (dollars).

ICI_i = Initial Capital Investment in capital good i (dollars).

DSV_i = Discounted Salvage Value of capital good i (dollars).

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[1]Mesa-Dishington, J.K. <u>Production Costs and Economies of Size in Cheddar Cheese Manufacturing: An Economic-Engineering Approach</u>," Unpublished Master's Thesis, 1986, Cornell University, Department of Agricultural Economics, Ithaca, NY.

APPENDIX A (Continued)

OD_i = Operating Days per year of capital good i (number).

SV_i = Salvage Value of capital good i (dollars).

DR = Annual real interest rate used to discount and to annualize the values of the different capital goods (percentage).

Definition Of Variables (continued)

OL_i = Adjusted Operating Life of capital good i (years).

EL_i = Expected Life of capital good i with plant operating at full capacity (years).

PCU_i = Plant Capacity Utilization (percentage).

i = Standard factor to annualize a current value over a period of years.

i = Standard factor to compute the present value of a future value.

APPENDIX B

LABOR REQUIREMENTS FOR THE MODEL PLANTS

Model	Direct Fixed	Direct Variable
	(Man Hours Per 24 Hour Day)	
Existing Cheddar Plant	39.5	428.5
	Labor Requirements For Alternate-Day or Concurrent Manufacturing	
AHJ	43.5	293.5
ALJ	43.5	343.5
CHJ	20.0	462.5
CLJ	20.0	484.0
AHH	52.5	360.5
ALH	52.5	422.5
CHH	23.0	499.0
CLH	23.0	511.0
	Labor Requirements For Specialty-Only Plants	
SHJ	46.0	315.0
SLJ	46.0	335.0
SHH	49.0	346.5
SLH	49.0	362.5
LHJ	43.5	293.5
LLJ	43.5	343.5
LHH	52.5	360.5
LLH	52.5	422.5

APPENDIX C

ELECTRICITY REQUIREMENTS FOR THE MODEL PLANTS

Model	Fixed	Variable
	(KW/Oper. Hour)	(KW/Million Lbs. Milk)
Existing Cheddar Plant	55.8	2282.0
	Electricity Requirements For Alternate-Day or Concurrent Manufacturing	
AHJ	87.3	203.8
ALJ	104.3	193.8
CHJ	64.2	3160.8*
CLJ	77.1	3127.2*
AHH	107.2	197.4
ALH	121.5	183.3
CHH	74.0	3322.9*
CLH	87.8	3270.5*
	Electricity Requirements For Specialty-Only Plants	
SHJ	90.0	512.0
SLJ	103.0	493.0
SHH	109.0	584.0
SLH	125.0	561.0
LHJ	122.7	203.8
LLJ	139.7	193.8
LHH	160.1	215.3
LLH	174.4	201.2

* Variable electricity requirements for concurrent manufacturing of specialty and Cheddar cheese are high relative to other manufacturing scenarios because of inefficiencies in processing. Concurrent manufacturing requires both Cheddar and specialty equipment to remain in operation between batches. Therefore, the average KW usage per pound of milk is very high.

APPENDIX D

NATURAL GAS REQUIREMENTS FOR THE MODEL PLANTS

Model	Fixed	Variable
	(Therms/Day)	(Therms/Million Lbs. Milk)
Existing Cheddar Plant	359.8	1959.8
	Natural Gas Requirements For Alternate-Day or Concurrent Manufacturing	
AHJ	95.0	867.2
ALJ	95.0	867.2
CHJ	125.0	1146.5
CLJ	125.0	983.9
AHH	95.0	1147.8
ALH	95.0	1147.8
CHH	125.0	1345.3
CLH	125.0	1241.0
	Natural Gas Requirements For Specialty-Only Plants	
SHJ	298.0	2792.0
SLJ	282.0	2572.0
SHH	288.0	3277.0
SLH	288.0	2999.0
LHJ	95.0	867.2
LLJ	95.0	867.2
LHH	95.0	1147.8
LLH	95.0	1147.8

APPENDIX E

WATER REQUIREMENTS FOR THE MODEL PLANTS

Model	Fixed	Variable
	(Gallons/Day)	(Gal./Million Lbs. Milk)
Existing Cheddar Plant	64,753	N.A.
	Water Requirements For Alternate-Day or Concurrent Manufacturing	
AHJ	35,044	69,572
ALJ	29,044	69,572
CHJ	32,807	155,003*
CLJ	27,557	155,003*
AHH	37,294	75,930
ALH	29,044	75,930
CHH	32,807	170,821*
CLH	27,557	170,821*
	Water Requirements For Specialty-Only Plants	
SHJ	24,015	137,594
SLJ	19,481	130,538
SHH	24,575	159,110
SLH	17,981	147,014
LHJ	35,194	69,572
LLJ	29,194	69,572
LHH	37,509	75,930
LLH	29,259	75,930

* Variable water requirements for concurrent manufacturing of specialty and Cheddar cheese are high relative to other manufacturing scenarios because of inefficiencies in processing. Concurrent manufacturing requires both Cheddar and specialty equipment to remain in operation between batches (including cheese mold and hoop washers). Therefore, the average water usage per pound of milk is very high.

N.A. = not applicable

APPENDIX E (Continued)

SEWAGE OUTPUT FOR THE MODEL PLANTS

Model	Fixed	Variable
	(Gallons/Day)	(Gal./Million Lbs. Milk)
Existing Cheddar Plant	62,141	N.A.
	Sewage Output For Alternate-Day or Concurrent Manufacturing	
AHJ	28,934	52,304
ALJ	22,934	52,304
CHJ	26,697	137,737*
CLJ	21,447	137,737*
AHH	31,184	50,659
ALH	22,934	50,659
CHH	26,697	145,549*
CLH	21,447	145,549*
	Sewage Output For Specialty-Only Plants	
SHJ	24,015	137,474
SLJ	19,481	130,418
SHH	24,575	158,990
SLH	17,981	146,894
LHJ	29,084	52,304
LLJ	23,084	52,304
LHH	31,399	50,659
LLH	23,149	50,659

* Variable sewage requirements for concurrent manufacturing of specialty and Cheddar cheese are high relative to other manufacturing scenarios because of inefficiencies in processing. Concurrent manufacturing requires both Cheddar and specialty equipment to remain in operation between batches (including cheese mold and hoop washers). Therefore, the average water and sewage usage per pound of milk is very high.

N.A. = not applicable

APPENDIX F

CHEDDAR CHEESE PRODUCTION MATERIALS

	Requirement Per 1,000 Pounds Raw Milk		Cost
	(Quantity)	(Units)	(Dollars)
Rennet[1] (Single Strength)	3.00	fl oz	1.3580
Salt	2.85	lbs	0.0203
Calcium Chloride	3.00	fl oz	0.0730
Color[2]	0.50	fl oz	0.0730
Starter Culture:[3]			
Bulk Starter Media	1.20	lbs	1.0310
Starter Bacteria	1.44	ml	0.0418
Total Cost Per 1,000 Pounds Raw Milk			2.5971

[1]Assumes calf rennet was used for manufacturing high quality aged Cheddar cheese.

[2]Assumes production of 50 percent white and 50 percent colored Cheddar cheese.

[3]Assumes bulk starter culture used at one percent of milk volume; bulk starter culture media with 12 percent solids; and 1.2 milliliters of frozen bacteria concentrate sets about one gallon of bulk starter.

APPENDIX F (Continued)

JARLSBERG-TYPE CHEESE PRODUCTION MATERIALS

	Requirement Per 1,000 Pounds Standardized Milk		Cost
	(Quantity)	(Units)	(Dollars)
Rennet[1] (Single Strength)	3.00	fl oz	1.3580
Salt	1.25	lbs	0.0090
Starter Culture:[2]			
Bulk Starter Media	1.20	lbs	1.0310
Chris Hansen's BDCHNOI	1.00	Package	0.0474
Propionic Acid Bacteria	1.75	ml	0.2690
Total Cost Per 1,000 Pounds Raw Milk			2.7144

[1]Assumes calf rennet was used for manufacturing high quality aged Jarlsberg-type cheese.

[2]Assumes bulk starter culture used at one percent of milk volume; bulk starter culture media with 12 percent solids; one package Chris Hansen's BDCHNO1 sets 220,000 pounds standardized milk; and 70 milliliters frozen Propionic acid bacteria sets 40,000 pounds standardized milk.

APPENDIX F (Continued)

HAVARTI CHEESE PRODUCTION MATERIALS

	Requirement Per 1,000 Pounds Standardized Milk		Cost
	(Quantity)	(Units)	(Dollars)
Rennet[1] (Single Strength)	3.00	fl oz	1.3580
Salt	3.09	lbs	0.0220
Starter Culture:[2]			
Bulk Starter Media	1.20	lbs	1.0310
Chris Hansen's BDCHNOI	1.00	Package	0.0474
Total Cost Per 1,000 Pounds Raw Milk			2.4584

[1]Assumes calf rennet was used for manufacturing high quality aged Havarti cheese.

[2]Assumes bulk starter culture used at one percent of milk volume; bulk starter culture media with 12 percent solids; and one package Chris Hansen's BDCHNO1 sets 220,000 pounds standardized milk.

APPENDIX G

LABORATORY SUPPLIES

Standard Tests	
Antibiotics In Raw Milk	
Bacteria Count In Raw Milk	
Milk Fat	
Milk Protein	
pH	
Protein In Unseparated Whey	
Fat In Unseparated Whey	
Fat In Separated Whey	
Fat In Whey Cream	
Cheese Moisture	
Cheese Fat	
Cheese Salt	
Waste Water BOD	
Total Cost Per 1,000,000 Pounds Raw Milk	\$63.10[1]

[1]Includes only the cost of chemicals and materials for the tests listed.

APPENDIX H

CLEANING SUPPLIES FOR THE MODEL PLANTS

Model	Cost
	(Dollars/Operating Day)
Existing Cheddar Plant	340
	Cleaning Supplies For Alternate-Day or Concurrent Manufacturing
AHJ	195
ALJ	195
CHJ	80
CLJ	80
AHH	192
ALH	192
CHH	77
CLH	77
	Cleaning Supplies For Specialty-Only Plants
SHJ	263
SLJ	263
SHH	254
SLH	254
LHJ	195
LLJ	195
LHH	192
LLH	192

APPENDIX I

OTHER EXPENSES FOR ALTERNATE-DAY, CONCURRENT, AND LARGE MODEL PLANTS

Item	Cost
	(Dollars/Year)
Accounting and Office Supplies	8,400
Communication and Travel	5,136
Laundry	20,169
Telephone	23,760
Other Services	5,300
Total Annual Cost	62,755

OTHER EXPENSES FOR SMALL MODEL PLANTS

Item	Cost
	(Dollars/Year)
Accounting and Office Supplies	4,000
Communication and Travel	2,675
Laundry	10,080
Telephone	11,880
Other Services	3,200
Total Annual Cost	31,835

APPENDIX J

PRODUCTION COSTS FOR 960,000 POUNDS OF MILK PER DAY EXISTING CHEDDAR CHEESE PLANT USED FOR ALTERNATE-DAY AND CONCURRENT MANUFACTURING[1]

Item	Cost
	(Cents per Pound of Cheddar Cheese)
Labor	
Supervisory	0.5
Direct Fixed	0.5
Direct Variable	5.5
Total Labor	6.4
Capital Costs	
Depreciation & Interest	2.5
Utilities	
Electricity	0.2
Fuel	0.9
Water & Sewage	0.1
Total Utilities	1.2
Materials	
Laboratory	0.1
Production	2.9
Packaging	1.3
Cleaning	0.4
Total Materials	4.3
Repair & Maintenance	0.2
Property Tax & Insurance	0.7
Production Inventory	0.2
Other Expenses	0.3
TOTAL	15.8

[1]Production costs updated to Spring 1987 levels from Mesa-Dishington study; production costs for 960,000 thousand pounds of milk per day Cheddar plant operating 5 days per week·24 hours per day, manufacturing 2,496,000 pounds of Cheddar cheese a year.

APPENDIX K

WHEY HANDLING COSTS FOR
LARGE JARLSBERG-TYPE, SPECIALTY-ONLY PLANT

Cost Item	Cost Range Over Production Schedules[1]
	(Cents per Pound of Jarlsberg-type Cheese)
Labor	
Supervisory	(0.2 - 0.2)
Direct Fixed	(0.1 - 0.2)
Direct Variable	(1.7 - 1.7)
Total Labor	(2.0 - 2.1)
Capital Costs	
Depreciation & Interest	(1.5 - 7.7)
Utilities	
Electricity	(0.04 - 0.04)
Fuel	(0.8 - 0.8)
Water & Sewage	(0.2 - 0.2)
Total Utilities	(1.0 - 1.1)
Materials	
Laboratory	(N.A. - N.A.)
Production	(0.1 - 0.1)
Packaging	(0.4 - 0.4)
Cleaning	(0.1 - 0.2)
Total Materials	(0.6 - 0.6)
Repair & Maintenance	(0.2 - 0.3)
Property Tax & Insurance	(0.5 - 2.5)
Production Inventory	(0.0 - 0.0)
Other Expenses	(0.0 - 0.2)
TOTAL	(5.9 - 14.6)

[1]Cost range is reported for large whey plant processing liquid whey into Grade A and animal grade whey powder for the large Jarlsberg-type plant producing between 33,091,968 and 6,303,232 pounds of cheese annually.

N.A. = not applicable

APPENDIX L

WHEY HANDLING COSTS FOR
LARGE HAVARTI, SPECIALTY-ONLY PLANT

Cost Item	Cost Range Over Production Schedules[1]
	(Cents per Pound of Havarti Cheese)
Labor	
Supervisory	(0.1 - 0.2)
Direct Fixed	(0.1 - 0.1)
Direct Variable	(1.2 - 1.2)
Total Labor	(1.4 - 1.4)
Capital Costs	
Depreciation & Interest	(1.0 - 5.2)
Utilities	
Electricity	(0.02 - 0.02)
Fuel	(0.5 - 0.5)
Water & Sewage	(0.1 - 0.2)
Total Utilities	(0.6 - 0.7)
Materials	
Laboratory	(N.A. - N.A.)
Production	(0.04 - 0.04)
Packaging	(0.3 - 0.3)
Cleaning	(0.1 - 0.1)
Total Materials	(0.4 - 0.4)
Repair & Maintenance	(0.2 - 0.2)
Property Tax & Insurance	(0.3 - 1.7)
Production Inventory	(0.0 - 0.0)
Other Expenses	(0.0 - 0.1)
TOTAL	(3.9 - 9.7)

[1]Cost range is reported for large whey plant processing liquid whey into Grade A and animal grade whey powder for the large Havarti plant producing between 49,201,152 and 9,371,648 pounds of cheese annually.

N.A. = not applicable

APPENDIX M

WHEY HANDLING COSTS FOR SMALL JARLSBERG-TYPE, SPECIALTY-ONLY PLANT

Cost Item	Cost Range Over Production Schedules[1]
	(Cents per Pound of Jarlsberg-type Cheese)
Labor	
Supervisory	(0.4 - 0.6)
Direct Fixed	(0.3 - 0.4)
Direct Variable	(4.3 - 4.3)
Total Labor	(5.0 - 5.3)
Capital Costs	
Depreciation & Interest	(2.9 - 14.4)
Utilities	
Electricity	(0.04 - 0.1)
Fuel	(0.8 - 0.8)
Water & Sewage	(0.3 - 0.3)
Total Utilities	(1.1 - 1.2)
Materials	
Laboratory	(N.A. - N.A.)
Production	(0.1 - 0.1)
Packaging	(0.4 - 0.4)
Cleaning	(0.2 - 0.3)
Total Materials	(0.7 - 0.8)
Repair & Maintenance	(0.4 - 0.6)
Property Tax & Insurance	(0.9 - 4.7)
Production Inventory	(0.0 - 0.0)
Other Expenses	(0.1 - 0.4)
TOTAL	(11.0 - 27.2)

[1]Cost range is reported for small whey plant processing liquid whey into Grade A and animal grade whey powder for the small Jarlsberg-type plant producing between 13,268,895 and 2,527,409 pounds of cheese annually.

N.A. = not applicable

APPENDIX N

WHEY HANDLING COSTS FOR
SMALL HAVARTI, SPECIALTY-ONLY PLANT

Cost Item	Cost Range Over Production Schedules[1]
	(Cents per Pound of Havarti Cheese)
Labor	
Supervisory	(0.3 - 0.4)
Direct Fixed	(0.2 - 0.3)
Direct Variable	(2.9 - 2.9)
Total Labor	(3.4 - 3.6)
Capital Costs	
Depreciation & Interest	(1.9 - 9.7)
Utilities	
Electricity	(0.03 - 0.04)
Fuel	(0.5 - 0.5)
Water & Sewage	(0.2 - 0.2)
Total Utilities	(0.7 - 0.7)
Materials	
Laboratory	(N.A. - N.A.)
Production	(0.04 - 0.04)
Packaging	(0.3 - 0.3)
Cleaning	(0.1 - 0.2)
Total Materials	(0.4 - 0.5)
Repair & Maintenance	(0.3 - 0.4)
Property Tax & Insurance	(0.6 - 3.2)
Production Inventory	(0.0 - 0.0)
Other Expenses	(0.0 - 0.2)
TOTAL	(7.3 - 18.3)

[1]Cost range is reported for small whey plant processing liquid whey into Grade A and animal grade whey powder for the small Havarti plant producing between 19,716,812 and 3,755,583 pounds of cheese annually.

N.A. = not applicable

APPENDIX O

JARLSBERG-TYPE CHEESE:
LOW AUTOMATION CHEESE PRODUCTION COSTS
THREE MANUFACTURING SCENARIOS[1]

Approximate Jarlsberg-Type Production	Alternate-Day Manufacturing	Concurrent Manufacturing	Small Specialty-Only Plant
(1000/Lbs/Year)	(Cents per Pound)		
9,479	23.9	36.2	37.9
8,125	25.5	37.5	40.4
6,771	28.0	39.4	43.0
5,643	31.0	41.5	47.1
3,611	40.6	50.0	56.7
1,806	63.1	68.0	89.7

[1]Incremental costs were used to estimate alternate-day and concurrent production costs. Total production costs were used to estimate specialty-only plant production costs.

APPENDIX P

HAVARTI CHEESE: LOW AUTOMATION CHEESE PRODUCTION COSTS THREE MANUFACTURING SCENARIOS

Approximate Havarti Production	Alternate-Day Manufacturing	Concurrent Manufacturing	Small Specialty-Only Plant
(1000/Lbs/Year)	--------------(Cents per Pound)	---------------	
14,094	19.1	26.6	29.2
12,081	20.5	27.6	30.6
10,067	22.5	29.0	32.7
8,389	24.9	30.6	35.1
5,369	31.5	36.9	44.3
2,685	52.4	49.9	69.7

[1]Incremental costs were used to estimate alternate-day and concurrent production costs. Total production costs were used to estimate specialty-only plant production costs.

APPENDIX Q

NEW YORK MILK COMPOSITION AND THEORETICAL PRODUCT YIELDS

	JAN 88	FEB 88	MAR 88	APR 88	MAY 88	JUN 88	JUL 88	AUG 88	SEP 88	OCT 88	NOV 88	DEC 88	AVG
MILK COMPOSITION													
Percent Fat	3.74%	3.61%	3.60%	3.56%	3.54%	3.44%	3.37%	3.41%	3.58%	3.60%	3.70%	3.68%	3.57%
Percent Protein	3.28%	3.20%	3.23%	3.22%	3.18%	3.18%	3.10%	3.14%	3.22%	3.32%	3.30%	3.29%	3.22%
CHEESE YIELDS (LBS)													
Cheddar	10.27	9.95	9.98	9.90	9.82	9.65	9.44	9.55	9.93	10.09	10.23	10.18	9.92
Jarlsberg	9.48	9.26	9.35	9.33	9.21	9.22	8.99	9.11	9.32	9.62	9.55	9.52	9.33
Havarti	15.60	15.20	15.37	15.32	15.11	15.15	14.73	14.93	15.32	15.85	15.72	15.66	15.33
WHEY POWDER YIELD (PER CWT Of MILK)													
Cheddar	5.98	5.79	5.87	5.82	5.94	5.84	5.85	5.73	5.67	5.74	5.77	5.74	5.81
Jarlsberg	5.87	5.71	5.78	5.74	5.86	5.77	5.78	5.65	5.6	5.66	5.68	5.66	5.73
Havarti	6.08	5.99	5.99	5.95	6.07	5.97	5.98	5.85	5.8	5.87	5.89	5.87	5.94
LBS FRESH CREAM (ADDED OR REMOVED)													
Cheddar	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Jarlsberg	-2.13	-1.98	-1.88	-1.80	-1.84	-1.58	-1.58	-1.59	-1.85	-1.67	-1.98	-1.95	-1.82
Havarti	8.41	8.29	8.49	8.55	8.36	8.64	8.35	8.48	8.49	9.04	8.64	8.63	8.53
WHEY CREAM YIELD (LBS Of CREAM)													
Cheddar	0.59	0.56	0.56	0.56	0.56	0.54	0.54	0.54	0.56	0.56	0.59	0.59	0.56
Jarlsberg	0.79	0.77	0.77	0.77	0.77	0.77	0.74	0.74	0.77	0.79	0.79	0.79	0.77
Havarti	2.41	2.34	2.36	2.36	2.32	2.32	2.27	2.30	2.36	2.43	2.41	2.41	2.36

APPENDIX R

WISCONSIN MILK COMPOSITION AND THEORETICAL PRODUCT YIELDS

	JAN 88	FEB 88	MAR 88	APR 88	MAY 88	JUN 88	JUL 88	AUG 88	SEP 88	OCT 88	NOV 88	DEC 88	AVG
MILK COMPOSITION													
Percent Fat	3.87%	3.72%	3.73%	3.63%	3.55%	3.54%	3.46%	3.46%	3.73%	3.78%	3.87%	3.78%	3.68%
Percent Protein	3.33%	3.27%	3.26%	3.25%	3.20%	3.22%	3.13%	3.19%	3.30%	3.40%	3.37%	3.36%	3.27%
CHEESE YIELDS (LBS)													
Cheddar	10.54	10.22	10.23	10.05	9.86	9.87	9.62	9.70	10.28	10.49	10.56	10.44	10.16
Jarlsberg	9.61	9.45	9.63	9.59	9.44	9.33	9.07	9.25	9.54	9.84	9.70	9.72	9.51
Havarti	15.83	15.55	15.48	15.48	15.22	15.33	14.87	15.20	15.71	16.22	16.00	16.02	15.58
WHEY POWDER YIELD (PER CWT OF MILK)													
Cheddar	5.79	5.78	5.83	5.82	5.93	5.83	5.78	5.74	5.70	5.72	5.77	5.72	5.78
Jarlsberg	5.70	5.70	5.73	5.73	5.84	5.75	5.70	5.67	5.61	5.64	5.68	5.63	5.70
Havarti	5.91	5.91	5.95	5.95	6.06	5.95	5.90	5.87	5.82	5.85	5.89	5.84	5.91
LBS FRESH CREAM (ADDED OR REMOVED)													
Cheddar	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Jarlsberg	-2.36	-2.10	-2.15	-1.92	-1.82	-1.75	-1.75	-1.61	-2.06	-1.96	-2.26	-2.05	-1.98
Havarti	8.35	8.40	8.31	8.53	8.45	8.60	8.28	8.64	8.55	9.02	8.55	8.78	8.54
WHEY CREAM YIELD (LBS OF CREAM)													
Cheddar	0.61	0.59	0.59	0.56	0.56	0.56	0.54	0.54	0.59	0.59	0.61	0.59	0.58
Jarlsberg	0.79	0.79	0.79	0.77	0.77	0.77	0.74	0.74	0.79	0.81	0.79	0.79	0.77
Havarti	2.43	2.39	2.39	2.39	2.34	2.36	2.30	2.34	2.41	2.50	2.45	2.45	2.39

APPENDIX S

NEW YORK PRICE AND COST DATA

	JAN 88	FEB 88	MAR 88	APR 88	MAY 88	JUN 88	JUL 88	AUG 88	SEP 88	OCT 88	NOV 88	DEC 88	AVG
PRICE DATA													
Raw Milk/Cwt	$11.85	$11.34	$11.08	$10.88	$10.83	$10.66	$10.90	$11.49	$12.21	$12.64	$13.14	$13.15	$11.6
Whey Powder (extra)/Lb	0.20	0.17	0.16	0.18	0.21	0.26	0.29	0.27	0.21	0.16	0.15	0.16	0.2
Fresh Cream (40% bf)/Lb Fat	0.61	0.60	0.60	0.60	0.60	0.62	0.62	0.62	0.62	0.61	0.60	0.60	0.6
Whey Cream (40% bf)/Lb Fat	0.53	0.53	0.53	0.53	0.53	0.54	0.55	0.55	0.54	0.53	0.53	0.53	0.5
Cheddar/Lb of Cheese	1.36	1.32	1.32	1.32	1.32	1.33	1.35	1.43	1.48	1.50	1.50	1.50	1.3
Jarlsberg/Lb of Cheese	1.79	1.75	1.75	1.75	1.75	1.76	1.78	1.86	1.91	1.93	1.93	1.93	1.8
Havarti/Lb of Cheese	1.64	1.60	1.60	1.60	1.60	1.61	1.63	1.71	1.76	1.78	1.78	1.78	1.6
CHEESE MANUFACTURING COSTS													
Cheddar/Cwt Milk	1.58	1.58	1.58	1.58	1.58	1.58	1.57	1.57	1.58	1.58	1.58	1.58	1.5
Jarlsberg/Cwt Milk	3.22	3.22	3.22	3.22	3.22	3.22	3.21	3.22	3.22	3.22	3.22	3.22	3.2
Havarti/Cwt Milk	4.30	4.29	4.29	4.29	4.29	4.29	4.28	4.28	4.29	4.31	4.30	4.30	4.2
WHEY MANUFACTURING COSTS													
Cheddar/Lb Whey Powder	0.105	0.108	0.107	0.108	0.106	0.107	0.107	0.109	0.110	0.109	0.109	0.109	0.1
Jarlsberg/Lb Whey Powder	0.062	0.064	0.063	0.063	0.062	0.063	0.063	0.064	0.065	0.064	0.064	0.064	0.0
Havarti/Lb Whey Powder	0.069	0.070	0.070	0.070	0.069	0.070	0.070	0.071	0.072	0.071	0.071	0.071	0.0

APPENDIX T

WISCONSIN PRICE AND COST DATA

	JAN 88	FEB 88	MAR 88	APR 88	MAY 88	JUN 88	JUL 88	AUG 88	SEP 88	OCT 88	NOV 88	DEC 88	AVG
PRICE DATA													
Raw Milk/Cwt	$12.17	$11.63	$11.48	$11.23	$11.12	$11.10	$11.16	$11.62	$12.53	$13.01	$13.49	$13.39	$11.99
Whey Powder (extra)/Lb	0.18	0.16	0.15	0.16	0.19	0.24	0.27	0.25	0.20	0.15	0.14	0.15	0.19
Fresh Cream (40% bf)/Lb Fat	0.61	0.60	0.60	0.60	0.60	0.62	0.62	0.62	0.62	0.62	0.61	0.60	0.61
Whey Cream (40% bf)/Lb Fat	0.53	0.53	0.53	0.53	0.53	0.54	0.55	0.55	0.54	0.53	0.53	0.53	0.54
Cheddar/Lb of Cheese	1.23	1.19	1.19	1.19	1.19	1.20	1.22	1.30	1.35	1.37	1.37	1.37	1.26
Jarlsberg/Lb of Cheese	1.79	1.75	1.75	1.75	1.75	1.76	1.78	1.86	1.91	1.93	1.93	1.93	1.82
Havarti/Lb of Cheese	1.64	1.60	1.60	1.60	1.60	1.61	1.63	1.71	1.76	1.78	1.78	1.78	1.67
CHEESE MANUFACTURING COSTS													
Cheddar/Cwt Milk	1.59	1.58	1.58	1.58	1.58	1.58	1.58	1.58	1.58	1.59	1.59	1.59	1.58
Jarlsberg/Cwt Milk	3.22	3.22	3.22	3.22	3.22	3.22	3.22	3.22	3.22	3.23	3.23	3.23	3.22
Havarti/Cwt Milk	4.31	4.30	4.30	4.30	4.29	4.29	4.28	4.29	4.30	4.32	4.31	4.31	4.30
WHEY MANUFACTURING COSTS													
Cheddar/Lb Whey Powder	0.108	0.108	0.107	0.107	0.106	0.107	0.108	0.109	0.110	0.109	0.108	0.109	0.11
Jarlsberg/Lb Whey Powder	0.064	0.064	0.063	0.063	0.062	0.063	0.064	0.064	0.065	0.064	0.064	0.064	0.06
Havarti/Lb Whey Powder	0.070	0.070	0.070	0.070	0.069	0.070	0.071	0.071	0.071	0.071	0.071	0.071	0.07

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