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Minnesota Farm Business Notes

Do Flexible Dairy Manufacturing Plants Pay?

Orval G. Kerchner and E. Fred Koller

Should Minnesota dairy plant managers increase the flexibility of their operations? Recent cheese prices have been relatively high compared to butter prices. Perhaps dairy plants should be flexible enough to take advantage of these price differences. If cheese prices should drop, a flexible plant could shift to butter production within a short time.

Recently, the University's Department of Agricultural Economics and the U. S. Department of Agriculture (USDA) made a joint study of dairy plant flexibility. Flexibility is the capacity to shift from manufacturing one group of products to another as prices change. The two product combinations considered were: (1) butter, nonfat dry milk, and dry buttermilk and (2) Cheddar cheese, dry whey, and whey cream butter.

Table 1. Fixed costs of the model flexible dairy plant for each alternative operation, 1965*

Operation	Daily fixed cost	Unit cost†
	- - - - - dollars - - - - -	
Butter	781.94	1.56
Cheese	862.44	1.72

* Plant is equipped to process a maximum of 500,000 pounds of whole milk per day.
† Per 1,000 pounds of whole milk.

Table 2. Variable costs of the model flexible dairy plant per 1,000 pounds of whole milk manufactured for each alternative operation, 1965*

Item	Operation: Butter	Cheese
	- - - - - dollars - - - - -	
Labor	0.30	1.01
Fuel	0.27	0.31
Electricity	0.13	0.13
Water and sewage	0.01	—†
Packaging supplies	0.37	1.03
General supplies	0.06	0.34
Total	1.14	2.82

* Plant is equipped to process a maximum of 500,000 pounds of whole milk per day.
† Less than 1 cent.

The Model Plant

A model flexible plant was designed that handled a maximum daily capacity of 500,000 pounds of whole milk. We used this plant as the basis for synthesizing selected dairy product processing costs for the year 1965. Equipment engineers and dairy industry personnel helped design the plant. They supplied equipment specifications and input-output relationships needed to calculate processing costs.

We divided the model plant into physically definable areas called processing centers. These processing centers were: receiving, butter making, evaporating and drying, powder packaging and warehouse, starter room, cheese making, cooler, boiler, refrigeration, laboratory, general service, and office.

In developing cost data, the input-output relationships used for each center represented, as nearly as possible, ideal plant organization and operation.

Model Plant Costs

We divided the flexible plant's processing costs into fixed and variable categories. Fixed costs are incurred as soon as a plant begins operation; they remain constant regardless of how much milk is processed. But variable costs change as the amount of milk processed varies.

For each of the two alternative operations in the flexible plant, we determined the fixed processing costs. Fixed costs included: depreciation; insurance; taxes; interest; repairs and maintenance; and the labor, fuel, electricity, water, and supplies associated with equipment setup and cleanup.

Because of differences in certain fixed inputs, fixed costs differed for the two operations (table 1). In the cheese operation, some costs were incurred in the starter room and cheese making

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Processing Costs in Minnesota Butter-Powder Plants

J. W. Hanlon and E. Fred Koller

Much of the milk produced in Minnesota is manufactured into butter and nonfat dry milk. In recent years, about 70 percent of the state's milk output was processed into these products. This processing is done at several types of dairy plants, including: (1) specialized butter plants, (2) specialized milk drying plants, and (3) combination butter-nonfat dry milk or butter-powder plants.

The trend has been a movement away from specialized plants toward butter-powder plants. The number of butter-powder plants in Minnesota rose from 7 in 1938 to 55 in 1963. During the same time, the output of butter from these plants increased from 1 percent of the state's total to 51 percent.

In view of the importance of butter-powder plants, dairy leaders are interested in the methods of operation and the sizes of plants that are most efficient and yield the lowest average processing costs. Plants in Minnesota vary greatly in size.

Recently, the Department of Agricultural Economics studied the relationships between processing costs and plant size in butter-powder firms. This article presents a brief summary of our method of analysis and some results.

Method of Cost Study

In economic studies, relationships between cost and size differ according to the time period involved. The short run is a period so short that plant size cannot be changed. Therefore, a short-run cost curve indicates the effect on unit cost of changing the volume of milk processed in a given plant. Within a given plant, the cost of processing 1,000 pounds of milk can be reduced to a minimum point as volume is increased and increasing use is made of buildings, equipment, and other fixed resources.

Short-run costs are either variable or fixed. Variable costs increase as output increases beyond the first unit; fixed costs do not change beyond the first unit of output.

The long run is a period sufficiently long to allow all resources to be varied in amount. In the long run, the size of plant and equipment can be changed. The long-run cost curve (also known as the economies-to-size curve) shows the lowest processing cost for each volume over the entire range of plant sizes. Managers must consider short-run

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Dairy Manufacturing Plants . . .

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centers which did not exist when butter was made. Based on a maximum of 500,000 pounds of milk per day, fixed costs per 1,000 pounds of whole milk were $1.56 and $1.72 in the flexible plant's butter and cheese operations, respectively.

Variable costs for the two operations also differed (table 2). Total variable costs per 1,000 pounds of milk were $1.14 for the butter operation and $2.82 for the cheese operation. The cheese operation required more labor and more costly packaging supplies than did the butter operation.

In both operations, labor and packaging supplies accounted for the largest proportion of variable costs. Labor costs were 26 and 36 percent of total variable costs in the butter and cheese operations, respectively. Labor requirements in cheese making were greater than in butter making.

For the year, average processing costs were $3.16 and $5.05 per 1,000 pounds of milk in the flexible butter and cheese operations, respectively. Average costs in the butter operation ranged from $2.70 in May, the month of highest production, to $4.49 in September, the month of lowest production. Average cheese processing costs varied from $4.55 in May to $6.51 in September.

For comparative purposes, we also computed processing costs for: (1) a combination butter-powder plant and (2) a cheese and dry whey plant using the flexible plant's data. By including only the needed processing centers for each combination plant, we made the necessary cost adjustments. The same daily capacity and annual volume used in the flexible plant were used for each combination plant.

On a yearly basis, the average processing costs per 1,000 pounds of whole milk were $2.91 in the butter-powder plant and $4.98 in the cheese-dry whey plant.

Product Prices

Once processing costs were calculated, we used product prices and yields to determine monthly gross receipts for the flexible and the two combination plants. Monthly product prices were obtained from published USDA reports. Product yields were based on whole milk containing 3.5 percent butterfat and 8.5 percent nonfat solids.

Of course, cheese and butter prices varied from month to month, but not always to the same degree or direction. To determine the relationship between the two price series, we computed the monthly cheese-butter price ratios (the wholesale cheese price per pound divided by the wholesale butter price per pound).

Since 1950, the ratio has fluctuated, showing a general upward trend. Some significant fluctuations occurred from late 1959 to early 1961—a period when cheese prices increased relative to butter prices. In December 1960, the ratio reached a high of 0.625 from a low of 0.506 in September 1959. This change was an increase of 24 percent from the low to the high.

Rather large fluctuations and differences in butter and cheese prices again occurred in 1965 and early 1966. In December 1964, the cheese-butter price ratio was 0.618 and dropped to 0.575 in January 1965. The ratio reached a low of 0.565 in September 1965 but advanced to 0.685 in March 1966—an increase of 21 percent.

Net Returns

With the cost, price, and yield information, we were able to determine the relative profitability of the flexible dairy plant compared to the butter-powder and cheese-dry whey plants. For this purpose, we studied the monthly and annual net returns per 1,000 pounds of milk in the three plants. Net returns consisted of gross product receipts minus processing costs per 1,000 pounds. We determined the net returns of these plants by using product price data for 1959-64.

Monthly net returns for the flexible plant were the returns from either the butter or cheese operation, whichever was larger. We assumed that the flexible plant shifted each month to the products that produced the largest net return per 1,000 pounds of milk.

When comparing net returns, we found that the flexible plant was more profitable than the butter-powder plant in only 3 of the 72 months during 1959-64. In these 3 months, the return for the flexible plant was from 2 to 41 cents higher per 1,000 pounds of milk. However, net returns to the butter-powder plant in the other 69 months ranged from 19 to 42 cents per 1,000 pounds greater than returns to the flexible plant.

The flexible plant's returns were higher than returns of the cheese plant producing dry whey for animal feed in 69 of the 72 months by amounts ranging from $0.09 to $5.58 per 1,000 pounds. The cheese plant had larger returns than the flexible plant in only 3 months and in amounts ranging from 7 to 10 cents per 1,000 pounds of milk.

On a yearly average returns basis during 1959-64, the flexible plant was always less profitable than the butter-powder plant. But the flexible plant consistently maintained an annual return advantage over the cheese-dry whey plant producing animal feed.

When we considered production of dry whey for human use, at 3 cents a pound over the animal feed price, the flexible plant yielded a higher net return than the cheese-dry whey plant in 49 of the 72 months.

Other Considerations

Some further assumptions underlie the analysis and results stated above. We assumed that:

1. Processing costs did not vary from year to year in the period studied.
2. It was physically possible to shift operations in the flexible plant each month. However, limitations may exist. For instance, acquiring sufficient skilled labor when needed may be impossible without keeping extra personnel on the payroll.

Conclusions

Apparently, the economic feasibility of operating a flexible dairy manufacturing plant is questionable, based on product price relationships and conditions in 1959-64. During most of this period, processing milk was more profitable in the standard butter-powder plant than in the flexible plant.

Plant managers who are thinking about a flexible plant should consider carefully the product price relationships. The degree and duration of price differences between butter and cheese are important. Study results are based on 1959-64 price relationships. For another period, results might be different.

In a flexible plant operation, additional standby plant and equipment must be maintained. Therefore, additional costs must be taken into account.

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Processing Costs . . .

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and long-run relationships when evaluating costs in different size plants.

For this study, we selected four Minnesota butter-powder plants that had daily whole milk capacities of 500,000; 750,000; 1,260,000; and 1,670,000 pounds. Given Minnesota's seasonal pattern of milk production, these amounts are equivalent to an annual plant volume range of 140-470 million pounds.

Costs included in the study were the costs of receiving and processing whole milk into butter and nonfat dry milk. All buttermilk was sold as fluid in bulk. Costs of transporting whole milk and of marketing finished products were not included. Reflected in the annual costs was a seasonal pattern of milk receipts in which 6 percent of the annual receipts occurred in the lowest month and 11 percent in the highest month.

The plants selected had histories of low cost and represented highly efficient operations within their size groups. We obtained data from plant records and interviews with managers, technical plant personnel, and dairy equipment engineers. Since all four plants received both whole milk and skim milk, all plant data were adjusted to a completely whole milk basis.

Cost Rates and Cost Results

Cost rates included in the study represented those currently experienced at dairy plants in central and southeastern Minnesota.

Labor costs included union wages and benefits. Straight time hourly wage rates ranged between $2.18 for common labor and $2.59 for chief engineers and mechanics. A premium of 50 percent of the straight time rate was given for hours in excess of 40 per week. Benefits were social security, 2 weeks of paid vacation, 6 paid holidays, 56 hours of paid sick leave, workmen's compensation, and employee liability insurance.

Included in fuel costs was the use of natural gas. We made an upward adjustment for the propane gas and fuel oil required as standby fuels during cold weather interruptions in natural gas service. The price per 1,000 cubic feet of natural gas was 35 cents for Plants 1 and 2 and 33 cents for 3 and 4.

Electrical energy rates were graduated at 1.55 cents per kilowatt hour (KWH) for the first 20,000 KWH, 1.20 cents for the next 30,000, 1.05 cents for the next 50,000, and 0.94 cent for the next 400,000 KWH. The electrical demand charge, based on the maximum rate at which electricity was used, ranged from $560 to $1,396 per month for the four plants.

We derived two generalizations from the estimated relationships between short-run **total** cost and volume: (1) annual fixed costs increase as plant size increases, and (2) variable costs per unit of whole milk decrease as plant size increases.

Estimated fixed costs totaled $204,000 per year for Plant 1; $295,000 for Plant 2; $499,000 for Plant 3; and $674,000 for Plant 4. As indicated, larger plants required greater capital investment as well as more fuel and electricity to start, clean, and maintain their larger and more numerous equipment items than did smaller plants.

The variable costs per 1,000 pounds of whole milk were approximately $1.45 for Plant 1, $1.21 for Plant 2, $1.19 for Plant 3, and $1.11 for Plant 4. Larger plants also required less additional labor, fuel, and electricity to process an additional unit of milk.

For example, one man or crew may be required to operate a machine or complex of machines regardless of the hourly capacity. Also, a machine with twice the hourly capacity of another probably would require less than twice as much fuel and electricity per additional hour of operation.

Plant labor was the largest cost component for all four plants. At maximum annual capacity, the average cost of plant labor was $1.01 per 1,000 pounds of milk for Plant 1, $0.92 for Plant 2, $0.93 for Plant 3, and $0.97 for Plant 4 (table 1).

Average total costs per 1,000 pounds of milk declined as volume increased within the full range of volumes studied for each plant (table 2). This decrease was due to the spreading of overhead and fixed portions of labor, fuel, and electricity over increased volumes.

Short-run cost estimates indicate that small plants suffered more severe consequences from comparable percentage declines in volume than did large plants. When dropping from 100 to 60 percent of annual capacity, the average cost per 1,000 pounds of whole milk for Plant 1 increased by $1.09; increases for Plants 2, 3, and 4 were only $1.06, $0.87, and $0.89, respectively.

The low cost points of the four short-run average cost curves were estimated points on the long-run average cost curve for the industry. These low points were $2.89, $2.59, $2.58, and $2.54 per 1,000 pounds for the respective plants (table 2).

The estimated long-run average cost curve (economies-to-scale curve) may be represented graphically by a downsloping line connecting these low cost points. According to this curve, there are economies to large scale production in the butter-powder industry since the minimum attainable average cost dropped as the size of plants increased over the full range of volumes studied. However, the cost advantage diminished at large plant sizes until the long-run cost curve became nearly flat at volumes greater than 210 million pounds.

Conclusions

Results of our study indicate the need for a large volume of milk in butter-powder plants if processing costs are to be reduced. Combining the milk volume of several small plants into a large size organization by purchase or consolidation could result in the cost savings described in this article.

Larger butter-powder plants can achieve lower processing costs than smaller plants—economies to size do exist in this industry. Underutilization of capacity in any size plant is costly.

Table 1. Average costs per 1,000 pounds of whole milk at maximum annual capacity in four Minnesota butter-powder plants

Cost component	Plant No. 1	No. 2	No. 3	No. 4
	- - - - dollars	- - - -		
Plant labor	1.01	0.92	0.93	0.97
Overhead*	0.89	0.64	0.75	0.60
Fuel and electricity	0.49	0.52	0.42	0.44
Packaging supplies and salt	0.38	0.38	0.38	0.38
Repairs and maintenance	0.12	0.13	0.10	0.15
Total	2.89	2.59	2.58	2.54
Annual milk volume	- - - million pounds	- - - -		
at capacity	140	210	355	470

* Includes depreciation, miscellaneous plant costs, and administrative costs including salaries and taxes.

Table 2. Average total cost per 1,000 pounds of whole milk in four Minnesota butter-powder plants

Annual whole milk volume	Plant No. 1	No. 2	No. 3	No. 4
million pounds	- - - - dollars	- - - -		
70	4.36			
100	3.48	4.14		
140	2.89	3.09		
180		2.84		
210		2.59	3.56	
270			3.05	3.60
310			2.80	3.28
355			2.58	3.01
430				2.68
470				2.54

the outlook corner

Consumption of Food Fats and Oils

Jerome Hammond

Consumption trends for edible fats and oils are important to Minnesota's farm economy. In 1964, Minnesota produced 26 percent of the nation's butter. Soybeans, the most important source of margarine, shortening, and cooking and salad oils, are produced abundantly in Minnesota. In recent years, butterfat and soybeans together contributed about 24 percent of Minnesota's farm income.

The consumption trends show some important changes in eating habits. Although per capita figures do not reflect directly what happens to total consumption, they do reflect changing relative importance of food fat and oil markets. The figures also indicate the increased importance of producing oil-bearing crops rather than producing fats and oils through livestock.

At first glance, little change may be apparent in the food fat and oil markets since before World War II. Per capita consumption of food fats and oils has remained relatively stable since the 1935-39 period when it averaged 45.4 pounds per year. The 1961-65 average was 46.2 pounds. However, significant changes have occurred in the makeup of this total.

Total food fat and oil consumption has been characterized by a large shift from animal fats to vegetable fats and oils. In 1947, animal fat use (which includes a small quantity in nonfood uses) was 24.3 pounds per capita, more than half of all food fat and oil consumption. By 1964, use of animal fat had dropped to 17.4 pounds, about 37 percent of food fat and oil consumption.

Per capita consumption of all table spreads declined from 19.4 pounds in 1940 to 16.3 pounds in 1965. However, use of margarine moved upward steadily, from 2.9 pounds in 1940 to 9.5 pounds in 1965. On the other hand, butter lost ground in terms of per capita consumption—from 17 pounds in 1940 to 6.5 pounds in 1965. Now margarine leads butter consumption by about 3 pounds per person annually.

The major cause for this shift has been the price advantage of margarine. Nationally, the retail price for butter is about 2½ times the retail margarine price. Where there are no legal restrictions and high taxes on margarine, this shift probably will continue. In addition, some consumers are concerned about the possible relationship between blood cholesterol-animal fat intake and heart disease.

Consumption trends for lard (consumed directly as lard) and shortening are similar to those for butter and margarine (see the figure). Generally, shortening consumption has been increasing. But total consumption of lard and shortening dropped from 23 pounds per capita in the early 1940's to about 20 pounds in 1965. Currently, direct per capita lard consumption is about half that of shortening.

However, some lard is consumed indirectly as an ingredient in shortening and margarine. About 25 percent of domestic lard consumption is currently indirect use as an ingredient in shortening. Eventually, most lard may move into use as shortening.

The shift from lard to shortening seems to be more a matter of consumer preference than price. The heart disease-cholesterol relationship also may be a cause. Some factors that make shortening preferable to lard are: more consistent quality, fewer storage problems, and ease of use.

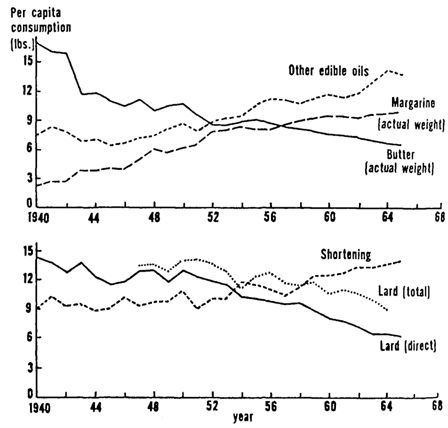
Decreases in total per capita food fat and oil use in the above groups of products were offset by increases in consumption of salad and other edible oils, all primarily vegetable oils (see the figure). The 1965 level of per capita consumption of these oils exceeded 1940 consumption by more than 7 pounds. Data for the years since 1959 show the increase to be for cooking and salad oils. Cooking oils are, of course, competitive with lard and shortening.

According to the above trends, some implications for the fat and oil markets are:

1. Markets for vegetable fats and oils in food uses will continue to expand.

2. Milkfat, at its present price, will continue to be at a disadvantage in the market for fats and oils.

3. Lard utilization will become increasingly indirect, being used as an ingredient in shortening manufacture.



Annual per capita consumption of food fats and oils

Source: *Fats and Oils Situation,* USDA, Jan. 1965, Mar. 1966. *National Food Situation,* USDA, Feb. 1966.

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