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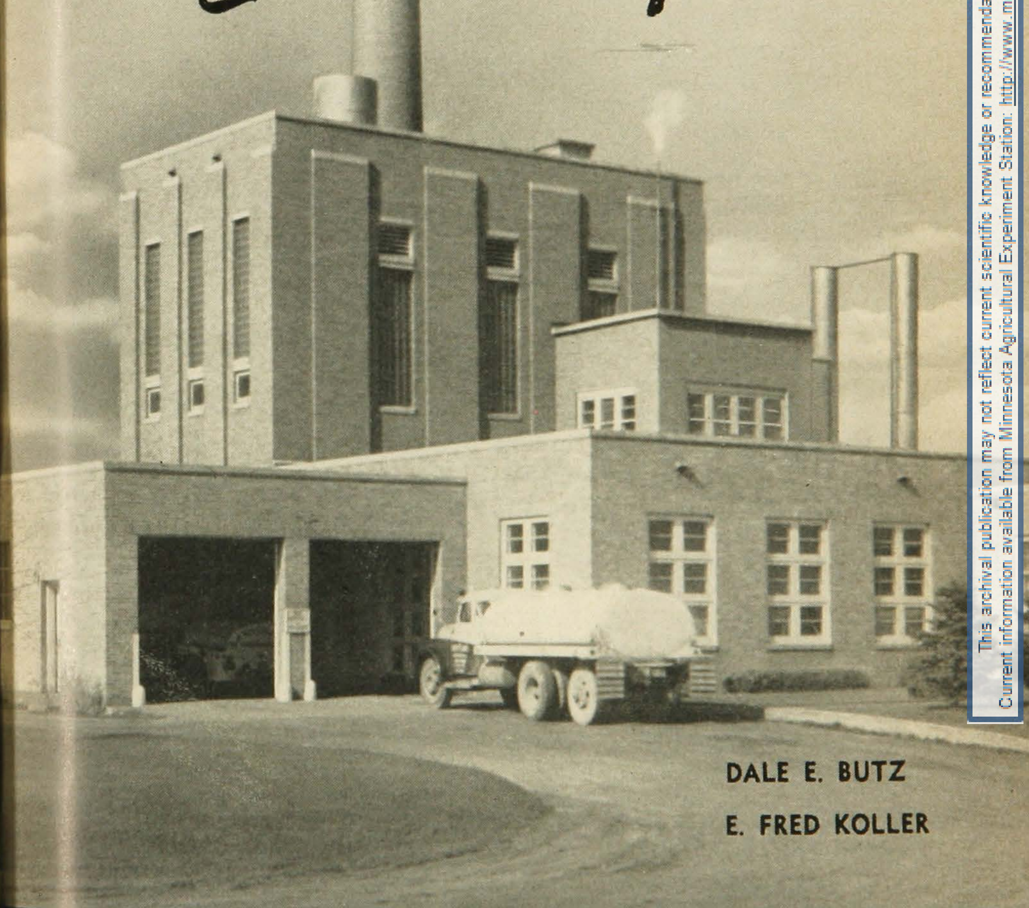

DALE E. BUTZ

E. FRED KOLLER

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Costs of Drying Milk in Minnesota Plants

Dale E. Butz and E. Fred Koller[1]

DAIRYING is one of the major sources of farm income in Minnesota. Prior to World War II, most of this income was realized on the sale of farm-separated cream to the local creameries. During the war there was a very rapid shift from the delivery of farm-separated cream to the delivery of whole milk to the dairy plants. This shift had already started prior to the war, but was greatly accelerated by the relatively favorable prices paid for nonfat milk solids.

In order to handle and process this increased supply of whole milk, a number of new centralized drying plants were put into operation and production facilities at existing plants were increased. This rapid growth in the dry milk industry was accompanied by many marketing problems. Most of these problems were intensified after the cessation of hostilities in 1945.

In the postwar era much attention has been directed toward the improvement of marketing efficiency or the reduction of marketing costs in this industry. Considerable interest has been shown in the costs of drying milk products and in measures that might be adopted to lower such costs. Preliminary surveys indicated that there were quite wide differences in the costs of processing dry milk in Minnesota plants. This suggested that it might be possible to reduce costs particularly in the less efficient plants and thus increase the over-all efficiency of the industry.

Increased efficiency and low processing costs should enable the plants to return to the farmer a higher percentage of the consumer's dollar. In some cases it might be desirable to pass these savings on to the consumers in the form of lower sales prices. This latter course of action would appear to be desirable if the consumer demand were elastic or such that a small decline in price would result in a more than proportionate increase in dry milk sales.

PURPOSE OF STUDY—SCOPE AND SOURCES OF DATA

This study is designed to present a general picture of the Minnesota dry milk industry with particular emphasis on the costs involved in assembling the milk supplies and processing the dry milk. Factors affecting costs will be pointed out and ways of reducing costs will be discussed. Physical outputs of dry milk per units of physical inputs

[1] The authors acknowledge with appreciation the generous cooperation of dry milk plant managers and others in the industry who supplied the basic data for this study. They also express their appreciation to O. B. Jesness and R. W. Cox of the Division of Agricultural Economics for their valuable suggestions in the preparation of this bulletin.

such as hours of labor or units of fuel will be compared at various plants. Different methods of improving these physical efficiency factors will be presented and analyzed.

This study is limited to milk drying plants in Minnesota. Particular emphasis is placed on specialized and diversified plants which together produce a very large part of the total annual output of dry milk in the state. Although many different kinds of dry milk products are produced in Minnesota, nonfat dry milk solids are by far the most important in terms of pounds of powder produced. Most of the analysis to follow will be concerned with the processing of nonfat dry milk solids. In general, the data refer to the operations carried on during the calendar years 1947 and 1948. Where possible, data for the years 1949 and 1950 were added for comparative purposes.

Much of the data was obtained with the aid of a survey schedule and from plant records. Personal visits to plants and informal discussions with industry representatives were a fruitful source of ideas and information. Other sources of data included published and unpublished reports of the Bureau of Agricultural Economics, reports of the Production and Marketing Administration, the Minnesota Department of Agriculture, Dairy and Food, and the American Dry Milk Institute, Chicago.

Dry Milk Production

PRODUCTION of most dry milk products in the United States has remained high since World War II (table 1). During the last few years the proportion of the total dry milk output produced with spray driers has increased.

UNITED STATES PRODUCTION

This is the result of increased construction of spray drying facilities under the wartime lend-lease program and of the price advantage usually enjoyed by spray powder. Dried skim milk for animal feed use dropped early

Table 1. Production of Dry Milk Products in United States, 1936-50*

Year	Nonfat dry milk solids			Dry skim milk (animal feed)	Dry whole milk	Dry buttermilk
	Spray	Roller	Total			
			thousand pounds			
1936-40†	....	....	269,432‡	142,813	21,447	59,590
1941	233,611	132,844	366,455	110,042	45,627	75,614
1942	283,863	276,551	565,414	61,148	62,167	69,637
1943	245,596	264,024	509,620	24,279	137,766	60,995
1944	266,448	316,464	582,912	16,407	177,754	56,683
1945	297,614	344,932	642,546	17,508	217,276	49,578
1946	365,110	288,355	653,465	13,704	188,406	38,627
1947	418,704	259,237	677,941	22,149	164,888	45,437
1948	436,071	245,461	681,532	13,045	170,087	41,839
1949	627,942	306,992	934,934	21,244	125,541	49,359
1950	623,967	257,111	881,078	17,573	124,986	48,668

* Source: Production of Manufactured Dairy Products, Bureau of Agricultural Economics, USDA
† Annual average.
‡ Spray and roller combined before 1941.

Table 2. Production of Dry Milk Products in Minnesota, 1936-50*

Year	Nonfat dry milk solids			Dry skim milk (animal feed)	Dry whole milk	Dry buttermilk
	Spray	Roller	Total			
			thousand pounds			
1936-40†	....	....	12,201‡	7,659	0	17,374
1944	52,582	64,166	116,748	930	19,856	24,660
1945	79,411	88,183	167,594	1,668	31,646	21,826
1946	112,498	84,839	197,337	2,758	27,365	17,677
1947	106,167	58,660	164,827	2,537	22,803	20,060
1948	106,928	56,069	162,997	2,434	34,763	19,643
1949	127,775	53,215	180,990	2,381	20,072	19,646
1950	123,023	37,451	160,474	2,280	15,904	18,961

* Source: Production of Manufactured Dairy Products, Bureau of Agricultural Economics, USDA.
† Annual average.
‡ Spray and roller combined before 1941.

in the war period when many of the plants were converted to human food production and has remained relatively low since that time.

MINNESOTA PRODUCTION

The production picture for Minnesota is very similar to that just presented for the nation as a whole (table 2). The increase in production during the last few years as compared with the pre-war period is very striking.

In order to get some idea of the relative importance of the Minnesota dry milk industry, its output may be compared with the national production. Figure 1 shows that during the past few years, Minnesota plants have produced a sizable proportion of the national output of nonfat dry milk solids. In 1950, 18 per cent of the nonfat dry milk solids and 13 per cent of the dry whole milk came from Minnesota plants. Drying plants located in Minnesota have processed about 40 per cent of the dry buttermilk produced in the United States.

OWNERSHIP, SIZE, AND TYPES OF DRYING PLANTS

Nearly three-fourths of the dry milk output of Minnesota in 1948 was produced in cooperative plants. These plants produced 90 per cent of the spray nonfat dry milk solids, more than 70 per cent of the roller powder and animal feed, 45 per cent of the dry whole milk and more than one-half of the dry buttermilk.

For purposes of this study, the plants were divided into various categories on the basis of the equipment and amount of diversification. Specialized drying plants included all those equipped to make only milk powder. The diversified plants are those that have several alternative market outlets

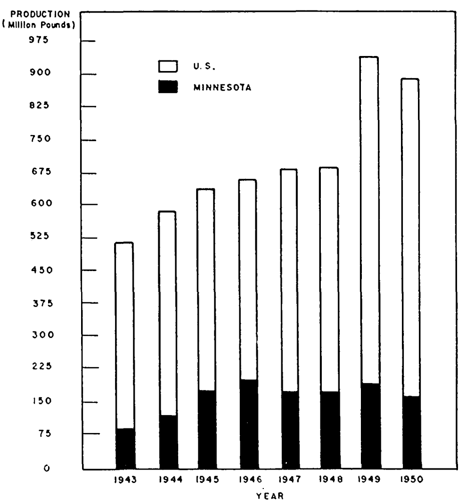


FIG. 1. Production of nonfat dry milk solids in U. S. and Minnesota, 1943-50.

for both butterfat and skim milk, and are equipped to produce many different dairy products. This same classification holds true for the partly diversified plants except that they have fewer alternative outlets for either butterfat or skim milk.

The creamery drying plants are plants which receive most of their milk directly from farmers, separate the

FIG. 2. A roller drier in operation showing dry milk coming from the roller.

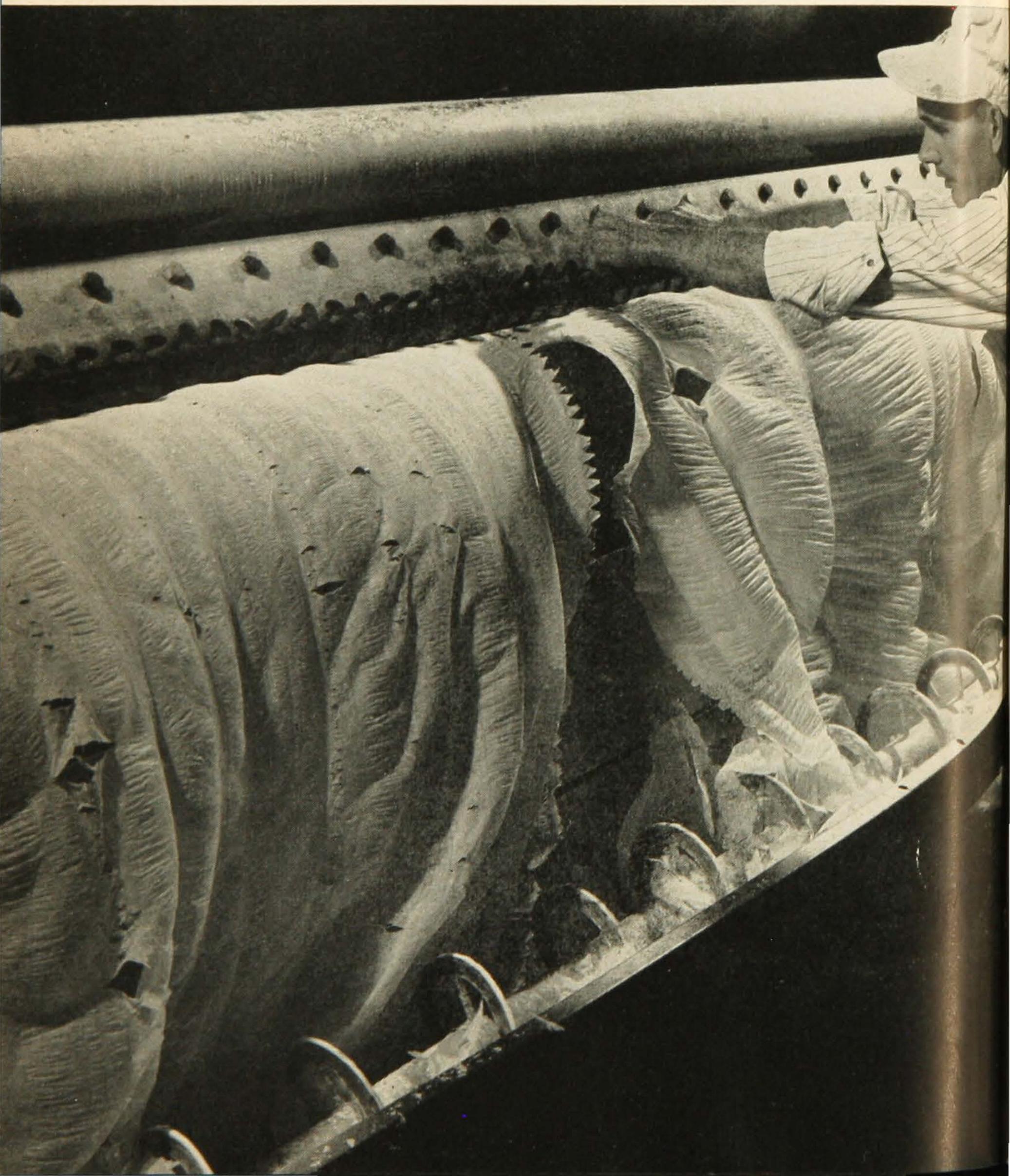


Table 3. Proportion of Dry Milk in Minnesota Produced by Different Type Plants, 1948

Type of dry milk	Type of drying plant					Total
	Special-ized	Diversi-fied	Partly di-versified	Creamery–human food	Creamery–animal feed	
	percentage of total production					
Nonfat dry milk solids						
Spray	56.5	23.1	19.7	.7	.0	100.0
Roller	16.6	11.6	18.3	53.5	.0	100.0
Dry skim milk	39.0	14.5	13.0	16.8	16.7	100.0
Dry whole milk	6.9	88.0	.0	5.1	.0	100.0
Dry buttermilk	62.4	5.9	14.0	8.0	9.7	100.0
Total production	38.7	28.9	15.6	15.7	1.1	100.0
Number of plants	23	9	17	30	21	100

milk, churn butter, and dry the skim. These plants are further subdivided according to whether human food or animal feed is produced. The specialized drying plants generally receive their milk supplies from local creameries and take in very little milk directly from farmers. The partly diversified and diversified plants often receive milk from other plants in addition to supplies delivered directly by their own patrons.

The specialized drying plants are the most important in terms of powder production. They produced more than one-half of the spray nonfat dry milk solids in the state in 1948. The diversified plants produced 88 per cent of the dry whole milk and nearly 30 per cent of the total dry milk output. Although the creamery drying plants made up more than one-half of the total number of plants, they produced only about 17 per cent of the powder. This indicates that in general, the creamery drying plants are much smaller than the other type of plants (table 3).

Number and Size of Plants

During the past few years, the number of drying plants in Minnesota has remained fairly constant, but there has been a decided increase in the average annual output of these plants. In 1942, there were 65 plants producing less than 400,000 pounds of powder annually, but there were only 36 plants with this relatively low volume of output in 1948. Similarly, there were only 25 plants producing more than one million pounds in 1942, but 51 plants manufactured more than this amount in 1948. There were not as many plants producing more than five millon pounds annually in either 1947 or 1948 as there were in 1946. In general, however, the trend has been toward a greater number of larger plants and fewer plants with very small output (table 4).

PLANT DIVERSIFICATION

The degree to which a dry milk plant is diversified has an important bearing

Table 4. Minnesota Milk Drying Plants Classified According to Size of Plant, 1942-48*

Annual output (1,000 pounds)	1942	1946	1947	1948
	number of plants			
Less than 100	28	18	22	17
100-199	17	9	7	11
200-399	20	12	11	8
400-599	7	4	4	7
600-799	5	6	2	0
800-999	3	2	6	6
1,000-1,999	8	19	18	15
2,000-2,999	7	8	10	7
3,000-3,999	2	8	10	8
4,000-4,999	2	5	8	10
5,000 and over	6	17	10	11
Total	105	108	108	100

* Size based upon total pounds of dry milk produced.

on the question of how readily the plant may adjust to market changes. In the event that dry milk markets should become temporarily depressed, the plant which is diversified would be able to shift more readily its utilization of milk to products giving higher returns.

Forty-three, or more than one-half of the drying plants, had condensing equipment and could easily shift to, or increase their production of plain or sweetened condensed skim milk. Ten plants were equipped to make cheese, and 10 to produce ice cream. Seventeen of the plants were equipped to bottle fluid milk, and a few plants could produce casein and other special dairy products.

Although more and more diversification of milk drying plants has occurred during the past few years, most of the drying plants still tend to be specialized. Very few of the plants have adequate equipment to allow a complete shift of milk utilization to some other product.

DRYING EQUIPMENT AND CAPACITY

According to the 1948 plant survey, only nine of the 79 plants producing dry milk for human consumption had spray driers alone. Twenty-five plants had both spray and roller facilities, and 45 organizations had only roller driers.

Most of the specialized drying plants had both spray and roller equipment. These plants usually tried to make maximum use of the spray driers, which involved a relatively large capital investment, and used the rollers only during the flush milk production season. Practically all of the creamery drying plants had only roller driers when the survey was made. Since that time, however, the situation has changed somewhat in that a few creameries have added small spray drying units.

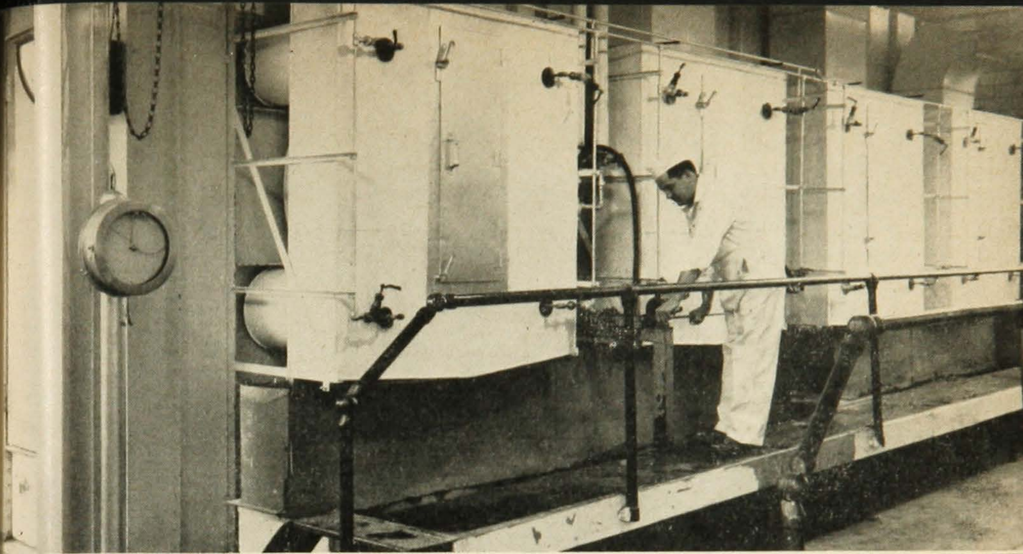
Most of the roller drying plants had one or two driers but there were 14 plants which had three or more driers. There was some variation in size of roll, but the standard size was about 120 inches long and 32 inches in diameter. Information obtained from the plant managers indicated that such a roll would dry on the average about 300 pounds of powder per hour.

Capacity of Drying Plants

Capacities of milk drying equipment are difficult to estimate because of the variable factors involved. There are differences in the amount of preheating and precondensing, as well as variations in the equipment and the personnel operating these machines. Some of the plants operate more hours per day than others, and the driers in some plants are shut down more often for repairs than are the driers in other plants. In most milk drying plants, it appears that the capacity of the drier itself is the limiting factor. This capacity can be changed by precondensing ahead of the drier. In general, the daily capacity can be computed by multiplying the hourly capacity of the drier by the number of hours that the drier is operated per day. Since the drying equipment must be washed and cleaned each day, it is usually assumed that maximum operation time is 20 or 21 hours per day.

The capacity figures in table 5 represent the summation of the capacity estimates obtained from managers in 79 human food drying plants. It should be pointed out that these estimates probably represent close to maximum output since no allowances were made

FIG. 3. Two of several types of spray driers used in drying milk. Concentrated skim milk is sprayed in a fine mist into heated drying chambers and dries as it falls.



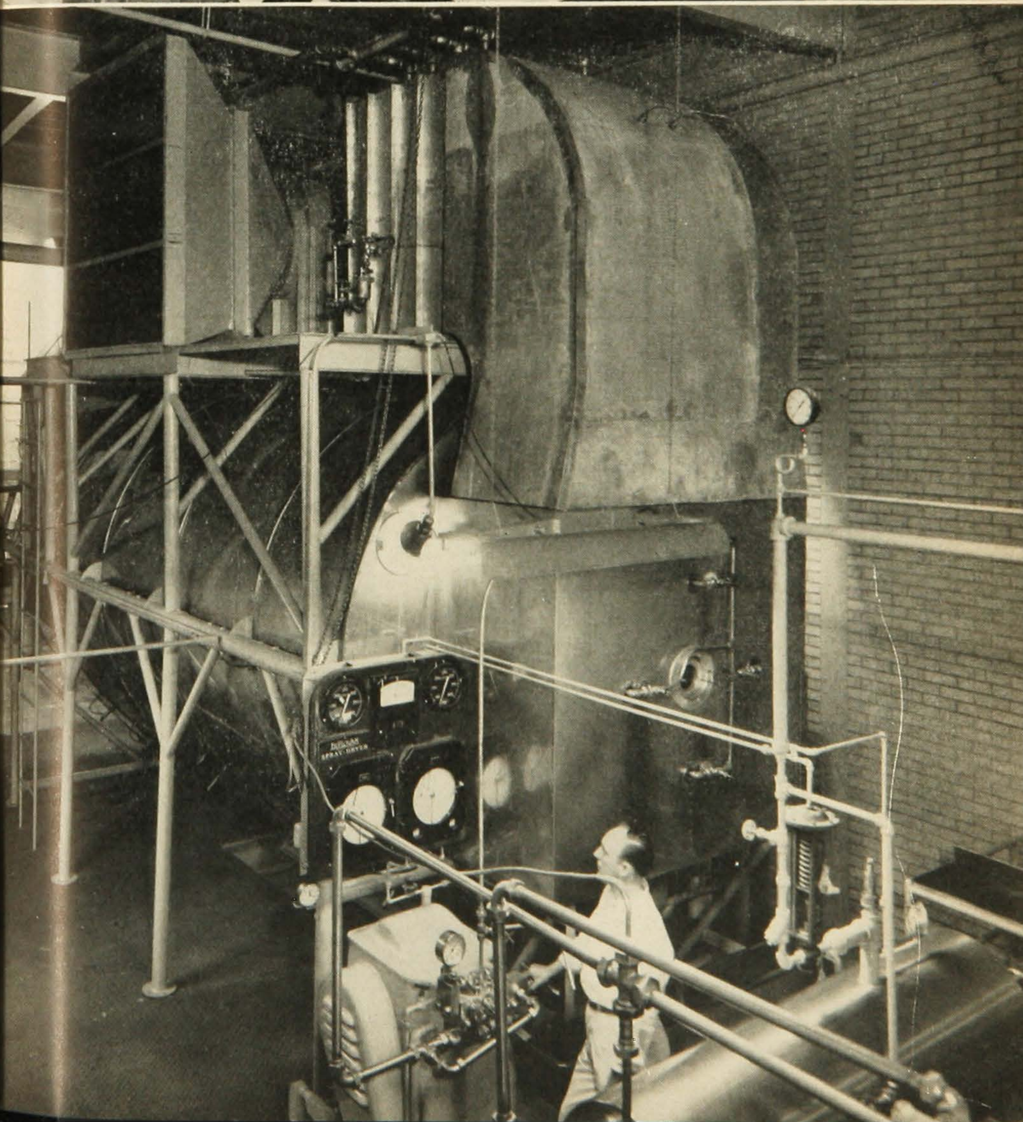

SPRAY DRYER

Table 5. Estimated Daily Drying Capacity of 79 Human Food Drying Plants in Minnesota, 1948*

Type of plant	Spray	Roller	Total
		pounds of dry milk	
Creamery drying plants	8,000	260,400	268,400
Partly diversified plants	135,000	163,800	298,800
Diversified plants	295,000	45,500	340,500
Specialized drying plants	373,000	252,600	625,600
Total estimated drying capacity	811,000	722,300	1,533,300
Actual daily output, June 1948			888,088
Daily output as a percentage of capacity			58%

* Daily capacity computed on the basis of estimated hourly capacity per drier multiplied by 20 hours per day.

for repair time or stoppages of any sort.

The total capacity of the Minnesota human food drying plants in 1948 was approximately 1,500,000 pounds of powder per day. The average daily output for June 1948 was about 888,000 pounds per day, or less than 60 per cent of capacity. These capacity estimates included both spray and roller facilities, and were computed on the basis of a 20-hour day. Much of the idle plant capacity probably occurred among the roller drying plants since they usually were not operated for longer than two shifts per day (16 hours) even during the peak production period. The spray drying facilities, on the other hand, were usually operated 20 or more hours per day during the flush period, and thus approached full plant capacity.

The foregoing calculations are rough, but they are sufficiently accurate to indicate that the Minnesota milk drying industry had considerable unused plant capacity even during the flush production season of 1948. This observation is substantiated by the fact that production in 1949 at some plants was much higher than production from the same plants in 1948. Since very few pieces of new equipment were added during this period, existing plant facilities and equipment must have been utilized more fully in order to increase the total production during the flush period of May and June 1949.

Milk Assembly

TWENTY-SEVEN of the creameries drying milk for human use received all of their milk supplies directly from farmer patrons. The fat in the milk was churned or sold as cream and the skim milk and buttermilk were dried.

SOURCES OF MILK RECEIPTS

The specialized drying plants as well as the diversified and partly diversified plants, relied on receipts from local creameries for a large proportion of their raw materials. These plants purchased whole milk, skim milk, or buttermilk from the local creameries and transported these products by tank truck to the central drying plant. Of the plants receiving milk from other creameries only, there were eight that gathered milk from 21 or more creameries. These eight plants specialized principally in dry buttermilk and

Table 6. Classification of Minnesota Human Food Milk Drying Plants According to Source of Milk Receipts, 1948

Source of milk receipts	Number of local supplying creameries					Total
	0	1-3	4-10	11-20	21 and over	
	number of drying plants					
Direct from farmers only	27	0	0	0	0	27
Direct from farmers and other creameries	0	12	8	4	0	24
Creameries only	0	2	7	11	8*	28
Total	27	14	15	15	8	79

* Three of these plants received buttermilk only, four received buttermilk and some skim milk, and one plant received skim and whole milk from other plants.

needed more supplying creameries in order to obtain an adequate volume of production (table 6).

MILK HAULING COSTS

Farm to Creamery

The costs of hauling milk from the farm to the local plant or creamery usually are paid directly by the individual producer or deducted from the returns which he receives from the creamery. Data for 1948 show that there was much variation in these local hauling rates. The most common charge was from 15 to 20 cents per hundredweight of milk, but there were some plants where the charges exceeded 25 cents (table 7). In general, the areas of relatively light milk production, where long hauls are common, had the highest hauling charges.

Creamery to Drying Plant

The milk usually is hauled from the farm to the creamery in cans. Large tank trucks, however, are used to transport the skim milk from the creamery to central drying plant. Costs of hauling milk from the local creamery to the central drying plant usually are borne by the central plant and, therefore, must be taken into account in determining the over-all cost of producing dry milk in this type of plant. For 21 milk drying plants, these costs averaged 0.87 of a cent per pound of dry milk produced in 1947 (table 8). On a liquid basis, this amounted to betwen 7 and 8 cents per hundredweight of fluid skim milk.

Labor, or driver's wages, made up nearly 43 per cent of the total hauling cost. Gas, oil, and truck maintenance were the other important cost items. There was considerable variation in hauling costs at the different plants (table 9).

The most important factor affecting hauling costs is distance to the supply-

Table 7. Hauling Charges from Farms to Local Plant Per 100 Pounds of Milk, 76 Minnesota Cooperative Creameries, 1948

Hauling charges (cents per hundredweight)	Number of plants
Under 15	3
15	10
16	4
17	11
18	13
19	1
20	25
21	0
22	1
23	3
24	0
More than 25	8
Total	79*

* Three creameries reported two rates depending upon distance hauled.

Table 8. Average Interplant Milk Hauling Cost Per Pound of Dry Milk Produced in 21 Plants Purchasing Milk from Creameries in Minnesota, 1947*

Cost item	Cost
	cents per pound
Driver's wages	0.37
Payroll tax	.01
Gas and oil	.17
Tires and tubes	.04
Truck maintenance	.13
Depreciation—trucks and trailers	.09
Depreciation—tanks	.02
Truck insurance	.01
Truck license	.02
Miscellaneous	.01
Total	0.87

* Tank truck transportation used in each case.

ing creameries. Size and regularity of loads, as well as efficiency of the trucking operation, also have an effect upon costs. Management influences hauling costs by planning routes and loads, speeding up loading and unloading, reducing drivers' idle time to a minimum, and by maintaining equipment in good working order so that costly breakdowns are held to a minimum.

Table 9. Classification of 21 Minnesota Drying Plants Purchasing Milk from Creameries According to Hauling Costs Per Pound of Dry Milk Produced, 1947

Hauling costs per pound of dry milk	Number of plants
cents per pound	
0.25-0.50	2
.51- .75	6
.76-1.00	3
1.01-1.25	6
1.26-1.50	2
1.51-1.75	1
1.76-and over	1
Total	21

Costs of Manufacturing Dry Milk

THE COST INFORMATION used in this study was obtained from audits, published reports and, in some cases, directly from the records of the various plants. Every effort was made to put the information on as comparable a basis as possible.

Generally speaking, the costs of manufacturing roller powder are much more difficult to compute than costs in spray drying plants. Many of the spray plants produce one main product and practically all of the expenses can be charged to that product. The plants manufacturing roller powder, however, are usually combination creamery drying plants or other types of multiproduct firms. In order to derive cost figures for the powder department, it was necessary to prorate many of the expenses among the various products. In some cases rather clear-cut divisions could be made in operating expenses, but it often was necessary to use arbitrary percentages or estimates. In some plants, these divisions had already been made by the auditor with the help and advice of the plant officials. In other plants, these allocations were made in conference with the plant manager. In all cases the endeavor was to standardize the method of allocation in order to obtain comparable results. Separation of costs between roller and spray powder was not attempted for plants producing both products.

As used here, the manufacturing costs do not include any allowances for selling costs or the interplant hauling costs mentioned previously. However, some managers estimated that costs for brokerage, cash discounts, and other selling costs amount to 0.8 cent per pound of powder. This does not include the freight from the plant to the buyer which is generally paid by the plants selling directly to end users of the powder.

MANUFACTURING COSTS AT ROLLER DRYING PLANTS

The average manufacturing costs per pound of dry milk for 24 roller drying plants in 1947 was 3.85 cents (table 10). Labor, packaging supplies, and fuel were the most important cost items. These items constituted 28, 22, and 17 per cent of total costs, respectively. The roller plants generally purchased their electric power and had a slightly higher cost for this item than did the spray plants which produced their own power. Administrative and general costs made up a very small part of the total manufacturing costs.

The average manufacturing costs were the lowest among the plants producing two million or more pounds of powder annually (table 11). Fuel, depreciation and rent, and general expenses were somewhat lower in the larger plants. While costs tend to fall as volume increases, both the high and low cost plants were in the group of smallest volume. This indicates that other factors than volume may affect costs. Management, plant layout, type of equipment, and a number of other factors also affect the level of costs at the various plants.

The labor costs per pound of dry milk were somewhat lower in the medium sized plant group than in either the extremely large or the very small plants. There was no apparent relationship between hourly wage rates and labor costs per pound of powder.

Fuel costs, as well as combined costs of fuel, power, light, and water, declined as volume increased. The type of fuel used affected fuel costs. In 1947, oil appeared to be the most expensive fuel on a per unit of product basis with coal a close second. Natural gas and lignite were the lowest cost fuels for drying. However, there was much variation among the plants and there were some plants with very low fuel costs among the plants burning coal. During this period, fuel oil supplies were short and prices high. For all the different types of fuel, costs were lower among the larger plants.

Table 10. Average Manufacturing Cost Per Pound of Dry Milk Produced in 24 Minnesota Roller Drying Plants, 1947

Cost item	Cost per pound
	cents
Plant expenses	
Labor	1.08
Payroll taxes	.03
Packaging supplies	.84
General supplies	.14
Fuel	.66
Power, light, and water	.28
Plant maintenance	.19
Depreciation and rent	.29
Other	.03
Total	3.54
Administrative expenses	
Office salaries	.08
Office supplies	.01
Telephone	.01
Other	.07
Total	.17
General expenses	
Insurance	.02
Interest	.02
Taxes	.06
Other	.04
Total	.14
Total manufacturing cost	3.85*

* The costs at individual plants ranged from a low of 2.11 cents to a high of 7.59 cents per pound. When arranged in order of magnitude, the plant at the first quartile had a cost of 3.41 cents. The median plant had a manufacturing cost of 3.90 cents per pound and the third quartile plant had costs of 4.83 cents. Since the variation among the different plants was quite large, the standard deviation of the individual plants about the mean was 0.65 cent.

Table 11. Relationship Between Manufacturing Costs Per Pound of Dry Milk and Annual Volume of Output in 24 Minnesota Roller Drying Plants, 1947

Cost item	Annual dry milk production in millions of pounds			Average all plants
	0-.9	1.0-1.9	2.0 and over	
		cents per pound		
Plant expenses				
Labor (including payroll taxes)	1.27	1.02	1.13	1.11
Packaging supplies	.83	.93	.78	.84
General supplies	.23	.12	.15	.14
Fuel	.79	.74	.59	.66
Power, light, and water	.25	.27	.29	.28
Plant maintenance	.24	.19	.18	.19
Depreciation and rent	.56	.28	.25	.29
Other	.01	.04	.02	.03
Total	4.18	3.59	3.39	3.54
Administrative and general expenses				
Administrative	.20	.18	.15	.17
General	.31	.13	.14	.14
Total	.51	.31	.29	.31
Total manufacturing cost	4.69	3.90	3.68	3.85
Range in costs	2.11-7.59	3.25-5.18	3.02-4.37	2.11-7.59
Median	5.13	3.78	3.41	3.90
Standard deviation	1.17	.53	.47	.65
Number of plants	8	9	7	24

COSTS AT BUTTER-POWDER PLANTS

Costs of manufacturing in specialized butter-powder plants usually are expressed in costs per hundredweight of milk or costs per pound of butterfat handled. Such cost figures include both the costs incurred in the production of butter and in the manufacture of powder. This eliminates the necessity of making allocations of certain costs between the two products.

This type of cost determination is meaningful if the plants receive about the same proportion of their butterfat in milk instead of farm-separated cream, and do not have much sideline business. Very few creameries in Minnesota receive all of their supplies of butterfat in the form of milk. Since there are differences in the cost of handling butterfat in cream as compared with milk, it is not very meaningful to combine costs in this way for plants receiving varying percentages of their butterfat receipts in the form of milk. Plants of this type located in Minnesota also have many sideline enterprises. Costs on sideline enterprises are usually calculated separately so it is possible to separate out the costs of the butter-powder operation.

Costs at six plants at which nearly all of the butterfat was received in the form of milk are shown in table 12. These costs are expressed on the basis of costs per pound of butterfat handled at the individual plants. Labor, fuel, and packaging supplies were the most important cost items, but depreciation, as well as general and administrative

Table 12. Average Butter and Dry Milk Manufacturing Costs Per Pound of Butterfat Handled in Six Specialized Butter-Powder Plants, Minnesota, 1947

Cost item	Plant						Average all plants
	1	2	3	4	5	6	
	cents per pound						
Labor	3.72	2.86	2.99	2.24	5.97	3.39	3.60
Fuel	2.44	2.71	2.07	2.35	2.51	2.13	2.34
Packaging supplies	2.02	2.07	2.37	2.59	2.87	2.43	2.46
Depreciation	2.13	.81	1.23	.55	1.57	.91	1.12
Light and power	.65	.90	.43	.59	1.08	.41	.66
Property taxes	.15	.67	.18	.03	.20	.23	.23
Manufacturing supplies	.46	.46	.68	.78	1.37	.47	.74
General and administrative	.83	.87	1.03	1.23	1.19	.89	1.03
Other expense	1.39	.64	.52	.26	.49	.52	.56
Total	13.79	11.99	11.50	10.62	17.25	11.38	12.74
Total butterfat handled (in 1,000 pounds)	565	770	910	1,176	1,254	1,525	1,033

expenses, also was quite high. There was no consistent relationship between volume of butterfat handled and costs. This may have been due to the relatively small number of plants. One of the largest plants had the highest manufacturing costs. This was due largely to the high labor cost, but most of the other costs at this plant were above the average costs for all plants. Some of the variation in costs can probably be explained by differences in volume of products handled, but other factors such as management also have a considerable effect upon costs of manufacturing the various products.

MANUFACTURING COSTS AT SPRAY DRYING PLANTS

Data obtained from 22 spray drying plants indicate that the average cost of manufacturing a pound of powder in 1947 was 4.4 cents per pound (table 13). Labor, fuel, and packaging supplies made up nearly three fourths of the

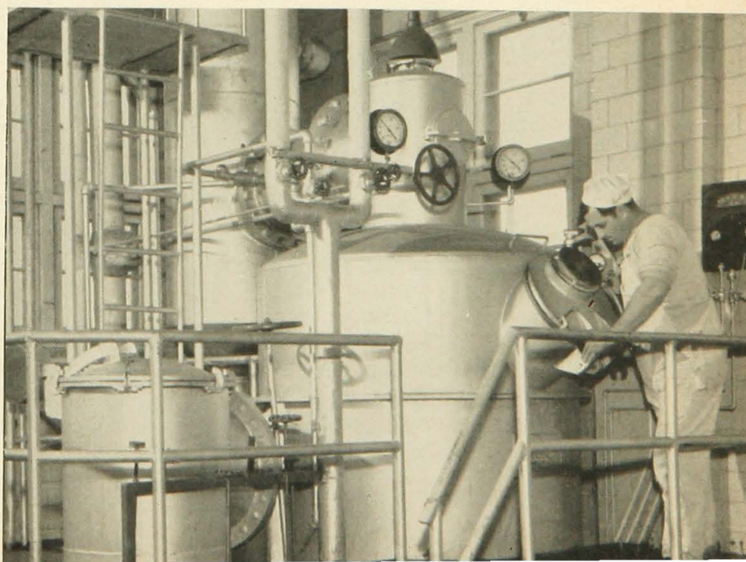


FIG. 4. Vacuum pans, or evaporators, are used to take much of the water out of the milk before it is dried.

Table 13. Average Manufacturing Cost Per Pound of Dry Milk Produced in 22 Minnesota Spray Drying Plants, 1947

Item	Cost per pound
	cents
Plant expenses	
Labor	1.16
Payroll taxes	.03
Packaging supplies	.88
General supplies	.21
Fuel	1.05
Power, light, and water	.06
Plant maintenance	.19
Depreciation and rent	.55
Other	.02
Total	4.15
Administrative expenses	
Office salaries	.07
Office supplies	.01
Telephone	.01
Other	.02
Total	.11
General expenses	
Insurance	.04
Interest	.03
Taxes	.06
Other	.04
Total	.17
Total manufacturing cost	4.43
Range in costs	3.35-5.64
Median	4.43
First quartile	4.12
Third quartile	5.11
Standard deviation	.57

total manufacturing costs. Plant expenses accounted for nearly all of the total operating costs. Administrative and general expenses totaled less than 0.3 cent per pound.

A comparison of these costs with costs for the roller plants shown in table 10 indicates that spray drying on the average costs about 0.6 cent per pound more than roller drying. Package costs were nearly the same in the two types of plants, but depreciation and rent were much higher in the spray plants. The spray plants generally had a larger investment in plant and equipment than did roller drying plants and thus incurred a greater depreciation expense. Fuel expenses were higher in the spray plants, but this was offset partially by lower power, light, and water costs. There was not much difference in the administrative and general expenses of the two types of plants.

Classification of the plants into volume groups showed that costs were the lowest in the largest plants. The group of small plants had the highest costs, and the medium sized plants had average costs between these two extremes. The group including plants which produced more than six million pounds of powder had manufacturing costs which were more than 1 cent a pound lower than average costs in the group of plants which produced less than four million pounds of powder.

Labor and fuel costs declined regularly as volume increased. Packaging costs remained nearly the same regardless of size of plant, but rent was considerably lower in the group containing the large plants (table 14). Adminis-

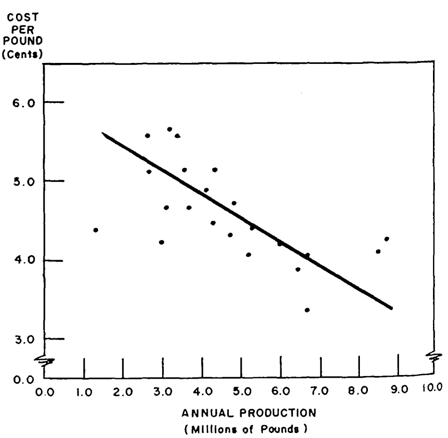


FIG. 5. Relationship of volume of dry milk produced and total drying costs per pound, 22 Minnesota spray drying plants, 1947.

trative and general expenses were nearly the same in the small and medium sized plants, but in the larger plants these costs, per unit produced, were nearly cut in half.

Costs showed a definite tendency to decline as volume increased (figure 5).[2] The one plant with relatively low volume and also low costs was quite diversified and produced large quantities of condensed milk. It may be that the apparent low cost at this plant was due to the way in which the expenses were allocated between the condensed and dry products.

There was a tendency for labor costs per pound of dry milk to fall as the volume increased, but the relationship was by no means close (figure 6). This figure indicates that there are many variations in labor costs even at plants with approximately the same volume of production. The uniformity of wage rates indicates that differences in rates are not important factors in variations in labor costs.

Like the roller drying plants, the spray plants using oil for fuel had the highest fuel cost per pound of powder produced. The plants using coal had a somewhat wider range of fuel costs per pound of powder than did the plants burning oil. The lowest fuel costs were found in the plants using natural gas or lignite.

[2] The lines of average relationship shown in this figure and in figures 3, 5, and 6 have been drawn free hand.

YEAR TO YEAR COST CHANGES

Data from a subsample of 17 spray drying plants showed total manufactur-

Table 14. Relationship Between Manufacturing Costs Per Pound of Dry Milk and Annual Volume of Output in 22 Minnesota Spray Drying Plants, 1947

Cost item	Annual dry milk production in millions of pounds			Average all plants
	0-3.9	4.0-5.9	6.0 and over	
	cents per pound			
Plant expenses				
Labor (including payroll taxes)	1.42	1.17	1.08	1.19
Packaging supplies	.87	.90	.86	.88
General supplies	.22	.20	.20	.21
Fuel	1.13	1.05	.99	1.05
Power, light, and water	.12	.03	.05	.06
Plant maintenance	.24	.19	.19	.19
Depreciation and rent	.62	.64	.41	.55
Other	.02	.03	.02	.02
Total	4.64	4.21	3.80	4.15
Administrative and general expense				
Administrative	.14	.14	.07	.11
General	.25	.19	.10	.17
Total	.39	.33	.17	.28
Total manufacturing costs	5.03	4.54	3.97	4.43
Range in costs	4.20-5.64	4.05-5.13	3.35-4.20	3.35-5.64
Median	5.09	4.45	4.06	4.43
Standard deviation	.49	.34	.28	.57
Number of plants	9	7	6	22

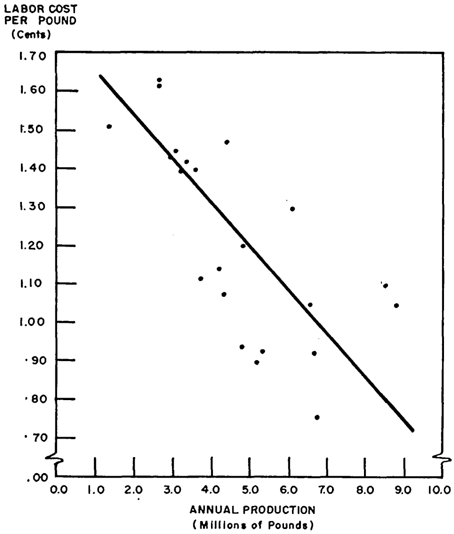


FIG. 6. Relationship of volume of dry milk produced and labor costs per pound of powder, 22 Minnesota spray drying plants, 1947.

ing costs were 4.88 cents a pound in 1948, or about 0.4 cent a pound higher than in 1947 (table 15). Most of this increase in cost was attributable to increases in fuel costs. Coal and fuel oil, the two principal fuels, increased from 20 to 30 per cent in price between 1947 and 1948. Wage rates increased about 8 per cent during 1948, but per unit labor costs for the year remained the same as improved utilization of labor was effected.

During 1949 per unit manufacturing costs were slightly below those of 1948. An important factor in this change was the peak volume of production in these plants in 1949. Also, plant managers have become much more cost conscious during the last few years and have taken steps to improve labor efficiency. Excess personnel has been released, and more labor saving devices have been introduced.

Reports on 1950 operations indicate that dry milk manufacturing costs had increased some more. However, these increases were not as large as increases in the general price level.

EFFECT OF SEASONAL PRODUCTION ON COSTS

The costs of manufacturing dry milk vary inversely during the year with seasonal changes in production. When production is high in the flush months of May and June, unit costs are low. Conversely, manufacturing costs are much higher during the periods of relatively low dry milk production, in October and November. Combined data for 20 drying plants during 1948, showed that there was a difference in manufacturing per pound of powder of nearly

Table 15. Comparison of Manufacturing Costs Per Pound of Dry Milk for 17 Minnesota Spray Drying Plants, 1947-48

Cost item	Cost per pound	
	1947	1948
	cents	
Plant expenses		
Labor	1.15	1.15
Payroll taxes	.03	.04
Packaging supplies	.87	.87
General supplies	.21	.23
Fuel	1.10	1.40
Power, light, and water	.06	.09
Plant maintenance	.20	.26
Depreciation and rent	.54	.52
Other	.02	.02
Total	4.18	4.58
Administrative expenses		
Office salaries	.06	.08
Office supplies	.01	.01
Telephone	.01	.01
Other	.01	.01
Total	.09	.11
General expenses		
Insurance	.04	.04
Interest	.04	.05
Taxes	.07	.07
Other	.03	.03
Total	.18	.19
Total manufacturing costs	4.45	4.88

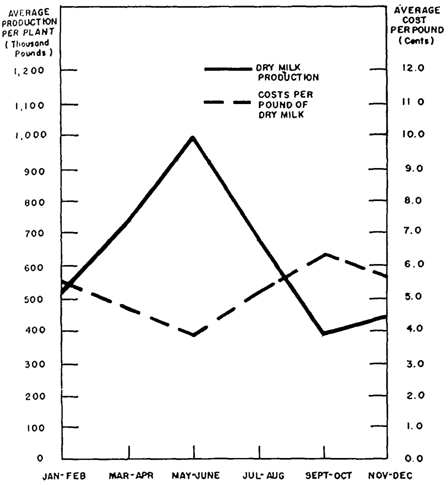


FIG. 7. Effect of seasonality of production on costs of manufacturing dry milk, 20 Minnesota drying plants, by two-month periods, 1948.

2½ cents between the high and low production periods (figure 7).

There are many fixed costs such as depreciation, taxes, interest, and insurance which tend to remain constant regardless of the amount of powder produced. In addition, many of the so-called variable costs such as labor, fuel, supplies, and power cannot be varied exactly with changes in production. When production falls, these costs usually remain relatively high and when production rises, these costs do not increase proportionately. The fixed costs and relatively inflexible variable costs have an important effect upon the per pound manufacturing costs at individual plants at different levels of production.

The effect of seasonal changes in the volume of production on the unit costs of individual drying plants is shown in figure 8. The monthly manufacturing costs of three spray drying plants operating in three different volume ranges are shown. At each of the three plants costs declined as volume of production increased. The variation in costs with changes in volume was most extreme in the smallest plant. For all of the plants included in this study, costs were lowest when the volume of output was the highest. There were no cases in which costs rose as production was increased. This can be explained by the fact that the plants were generally operating below their full capacity. Any increase in production, therefore, spread the fixed costs over a larger volume and tended to lower costs per unit of output. This emphasizes the advantage of large plants and the desirability of operating these plants as nearly as possible to their full capacity.

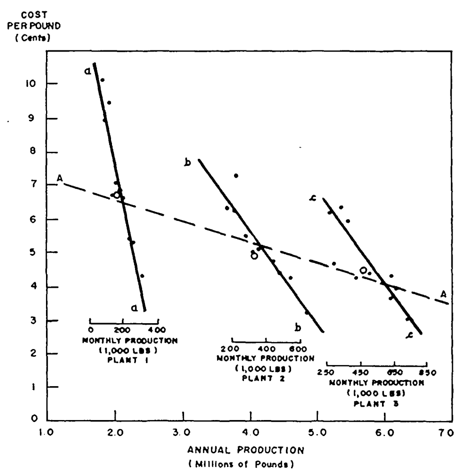


FIG. 8. Relationship of dry milk production and manufacturing costs at three Minnesota spray drying plants, 1948.

(Note: Each small dot represents *monthly* production and costs of the given plant. Only 10 observations are plotted for each plant since the records in these plants combined January-February data and November-December data. The larger dots represent *annual* averages of production and costs of these plants. Lines *aa*, *bb*, and cc show the average relationship between *monthly* production and costs in the various plants. Line *AA* shows the relationship between *annual* production and costs in these plants.)

Physical Output-Input Relationships

IN THIS STUDY data were obtained which made it possible to determine the output of dry milk for each hour of labor employed in these plants. Comparison of the relationship of physical output of product to physical inputs such as hours of labor is another way to measure the efficiency of the respective drying plants.

LABOR PRODUCTIVITY

The ratio of physical outputs to inputs is in many respects more useful than per unit cost data in making plant efficiency comparisons over time, since the cost data are subject to frequent changes brought on by shifts in the price levels and hence are soon out of date. Also, if the physical output to input ratios are known, current costs may be applied to arrive at unit costs without detailed cost accounting studies from year to year.

It is true that dry milk is produced by a combination of labor and equipment (capital) and it is impractical to determine the precise share of the product attributable to each. However, since the plants included in this analysis were quite similar with respect to their facilities, it is likely that no serious error resulted from measuring the relationship of product and input of labor.

Effect of Volume on Labor Productivity

The output of dry milk for each hour of labor employed in the various plants ranged from a low of 38.1 pounds in one plant to a high of 80.8 pounds in another (table 16). The average output of dry milk in all of the plants combined was 64.8 pounds for each hour of labor.

The average output of dry milk per hour of labor was about 70 per cent higher in the larger volume plants with an annual output of five million pounds and over than in the group of plants producing less than four million pounds annually. As the volume of output at individual plants is increased, certain economies of scale are brought into play. Labor requirements do not increase in direct proportion to increases in volume. For example, office and boiler room employees as well as some other parts of the labor force are not always increased with increases in milk

Table 16. Relationship of Volume of Production, Dry Milk Produced Per Hour of Labor and Labor Cost Per Pound of Dry Milk, 15 Minnesota Spray Drying Plants, 1948

Annual dry milk output per plant	Number of plants	Range in dry milk output per hour of labor	Average dry milk output per hour of labor	Average labor costs per pound of dry milk
million pounds		pounds	pounds	cents
0-3.9	3	38.1-44.8	42.2	2.19
4.0-4.9	7	54.8-76.3	65.6	1.44
5.0 and over	5	62.3-80.8	72.1	1.34
Average all plants	15	38.1-80.8	64.8	1.47

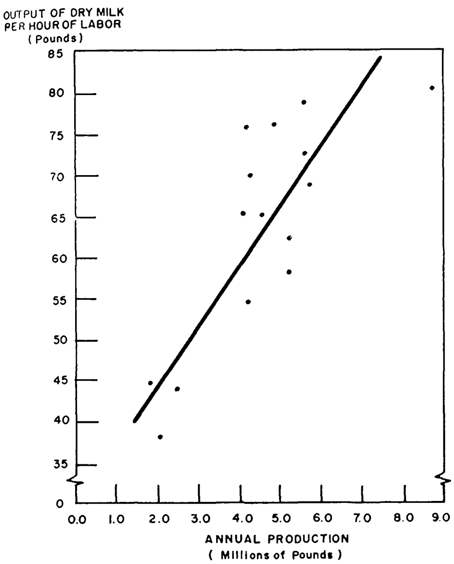


FIG. 9. Relationship of annual volume of output and dry milk output per hour of labor, 15 Minnesota spray drying plants, 1948.

receipts and powder production. Larger plants also tend to employ more labor-saving devices than do smaller plants. These factors tend to increase the output per hour of labor as volume of production expands.

That the larger drying plants are able to effect a better utilization of labor in terms of dry milk output per hour of labor than are the plants with a smaller annual production is shown graphically in figure 9.

Seasonal Variation in Output Per Hour of Labor

The number of men employed and hours worked vary greatly during the year. Since dry milk production varies much more from month to month than the hours worked, the output of dry milk per hour of labor shows a distinct seasonal pattern (figure 10). During the flush production months of May and June, total output is high, and the output per hour of labor also is at very high levels. In the fall months, the total output is low, and the output per hour of labor is only about half as high as during the flush period in May.

There was much variation among the 15 spray drying plants in the powder output per hour of labor in any particular month. Since the wage rates do not vary to the same degree, labor costs are much higher in some plants than in others. This indicates that it might be possible to reduce labor costs by increasing the efficiency or output per hour of labor in the relatively high costs plants.

Relationship of Management and Labor Productivity

Although the quality of labor may affect output, management is probably a larger factor. The management factor is reflected in the number of men required to do a certain job. In some

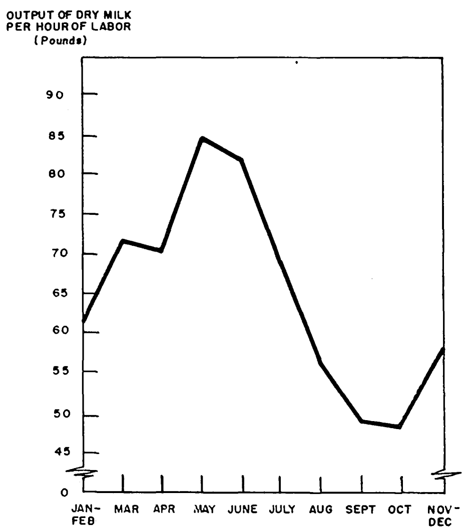


FIG. 10. Seasonal variation in dry milk output per hour of labor, 15 Minnesota spray drying plants, 1948.

plants, more men than necessary are hired to do certain jobs. In other plants, the managers plan the work so that nearly maximum output per hour of labor is attained. During the war years, there was a tendency for the drying plants to be operated rather inefficiently because prices were high and the emphasis was placed on volume of output regardless of cost. This situation has carried over into the postwar period, but price declines have brought about much greater interest in lower costs and higher plant efficiency.

One of the large organizations operating several drying plants adopted the policy of computing output per hour of labor at the various plants. Reports showing output at these plants were returned to the plant managers for comparison purposes. Some of the plants appeared to be relatively inefficient in comparison with the other plants. This technique was very successful because in a very short time, the output per man at the less efficient plants began to increase. Through close scrutiny of the operations, the managers were able to cut down on the number of men required and increased the output of the remaining personnel.

Adjustment of Labor to Changes in Production

There are many reasons why the labor supply is not adjusted closely to the variations in dry milk output. Probably the principal one is that the officials of most drying plants consider it poor personnel relations to be hiring and firing men during the year. Consequently, they try to operate during the flush season with as few employees as possible, and then try to keep most of these employees on the payroll for the entire year.

In the slack seasons, the powder production per hour of labor falls, but the employees are kept busy painting the plant, making repairs, and doing other odd jobs around the plant. This often results in inefficient use of labor and relatively high labor costs.

In some plants the workers voluntarily work longer hours during the flush seasons with the understanding that they will have extra time off during the slack production period. In other plants the variation in the number of laborers is reduced by working the personnel overtime during the flush season. Some plants adjust the labor supply more closely to output through the use of part-time help or help that is hired for only a few months of the year.

If labor costs are to be held to a minimum, it will be necessary for the plant managers to adjust the number of employees and hours worked with changes in powder output. This together with measures designed to give near maximum output per hour of labor should result in greater labor efficiency and lower labor costs.

FUEL USED PER POUND OF DRY MILK

Fuel use in these plants also was analyzed in physical output and input terms. Ratios of the units of fuel used per unit of dry milk produced were calculated for the plants using different types of fuel.

Plants Using Fuel Oil

On the average, .18 gallon of fuel oil was required to produce a pound of dry milk in six Minnesota spray drying plants in 1948 (table 17). Fuel oil used per pound of dry milk produced ranged from .17 to .21 gallon in the various plants.

At nearly all of the plants fuel used per pound of dry milk produced was highest during the low production

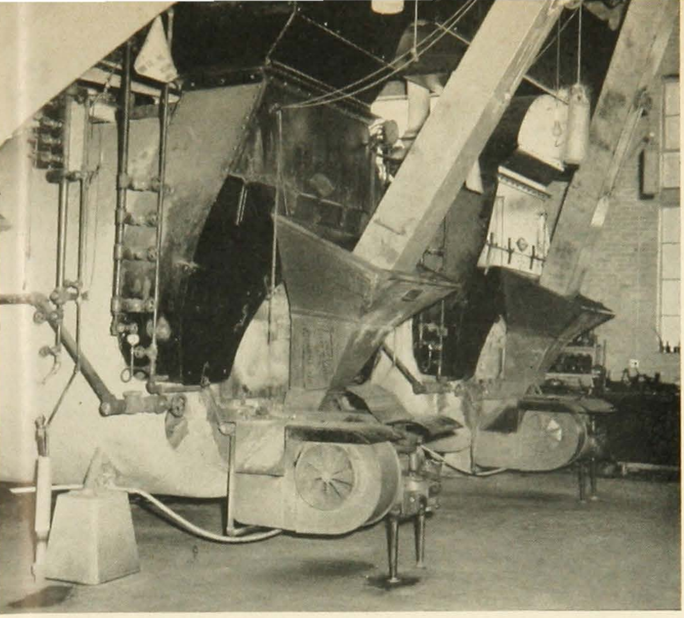


FIG. 11. Modern stokers and fuel handling equipment help to reduce milk drying costs.

months of the fall. Conversely, the amount of fuel used per pound of powder was lowest during the flush production months of May and June. In all of the plants combined the average amount of fuel oil used to produce a pound of dry milk varied from a low of .16 gallon in June and July to a high of .21 gallon in October and January.

It may be noted that occasionally fuel used per pound of powder showed considerable variations from month to month. Generally these are due to errors in making fuel inventory estimates, but over a period of months these errors tend to compensate for each other.

Plants Using Coal

Data from seven plants using coal for fuel indicate that on the average 2.24 pounds of coal were required to pro-

Table 17. Gallons of Fuel Oil Used Per Pound of Dry Milk Produced in Six Minnesota Spray Drying Plants, 1948

	Plant						Weighted average per month*
	1	2	3	4	5	6	
	gallons of fuel per pound of dry milk						
January	.16	.21	.22	.20	.19	.32	.21
February	.16	.18	.18	.21	.23	.25	.19
March	.15	.20	.16	.19	.17	.23	.18
April	.15	.16	.18	.20	.17	.22	.18
May	.15	.16	.23	.16	.15	.18	.17
June	.14	.16	.15	.16	.16	.21	.16
July	.14	.15	.15	.16	.17	.18	.16
August	.18	.16	.21	.17	.18	.16	.17
September	.49	.16	.17	.16	.18	.23	.20
October	.34	.26	.14	.21	.24	.20	.21
November	.18	.11	.17	.20	.23	.18	.18
December	.16	.16	.14	.20	.25	.20	.18
Average†	.17	.17	.17	.18	.18	.21	.18
Cost per pound (cents)	1.567	1.631	1.513	1.717	1.734	1.825	

* Weighted by pounds of dry milk produced at each plant each month.
† Weighted annual average.

duce a pound of dry milk (table 18). The individual plants varied from nearly two pounds of coal per pound of powder at Plant No. 1 to 2.4 pounds at Plant No. 5. As in the case of the plants using fuel oil, there appeared to be a season variation in coal consumption per pound of dry milk produced. Generally fuel use per unit was highest during the fall and winter and lowest during May and June.

Fuel costs per pound of dry milk produced were lowest in Plants No. 7 and No. 1 with costs of 1.074 and 1.157 cents a pound, respectively. Fuel used and costs were low in Plant No. 7 because this plant purchased relatively large quantities of power and electricity. Plant No. 1 appeared to have somewhat more efficient fuel utilization than did the other plants.

Plants Using Lignite

Only a few plants used lignite for fuel. At one plant, 3.56 pounds of lignite were used for each pound of powder produced. This is more than the 2.24 pounds of coal used per pound of powder, but lignite is lower in price than is coal. Cost comparison indicates that plants using lignite have somewhat lower fuel costs than plants burning oil or coal. However, more pounds of the fuel must be handled, and the lignite is often of poor quality. In spite of the apparently lower costs, some of the plants formerly using lignite have shifted back to coal.

Plants Using Natural Gas

Natural gas is the lowest cost fuel used to dry milk. However, it is impossible for plants to shift to gas unless they are located on a pipeline. The usual natural gas contract calls for the plants to be cut off during the peak loads of the winter heating season. This means that the plants must have stand-by heating equipment such as oil or coal burners. This additional cost and inconvenience is apparently more than compensated for by the low rates available on the natural gas.

Table 18. Pounds of Coal Used Per Pound of Dry Milk Produced in Seven Minnesota Spray Drying Plants, 1948

Month	Plant							Weighted average†
	1	2	3	4	5	6	7*	
	pounds of coal per pound of dry milk							
January	2.20	2.63	2.50	2.65	3.17	2.93	2.01	2.59
February	2.51	2.35	2.28	3.17	2.64	2.94	2.34	2.55
March	1.51	1.94	2.49	2.82	3.52	2.35	2.13	2.22
April	2.05	2.04	2.60	2.71	2.56	2.33	1.52	2.28
May	1.83	1.72	2.01	2.08	1.81	2.00	1.62	1.88
June	1.64	1.98	2.00	1.96	1.82	2.28	1.51	1.94
July	2.49	2.29	2.22	2.39	2.37	2.36	.97	2.35
August	2.12	3.11	2.06	2.12	2.32	2.42	1.70	2.36
September	1.81	2.52	2.59	2.26	2.98	2.57	1.36	2.39
October	1.90	2.14	2.40	1.86	.65	2.73	3.48	2.08
November	2.61	3.17	2.47	2.29	2.71	2.90	2.78	2.77
December	1.59	2.65	2.08	1.92	2.15	1.93	2.09	2.10
Average‡	1.99	2.27	2.27	2.33	2.34	2.41	1.75	2.24
Cost per pound (cents)	1.157	1.420	1.507	1.646	1.494	1.551	1.074	

* This plant purchased large quantities of power.
† Weighted by the monthly production at each plant. Plant No. 7 was excluded from this average because of purchased power.
‡ Weighted annual average.

Cost Reduction

IN THE FOREGOING sections data have been presented on the costs of assembling milk and on the costs of manufacturing dry milk. Factors affecting these various costs have been discussed. In this section some specific suggestions for reducing the costs of producing dry milk are presented.

REDUCING MILK ASSEMBLY COSTS

There is need to make some changes in the present farm-to-creamery-to-drying-plant system of assembling milk to be used in drying. In many areas the costs of assembling milk could be reduced by transporting all or a larger proportion of the milk directly from the farm to the central drying plant. This would eliminate handling and processing of milk in each of a number of creameries now receiving milk for transfer to central plants. Costs of receiving and handling relatively small quantities of milk in many small creameries are high and tend to reduce returns which can be paid to dairy farmers. The receiving, skimming, cooling, and other handling of milk could be done on a much larger scale and more economically at the central drying plants.

In the case of drying plants with small and nearby milk supply areas all of the milk could be hauled direct from farms to the central plant. In the plants where milk must be assembled from a much larger area it could be received in a few well-located creameries or specialized milk-receiving stations, and then transferred to the central plant by tank trucks.

Milk hauling costs can be reduced by giving more attention to planning truck routes and loads. The duplication of truck routes, cross-hauling between plants, and other wasteful transportation practices should be avoided to reduce hauling costs.

REDUCING MANUFACTURING COSTS

Increasing Size of Plants

Costs of producing dry milk could be reduced by increasing the volume of output of many of the drying plants. The volume of individual plants could be increased by reducing the number of plants, by inducing patrons to increase milk production, or by diverting milk supplies from other uses.

Consolidation and closing of some plants appear to be the most promising of the alternatives for increasing the volume of drying plants in this area at this time. Many of the larger plants in the state have unused plant capacity and could process to advantage the milk now handled by smaller neighboring plants. Both groups of plants could benefit from such arrangements.

The size of plant, of course, cannot be increased indefinitely since a point ultimately is reached where unit costs level out and start to increase with further increases in output. Also, to be considered is the fact that hauling costs will rise as a plant reaches out over a wider area for its milk supplies. Thus a point is reached where increased assembly costs equal or outweigh the economies of scale gained from having a larger plant. The most economical size of plant varies in different sections of the state because of differences in the density of milk production. For example, in the areas of denser milk production, per unit assembly costs would tend to be lower and larger scale operations would be feasible. In areas where milk production per acre is relatively low and unit assembly costs high the most economical size of plant would be somewhat smaller.

Evening Out of Seasonal Production

It has been shown that costs of manufacturing dry milk vary seasonally with changes in production. If seasonal production were evened out, manufacturing costs for the year could be reduced greatly. Fewer plant facilities and equipment would be needed and the difficult problem of adjusting the factors of production to changes in output would be greatly simplified.

Adoption of special seasonal pricing plans for milk could be of some help in regularizing production during the year. Under normal conditions prices of milk usually are somewhat higher in the fall than in the spring, but this price differential evidently is not large enough to induce farmers to produce more of the annual milk output in the fall. Additional seasonal price incentives are needed.

Plant officials, as well as farmers, are not generally aware of the large difference in dry milk manufacturing costs between the high and low production periods. To aid in evening out the seasonal milk flow this information should be disseminated and an educational campaign conducted among the patrons. Experience in city milk sheds indicates that information and education have been helpful in reducing the seasonal milk production problem.

Improving Labor Efficiency

Drying costs could be reduced if the output of powder per hour of labor employed could be raised. The employment of more part time workers for only the flush production period would make it possible to adjust the labor supply more closely to the seasonal fluctuations in production. Limited availability of qualified seasonal workers during the war and accelerated defense production periods has made this adjustment difficult. Employee vacations should be arranged so that they are taken during the period of low production rather than in the period of flush production.

A wider use of labor saving devices in milk drying plants would be of much value in improving the utilization of labor. Greater use of conveyors, power lift trucks, and other materials moving equipment would result in a more effective use of labor.

The number of men employed to perform identical operations such as plant clean-up, packing, boiler room operation, and others vary widely from plant to plant. This suggests possibilities for improvement in the way of more careful selection and training of employees, time and motion studies, better planning of work, and more adequate supervision.

In some cases, the plant layout and arrangement of equipment can be changed so that less labor is needed. In general, the efficient utilization of labor is largely a responsibility of management.

Lowering Fuel Costs

Differences in the fuel costs of various plants suggests the possibility of reducing those costs in the higher cost plants. The type of fuel used has an important influence on costs. Wherever possible, natural gas should be used since plants using gas had much lower fuel costs per pound of dry milk produced.

The larger plants, in general, had somewhat lower fuel costs, but there were small plants with relatively low costs. The principal difference between

FIG. 12. Stacking barrels of dry milk in a drying plant warehouse.

these plants appeared to be in management. The low cost plants were operated so that idle time and warm-up periods were held to a minimum. Better selection of boiler room personnel in these plants resulted in more efficient operation and a higher output of powder per unit of fuel used resulted.

Reducing Package Costs

Most of the output of nonfat dry milk solids intended for shipment is packed in wooden barrels or fiber drums with one or more moisture-proof liners. Some plants have packaged dry milk in waterproof bags and have reported good acceptance by buyers of the product. Other plants have used plastic containers inside burlap or paper bags. Bags are lower cost packages than barrels or drums, but they will not withstand rough handling in shipment so well. Dry milk to be stored for some time usually is packed in barrels or fiber drums. However, there are many uses for which dry milk could be packed in bags. This would result in lower packaging costs.

There is need for further research on dry milk packaging. The industry continues to search for a low cost package which will be satisfactory to users of the product, and which will do a good job of preserving the product as nearly as possible in the form in which it comes from the drier. The possibility of shipping dry milk to large commercial users in bulk, as some flour is shipped in the milling industry, has not been thoroughly explored. Shipment of the product in this form should result in reduced packaging costs.

Good Management Practices

The importance of good management practices in lowering costs of processing dry milk cannot be overemphasized. Differences in the costs of plants of the same size, similar equipment, and plant layout can be traced to differences in the quality of management.

To improve management of drying plants more attention needs to be given to the selection, training, and adequate compensation of the managers. Managers should be encouraged to refresh and supplement their training from time to time, not only in the field of dairy technology but also in various aspects of business management as well.

In view of the importance of management in cost reduction, boards of directors and others responsible for selecting managers should consider the qualifications of applicants for these positions with great care. Good salaries and other desirable job conditions should be provided in order to attract highly qualified individuals.

Summary

GROWTH AND DEVELOPMENT OF THE INDUSTRY

The dry milk industry in Minnesota expanded rapidly during the early years of World War II. Much of the increased milk supplies were obtained by inducing farmers to shift from the delivery of farm-separated cream to delivery of whole milk. To process this increased volume of milk many new drying plants were built and the capacity of many existing plants was expanded.

During the last few years the output of spray-process, nonfat dry milk solids has increased in relation to the production of roller powder. In 1950, Minnesota produced about 18 per cent of the total nonfat solids, 13 per cent of the whole milk powder, and about 40 per cent of the dry buttermilk processed in the United States.

The number of milk drying plants in Minnesota has remained about the same during the last few years, but there has been a large increase in average output per plant. In 1942, there were only 25 plants each producing more than one million pounds of dry milk each year. In 1948, 51 plants each produced more than this amount.

It was found that drying plants in the state have considerable unused plant capacity. A comparison of capacity estimates with production data indicates that facilities at many plants are not fully utilized even during the flush season.

HAULING COSTS

Most of the small creamery drying plants received their milk directly from producers. The most common charge for hauling milk from the farm to the local plant was from 15 to 20 cents a hundredweight. The large centralized plants

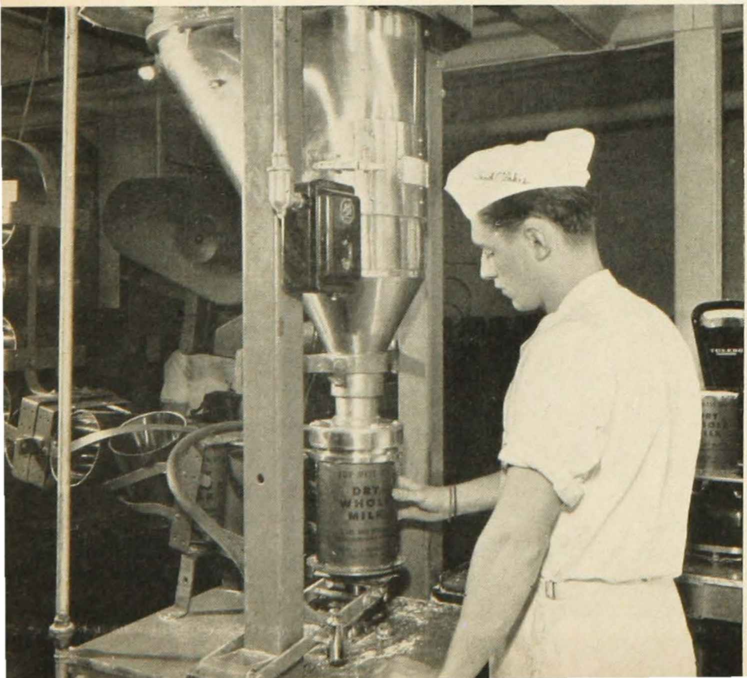


FIG. 13. Packaging dry milk in small containers for home and other uses.

bought the milk from the creameries and hauled it to their plants by tank truck. Data from 21 plants indicate that the average cost of hauling milk from the creamery to the drying plant in tank trucks was 0.87 of a cent per pound of dry milk produced.

MANUFACTURING COSTS

The average cost of manufacturing dry milk, exclusive of hauling and selling costs, at 24 Minnesota roller drying plants in 1947, was 3.85 cents a pound. Similar costs at 22 spray drying plants were 4.43 cents per pound. In both types of plants, the larger plants appeared to have somewhat lower costs. There was much variation among the different plants, however, and in some cases, small plants had lower costs than plants with a larger volume. The type and quality of the management was one of the most important factors affecting costs.

Costs in 1948 were approximately 0.4 cent higher than in 1947. Most of this increase occurred in fuel. Wage rates were higher, but labor efficiency was improved. As a result, labor costs per pound of powder remained about the same.

The three most important cost items were labor, packaging supplies, and fuel. Together, these costs made up nearly three fourths of the total manufacturing cost. In all cases, office and administrative expenses made up a very small part of the total processing costs. Oil appeared to be the highest cost fuel, and plants using natural gas or lignite had the lowest fuel costs per pound of powder.

The seasonal variation in powder production has considerable effect upon costs. During the flush production period, average costs at 20 Minnesota drying plants were nearly 2½ cents a pound lower than similar costs during the low production period in the fall.

There was a considerable difference in the productivity of labor in the various plants. The larger plants appeared to have a slightly higher output per hour of labor than did the smaller plants. Labor productivity was much higher during the flush production months than during the period of short production in the fall.

Records on fuel utilization indicated that it took approximately .18 gallons of fuel oil to produce a pound of dry milk. In plants burning coal, 2.24 pounds of coal were required to produce the same amount of powder.

REDUCING COSTS

In many cases hauling and milk assembly costs could be reduced by hauling the milk directly from the farm to the drying plant. The elimination of cross hauling and better planning of routes and loads would also bring about lower hauling costs.

Since the larger plants appear to have somewhat lower costs, costs could be reduced if the size of plants were increased. During the last few years there has been an increase in the average size of plant. It is probable that the development will continue as some of the smaller plants are closed or consolidated with larger plants.

The introduction of more labor saving devices, such as conveyors and power lift trucks, will help reduce labor costs. Careful consideration of the types of fuel and packaging used is important if costs are to be reduced.

Costs can also be reduced by keeping operations of the plant as nearly as possible at full plant capacity. In order to do this, it will be necessary for the manager to obtain adequate milk supplies and to make an attempt to even out as much as possible the seasonal variation in milk deliveries.

In general, the problem of reducing costs appears to center around management. In some plants, the output per hour of labor and the efficiency of the fuel utilization were far superior to the same factors in other plants of essentially the same size. Since the equipment and plant layout were very similar, these differences must have been due to the quality of management. In the plants operated by the better managers, the output per hour of labor was high, the fuel required per pound of powder was low, the plants operated at more nearly full capacity, and the operating costs were low.

Your Agricultural Experiment Station . . .

The Minnesota Agricultural Experiment Station functions as part of the University of Minnesota Department of Agriculture in serving the people of Minnesota.

The Department itself has three jobs:

- **Research** to develop new and better farm practices, crops, and animals and to learn basic facts about nature.
- **Teaching** to prepare young men and women for careers in agriculture, forestry, home economics, and veterinary medicine.
- **Extension** to bring the results of research to the farmer, his wife, and his children through demonstrations, meetings, home visits, newspaper articles, radio programs, and the like. Much of this work is done through your local county agricultural, home, and 4-H agents.

The Experiment Station conducts research in many widely varied fields. Research projects may range from improved diets for the family to better use of the products of our forests, and from the development of better varieties of farm crops to the discovery of new markets for agricultural products.

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Experimental work is conducted in many places. Some of it takes place in the laboratories and the fields of the St. Paul Campus; some is conducted at the Rosemount Station and at branch agricultural experiment stations at Waseca, Morris, Crookston, Grand Rapids, and Duluth. Specialized research is carried on at the Fruit Breeding Farm at Excelsior, the Potato Farm at Castle Danger, at the Forest Experiment Station at Cloquet, and at the Hormel Institute at Austin. Hundreds of farmers, too, are cooperating with the Station in experiments on their own farms either as individuals or in groups often representing several counties.

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