MH

Maleic hydrazide, MH, can be used for temporary suppression of quackgrass. Four to six pounds per acre, applied in spring or summer when the grass is 4 to 10 inches high and followed by plowing or thorough disking 4 to 8 days after treatment, will give seasonal control. Crop seeds sown after MH treatment are not affected by the chemical. Therefore, this method is useful in home gardens as well as in farm lands. Repeated use of the method for two seasons may be required for complete eradication of quackgrass.

Dalapon

Dalapon—sodium salt of 2, 2-dichloropropionic acid—is effective when applied to quackgrass that has a good growth of foliage from 4 to 10 inches tall. Fall treatments of 10 pounds per acre, followed in a week or two by plowing or other soil preparation, will give good control of quackgrass the following year. Repeated treatments will be necessary for eradication. Crops sown in the spring on treated areas will not be affected following such an application.

Dalapon may also be applied to quackgrass leaf growth in the spring. Application of 5 pounds per acre, when the grass is from 4 to 10 inches tall, is most satisfactory. This should be followed in about 2 weeks by plowing or some other form of soil preparation. Cultivated crops, smother crops, or clean tillage result in better control than small grains sown following treatment. Some hazard to crops follows the spring application; they should not be planted until 4 weeks after the application. Corn, wheat, red and alsike clovers, soybeans, and other types of beans are especially sensitive to small quantities of dalapon remaining in the soil.

A single application of 10 pounds of dalapon per acre in the early spring will give seasonal control in areas that cannot be cultivated. However, it may cause damage to shrubs or trees growing in the area. Two applications of 5 pounds per acre, with an interval of 6 weeks between treatments, will control the growth of quackgrass under mature fruit trees. Dalapon should not be used under trees that have not reached the fruiting stage.

Dosage ranges for all chemicals are broad enough to cover the entire region. However, local experiment stations should be consulted for the most effective rates in any particular area.

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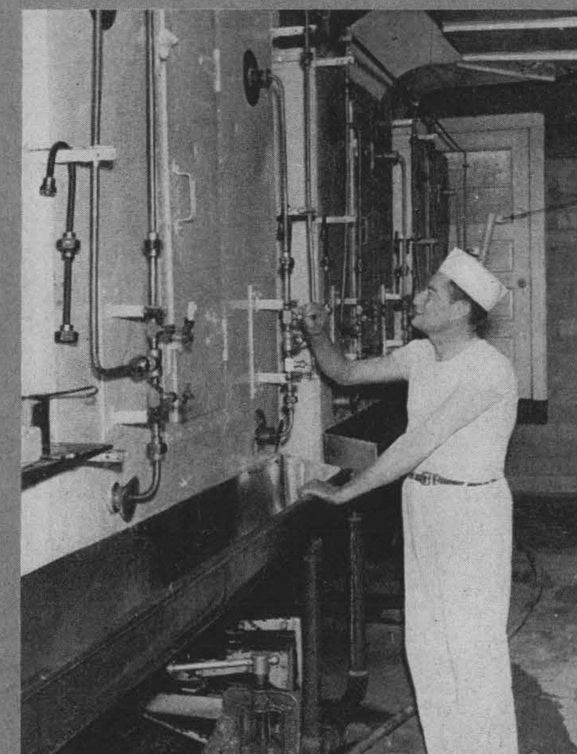

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Agricultural Experiment Station

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Costs of Drying Milk in Specialized Drying Plants

Linley E. Juers and E. Fred Koller[1]

WORLD WAR II and the early postwar years saw a rapid shift on Minnesota dairy farms from the selling of farm-separated cream to the selling of whole milk. While it had started prior to the war, the shift was greatly accelerated by the relatively favorable prices paid for nonfat dry milk solids in that period. To process the resulting increase in the supply of milk, a number of new centralized drying plants were built and production facilities at the existing plants were expanded.

Many marketing problems have accompanied this rapid growth in the dry milk industry. They have become intensified since the close of the Korean War. The supply of nonfat dry milk solids has greatly exceeded the demand in recent years, and much of the output has been purchased by the government under the price support program. Under this surplus situation, the difference between costs and prices received for dried milk have narrowed.

In view of these conditions, operators of milk-drying plants have shown an increased interest in processing costs and methods that might help lower them. Increased efficiency and lower costs should enable the plants to return to the farmer a higher percentage of the price consumers pay for dry milk products.

PURPOSE AND SCOPE OF STUDY

The purpose of this study was to determine the changes that have occurred in the cost of manufacturing dry milk in specialized drying plants during the period since World War II. Another aim was to determine the effect of plant volume, managerial policy, and other factors on the efficiency and costs of milk-drying plants.

The scope of the study was limited to 18 large specialized drying plants located in Minnesota. A "specialized drying plant" is one equipped principally to manufacture dried milk. All were "centralized" plants which dried milk assembled from several creameries or receiving stations in their area. The 18 plants selected were those from which data had been collected for an earlier study in 1947 and 1948.[2] This permitted comparison of costs over a period of time to show the changes which occurred.

Costs considered in this study are restricted to those directly associated with the manufacture of dried milk; costs incurred in the assembly of milk or selling of the finished product are not included. The objective was to obtain

[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. Credit is due Dr. S. T. Coulter of the Department of Dairy Husbandry and Drs. R. W. Cox and O. B. Jesness of the Department of Agricultural Economics, University of Minnesota, for many helpful suggestions.

[2] Dale E. Butz and E. Fred Koller, "Costs of Drying Milk in Minnesota Plants," Minn. Ag. Exper. Station Bul. 413, May 1952.

cost comparisons which reflect efficiency as influenced by plant volume and managerial policy. While assembly and selling costs are affected by volume and management, they are also influenced to a great extent by location and competitive conditions which are not comparable between plants.

The cost data used in this study were obtained from audit reports, plant production records, and personal interviews with plant managers and other personnel. The data were for the calendar year 1953 or the 1953 fiscal year, depending on the period used in the plant's bookkeeping system. In those plants where records were kept on a monthly basis, monthly production and cost information were also obtained.

Dry Milk Production

The production of nonfat dry milk solids in the United States has been increasing rapidly since 1951. Production in 1955 set a new record high of 1.48 billion pounds.

Along with the increase in dry milk production there has been a general shift to the spray process of drying. Table 1 shows the amount of nonfat dry milk solids manufactured by the spray and the roller process from 1947 to 1955. It is quite apparent that most of the increases in production over this period have been in spray drying.

In recent years, spray-drying equipment has replaced much of the roller equipment. The superior quality of the product made by the spray process is one of the major factors in this shift. Another important consideration is that spray-process dry milk commands a slightly higher price than that made by the roller process. This price differential is more than sufficient to offset the slightly greater cost of drying with spray equipment.

Table 1 also illustrates the importance of nonfat dry milk solids relative to the other dried milk products. Over the same period in which nonfat dry milk solids production has showed large increases, production of dry whole milk has declined significantly and dry buttermilk production has shown little change.

Government purchases under the price support program have been an important factor influencing the upward trend in nonfat dry milk solids production. Dry whole milk and buttermilk prices have not been supported and in consequence production of these products has been restricted to current market requirements. With the government willing to hold surpluses of nonfat dry milk solids while supporting the price, production has far exceeded domestic demand.

Table 1. Production of Dry Milk Products in United States, 1947-1955*

Year	Nonfat dry milk solids: Spray	Roller	Total	Dry whole milk	Dry buttermilk
	thousands of pounds				
1947	418,704	259,237	677,941	164,888	45,437
1948	436,071	245,461	681,532	170,087	41,839
1949	627,942	306,992	934,934	125,541	49,359
1950	623,967	257,111	881,078	124,986	48,668
1951	546,387	156,089	702,476	131,017	45,467
1952	665,076	198,144	863,220	101,732	47,067
1953	971,578	242,196	1,213,774	104,352	57,424
1954	1,158,537	243,837	1,402,374	93,874	56,348
1955†	1,282,000	202,600	1,484,600	103,220	58,350

* Source: *Production of Manufactured Dairy Products* (annual), Agricultural Marketing Service, USDA.
† Preliminary.

MINNESOTA DRY MILK PRODUCTION

Changes in dry milk production in Minnesota have followed a pattern very similar to that of the United States. There has been a substantial increase in the production of nonfat dry milk solids over the past decade with a strong trend toward the spray dried product. (See table 2.) The decline in production of dried whole milk has been greater, proportionately, in Minnesota than for the United States as a whole. Dried buttermilk production has also decreased considerably, while total production for the country has shown a slight increase.

Minnesota ranks second among the states in the production of nonfat dry milk solids, producing about 20 per cent of the total United States output. In 1953, the three leading states—Wisconsin, Minnesota, and New York—produced respectively 28, 21, and 11 per cent for a combined total of 60 per cent of the total United States production. Minnesota ranks first in the production of dry buttermilk and fourth in the production of dry whole milk.

DOMESTIC COMMERCIAL SALES

Domestic commercial sales of nonfat dry milk solids in the United States were 80 per cent of the total production in 1952. Since 1952, production has increased more rapidly than use and the percentage sold in domestic commercial channels has declined. In 1955 with production at 1.48 billion pounds, domestic commercial sales were 867 million pounds, or about 58 per cent of production.

The largest market for nonfat dry milk solids sold commercially has been the bakery industry. In 1955 bakery purchases amounted to 37.7 per cent of commercial sales. (See table 3.) Dairy uses including the manufacture of cottage cheese, ice cream, and others rank-

Table 2. Production of Dry Milk Products in Minnesota, 1947-1954*

Year	Nonfat dry milk solids: Spray	Roller	Total	Dry whole milk	Dry buttermilk
	thousands of pounds				
1947	106,167	58,660	164,827	22,803	20,060
1948	106,928	56,069	162,997	34,763	19,643
1949	127,775	53,215	180,990	20,072	19,646
1950	123,023	37,451	160,471	15,904	18,961
1951	113,224	22,518	135,742	19,241	17,200
1952	149,368	38,311	187,679	10,459	14,274
1953	202,663	43,931	246,594	8,435	16,761
1954	236,971	33,251	270,222	3,582	14,775

* Minnesota State-Federal Crop and Livestock Reporting Service, *Minnesota's Cattle and Dairy Industry: Dairy Supplement, 1955.*

Table 3. Domestic Sales of Nonfat Dry Milk Solids By End Use, United States, 1952-1955*

End use	1952 Million pounds	1952 Per cent	1953 Million pounds	1953 Per cent	1954 Million pounds	1954 Per cent	1955 Million pounds	1955 Per cent
Bakery	275.3	39.9	263.0	42.0	276.2	38.4	326.9	37.7
Dairy	160.1	23.2	125.9	20.1	146.0	20.3	200.8	23.1
Package for home use	84.9	12.3	96.4	15.4	141.7	19.7	149.7	17.2
Meat processing	87.6	12.7	64.5	10.3	67.5	9.4	88.4	10.2
Prepared dry mixes	30.3	4.4	42.0	6.7	47.9	6.7	55.2	6.4
Confectionery	15.2	2.2	12.5	2.0	16.8	2.3	16.6	1.9
Institutions	3.0	0.4	2.5	0.4	2.9	0.4	2.2	0.3
Soup manufacturers	6.2	0.9	3.1	0.5	2.6	0.4	3.2	0.4
Chemicals, etc.	3.4	0.5	3.2	0.5	2.5	0.3	0.8	0.1
Soft drinks	2.6	0.4	1.3	0.2	2.2	0.3	4.3	0.5
Animal feed†	11.8	1.7	5.6	0.9	3.7	0.5	9.0	1.0
All others	9.7	1.4	6.3	1.0	9.2	1.3	10.5	1.2
Total	690.1	100.0	626.3	100.0	719.2	100.0	867.6	100.0

* Source: *1955 Census of Dry Milk Distribution and Production Trends,* The American Dry Milk Institute, Inc., Chicago.

† This is nonfat dry milk solids processed for human consumption.

ed as the second largest market outlet and showed the largest gain in 1955.

Sales of nonfat powder in small packages for home use have shown substantial gain since 1947, from 2 million pounds in that year to over 149 million in 1955. This outlet ranked third in 1955. These three outlets combined accounted for 78 per cent of commercial sales in 1955. Only three end uses showed declines in the amount of nonfat dry milk solids used during 1955.

GOVERNMENT PURCHASES AND DISPOSITIONS

Government purchases of nonfat dry milk solids under the price support program have amounted to about 2 billion pounds from April 1952 through March 1956. This was approximately 39 per cent of the total production over that period. (See table 4.) Government purchases reached a peak of 666 million pounds in the crop year 1953-54.

Most of the dried nonfat solids purchased by the government have been disposed of through various outlets including sales for animal feed and domestic and foreign donations. (See table 4.) The largest outlet for surplus nonfat dry milk solids has been through donations under Section 416 of the Agricultural Act of 1949. This section provides for donations to school lunch programs and needy persons within the United States and in foreign countries in order to avoid waste of stored food commodities through spoilage or deterioration.

Sales for animal and mixed feed uses were the second largest outlet and represent the largest amount of nonfat dry milk solids to be sold out of storage. A large proportion of these sales were made to feed manufacturers in the summer of 1954 at prices of 3½ or 4 cents per pound. This was only a fraction of the cost of this powder to the government. Other outlets included some commercial domestic sales, commercial export sales, transfers to the army, and government exports sales—all of which were small relative to the

Table 4. Government Purchases and Dispositions of Nonfat Dry Milk Solids Under the Dairy Price Support Program, April 1, 1952 to March 31, 1956*

Item	pounds	per cent
Purchases		
Crop year†		
1952-53	210,410,097	
1953-54	665,871,918	
1954-55	523,207,269	
1955-56	624,005,209	
	2,023,494,493	
Dispositions		
Commercial domestic sales	5,294,501	0.3
Animal and mixed feed sales	601,238,008	30.4
Section 32 outlets	48,768,550	2.5
Section 416 donations		
Domestic	129,173,276	6.5
Foreign	720,272,081	36.4
Commercial export sales	41,391,404	2.1
Commercial export—animal feed	75,000,000	3.8
Noncommercial export sales	320,468,760	16.2
U. S. Army transfers	7,253,843	0.4
I. C. A. transfers	27,074,946	1.4
Other	1,116,875	‡
	1,977,052,244	100.0
Uncommitted supplies (March 31,1956)	46,442,249	

* Source: USDA Monthly Dairy Price Support Activity Report (Mimeo), April 1956.

† Crop year: April 1 to March 31.

‡ Less than .1 per cent.

two major outlets mentioned above. (See table 4.)

It is difficult to foresee an immediate end to the dry milk surplus problem in view of the current production and consumption levels. Present market outlets will have to be expanded and new markets found before there will be any hope of selling the entire production in commercial food channels.

Manufacturing Costs

The manufacturing costs considered in this study were those directly associated with the operation of the milk drying plants. These costs included such items as plant and administrative labor, fuel, depreciation, manufacturing supplies, repairs, and such general expenses as insurance, taxes, interest, and others. Costs incurred in the assembly of milk and the sale of the finished product were excluded.

For purposes of interplant comparison, manufacturing costs were classified into three groups. These groups are (1) plant expenses, (2) administrative expenses, and (3) general expenses. The total manufacturing cost was computed for each plant and compared with the average for all plants and with the data from the 1947 study.

Data on the hours of labor and physical units of fuel used were obtained from 13 of the 18 plants. These data on the input of physical units were used to supplement the cost data available on these components.

During the period under study, there were substantial increases in the volume of output of most of the plants observed. The average annual output per plant increased from 5.2 million pounds in 1947 to 7.1 million pounds in 1953. This is an increase of 36 per cent in the total production of the 18 plants. The volume of output of individual plants ranged from 2.3 million pounds to 14.5 million pounds in 1953 as compared with a range of 2.6 to 8.5 million pounds in 1947. Only 2 plants showed a decrease in volume over this period and 16 showed increases.

LABOR COSTS

Labor is the largest item of expense in the manufacture of dry milk. For the 18 plants in this study, labor costs averaged 34 per cent of the total manufacturing cost. Labor costs for the various plants ranged from .68 cent up to 2.03 cents for each pound of dry milk produced. The largest number of plants showed costs between 1.00 cent and 1.10 cents a pound. Table 5 shows the average labor cost per pound of dry milk for the 18 plants grouped by annual output.

Table 5. Relationship Between Annual Dry Milk Output per Plant and Labor Cost for 18 Minnesota Milk Drying Plants, 1953

Annual dry milk output per plant	Number of plants	Average labor cost per pound of dry milk
million pounds		cents
Under 2.5	1	2.03
2.5 to 4.9	3	1.21
5.0 to 7.4	7	1.12
7.5 to 9.9	3	1.02
10 and over	4	.97
Average all plants	18	1.10

The average labor cost per pound of dry milk for the 18 plants in 1953 was 1.10 cents as compared with 1.16 cents in 1947. This reduction in labor cost amounts to quite a substantial saving. On the basis of 1953 production, it amounts to an average of over 4,000 dollars per plant. With an estimated 38 per cent increase in hourly wage rates between 1947 and 1953, this reduction in labor cost reflects a very substantial improvement in labor efficiency.

Much of this increased labor efficiency is probably due to larger output in 1953 than in 1947. A certain amount of labor must be maintained at any level of output and this minimum amount of labor is a fixed cost of operating. As output is increased this fixed portion of labor cost is spread over more units of output and the resulting average cost of labor per unit of output is less. This effect is probably most easily observed in respect to labor used in daily plant cleanup. Cleaning each piece of equipment requires a certain amount of work regardless of the amount of product which has passed through it.

The relation between volume of production and the dry milk output per hour of plant labor is shown in figure 1. It is apparent from this figure that, in general, the plants with larger volume have a higher dry milk output per hour of labor than do plants with low volume.

Effect of Seasonality on Labor Costs

Also important in achieving low labor cost is the management of labor in accord with seasonal changes in volume. In all of the plants where monthly labor data were available it was found that labor cost and output per hour of labor varied with seasonal variations in production. However, the degree of variation was quite different in different plants.

In comparing plants having low labor costs with those having high labor costs, it appears that maintaining high labor

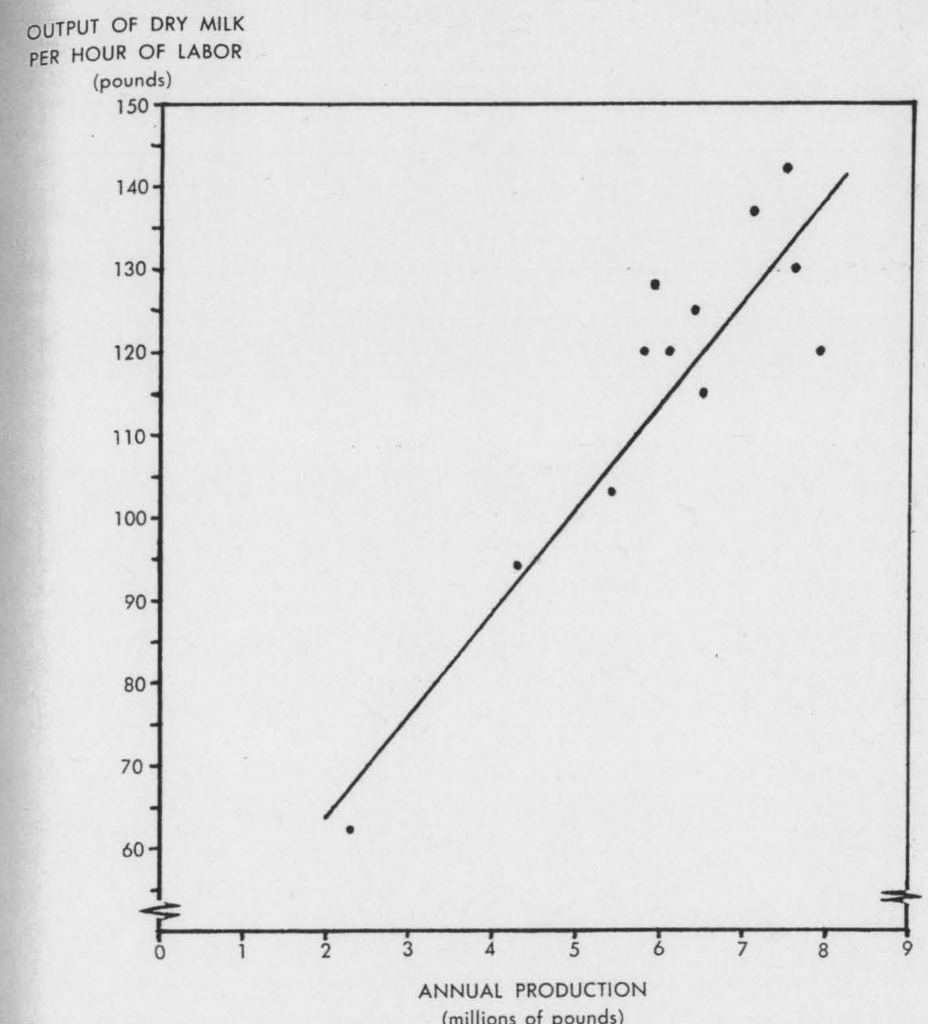

Fig. 1. Relationship between annual volume of production and dry milk output per hour of labor, 12 Minnesota drying plants, 1953. Each dot represents the annual production of dry milk and dry milk output per hour of labor of a given plant.

productivity through the flush or high production season is the important factor in keeping annual per unit labor cost low. The level of labor productivity is dependent upon how rapidly the amount of labor employed is adjusted to seasonal changes in production. Those plants showing high labor costs apparently hired extra labor in anticipation of higher production and in this way increased labor more rapidly than output. In the plants which had low labor costs, the employment policy seemed to be that of not hiring extra labor until the increase in production had taken place.

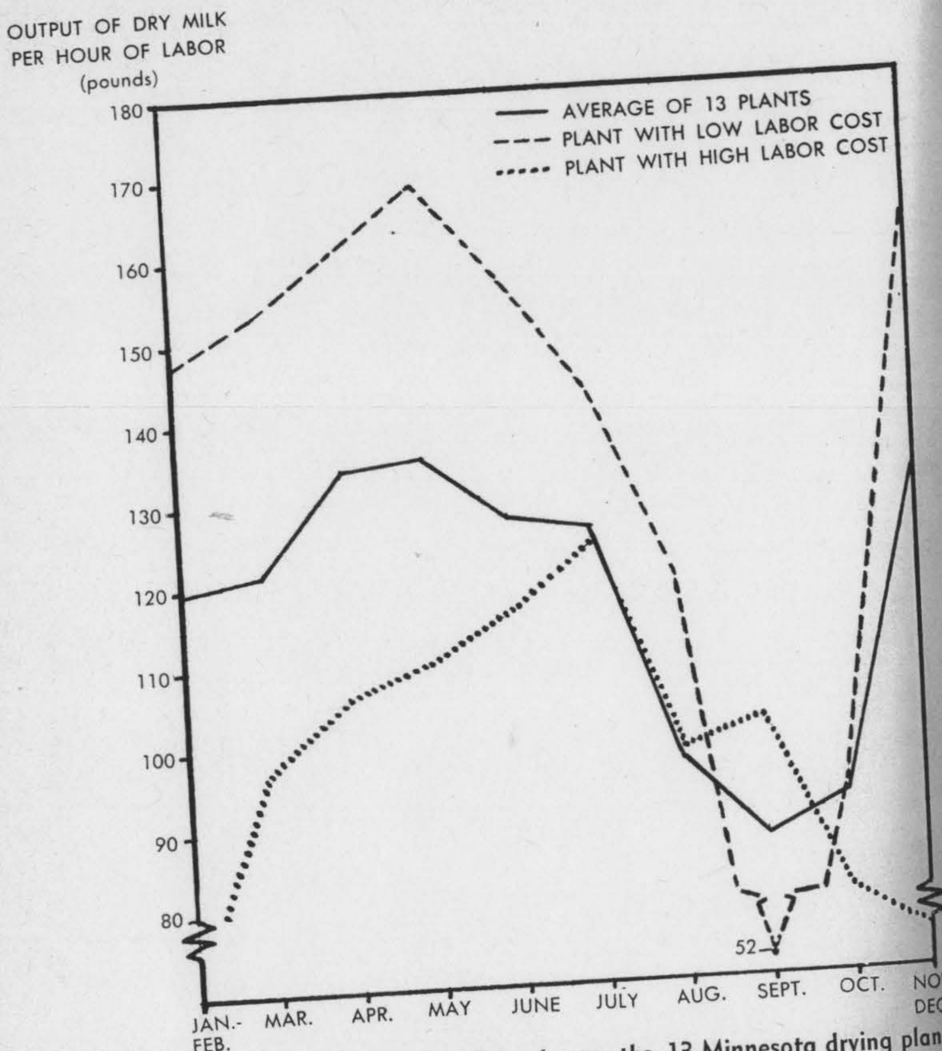

Fig. 2. Output of dry milk per hour of labor by months, 13 Minnesota drying plants, 1953. Only 10 observations were made for the year, since many of the plants combined January-February data and November-December data in their accounting records.

During the slack production period in the fall months, labor productivity fell for all plants because labor could not be reduced proportionately with the decline in level of production. After the plant labor had been reduced to the minimum needed for operation, no further cut could be made for further decline in production. Plant managers also indicated that it was often desirable to carry some surplus labor through the slack season in order to keep good men in reserve for the flush production period.

There was no significant relation between dry milk output per hour of labor during the slack season and the annual labor cost. Some of the plants having the lowest average labor cost for the year had the poorest labor efficiency during the slack season. This is because the volume during the slack season is small relative to the peak volume and the effect on total cost is small as compared with the heavy production months.

Figure 2 shows the average seasonal variation in labor productivity for 13 drying plants. The solid line represents the average output of dry milk per hour of labor of all 13 plants. The broken line shows the labor productivity by months in one plant having low labor costs per pound of dry milk and the dotted line shows similar data for a plant with relatively high labor costs. The high level of labor productivity from January through June is characteristic of all of the plants with low labor costs.

FUEL COSTS

Fuel costs were the second largest cost component in the 18 milk drying plants studied, making up 28 per cent of the total manufacturing cost. As in the case of labor, fuel costs showed considerable variation in different plants. Three different types of fuel were used by plants included in this study. Some of the variations in costs are due to this as well as to volume and the method of utilizing the fuel. Of the 18 plants, 10 had data available on the

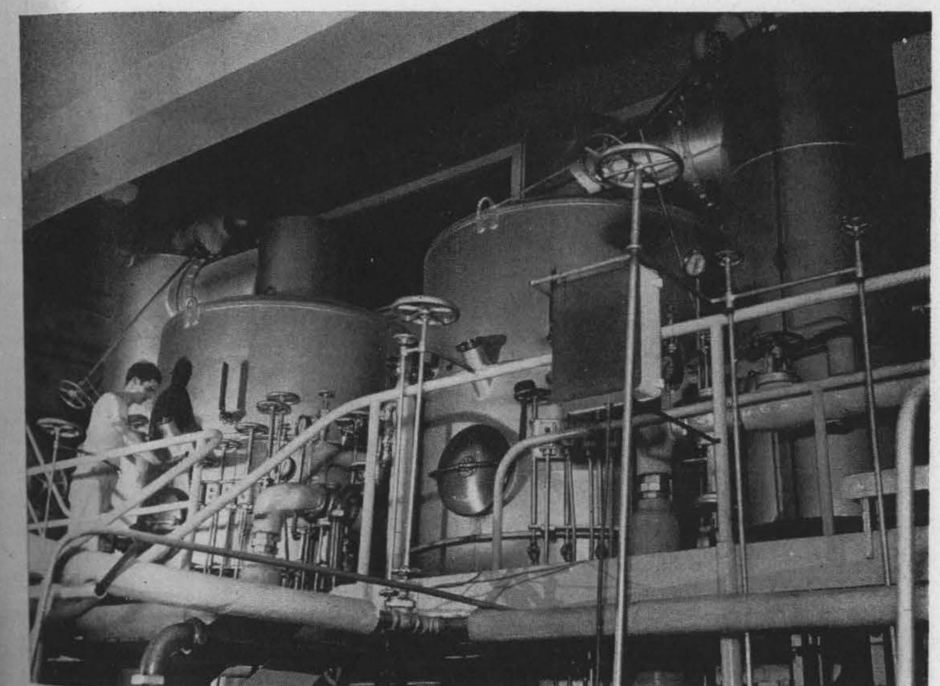

Fig. 3. The use of evaporators to remove much of the moisture from the milk increases the efficiency of the drier.

physical quantities of fuel used on a monthly basis.

The best measure of efficiency in fuel utilization is units of input per unit of output, rather than cost per unit of output. The cost of fuel per unit of output is not a desirable measure for comparisons of efficiency in fuel utilization since it varies with fuel transportation costs and the distance the plant is from the fuel supply as well as any other price differences which might exist. The use of physical units avoids these difficulties and provides a basis for comparison between plants using the same type of fuel. Physical input-output relations such as these are also more useful for future comparison in that they are not affected by price level changes.

Of the 10 plants with records of the amounts of fuel used, 5 used fuel oil and 5 used coal. For the analysis of input-output relations, the plants were separated by type of fuel. Comparisons between types of fuels were made only on the cost basis.

Plants Using Fuel Oil

In 1953, the average fuel oil consumption per pound of dry milk produced in five spray process plants was .155 gallon. (See table 6.) The annual volume of output of these plants ranged from 4.3 million to 7.7 million pounds of dry milk per year. The quantity of fuel oil used per pound of dry milk produced ranged from .139 gallon to .177 gallon in these plants and did not show any significant relation to the volume of output of the plants.

In all the plants observed, fuel oil used per pound of dry milk produced varied with the seasonal changes in production. The greatest fuel efficiency was achieved during the heavy production months of late winter and spring. As production declined through October, fuel efficiency fell again.

Some of the variations in fuel use from month to month arose from errors in estimation and the time at which fuel inventories were taken. While this

Table 6. Gallons of Fuel Oil Used per Pound of Dry Milk Manufactured in Five Minnesota Milk Drying Plants, 1953

	Plant No. 1	Plant No. 2	Plant No. 3	Plant No. 4	Plant No. 5	Average for five plants* 1953	Average for five plants* 1948†
				gallons			
Jan.-Feb.	.205	.148	.153	.180	.198	.174	.20
March	.193	.156	.120	.170	.191	.163	.18
April	.187	.140	.165	.159	.173	.163	.18
May	.140	.147	.152	.156	.167	.152	.17
June	.073	.089	.123	.088	.100	.093	.16
July	.164	.203	.187	.250	.226	.207	.16
August	.123	.160	.169	.175	.170	.158	.17
September	.136	.147	.171	.171	.187	.160	.20
October	.144	.169	.147	.170	.182	.163	.21
Nov.-Dec.	.104	.142	.125	.144	.191	.155	.18
Annual average*	.139	.147	.149	.165	.177	.155	.18
				cents			
Fuel cost per pound of dry milk	.92	.92	.98	1.06	1.07	.99	1.68

* Weighted averages.
† Plants compared in 1948 and 1953 are identical plants.

error may be large in some individual months, it will tend to average out over the year and errors due to these factors are of minor consequence.

It may be noted that some error existed in the June and July data for all five plants. This was because the production period and the fuel use period did not correspond exactly. While data for these two months are out of line, data for the other months and the annual figures are not affected.

Comparison of the 1953 data with those of 1948 shows some improvement in fuel utilization efficiency. The quantity of oil required to produce one pound of dry milk fell .025 gallon from .18 in 1948 to .155 gallon in 1953 for the five oil using plants which were analyzed. This is approximately a 14 per cent reduction in fuel requirements and quite a significant saving when achieved on a major expense item such as fuel. This reduction in fuel requirement was quite uniform throughout 1953, with each month, except July, showing a smaller fuel requirement than the corresponding month of 1948.

The main factor in the increase in fuel efficiency from 1948 to 1953 was probably the larger annual output of the individual plants. As in the case of labor, there is a fixed amount of cost involved at any level of operation. A certain amount of fuel is required to get up steam, regardless of the amount of milk to be dried. The greater the amount of product, the lower this cost will be on a per unit basis.

It is this effect that leads to much of the variation in fuel used per pound of dry milk produced as the level of production changes from month to month. The fuel used per pound of dry milk was lower in the spring when production was heavy than in the low production months of late summer.

There should be observable differences in the fuel utilization of large and small plants though it was not possible to illustrate them in the case of the five plants analyzed in this group. While the five plants had a fairly wide range of annual production, factors other than volume, such as type of boiler and heat losses in other pieces of equipment, also influence fuel efficiency. Thus, variations in fuel efficiency between different plants can be expected independent of differences in level of output. In order to compare differences in fuel efficiency due to differences in volume, the plants being compared would have to be similar in respect to these other factors.

Fuel costs per pound of dry milk produced for the five plants using oil are shown on the last line of table 6. These costs are directly related to the quantity of fuel used, unit prices of fuel oil, and transportation charges. Fuel costs in the five plants ranged from .92 to 1.07 cents per pound of dry milk with the average for the five plants being .99 cent.

This average is somewhat higher than the average fuel cost for all plants in the study, but some of the larger and more efficient plants are not included among the five studied for which detailed input-output data were available. Fuel costs were available from 2 other plants using oil out of the 18 studied. Both of these plants produced over 10 million pounds of dry milk in 1953 and their fuel oil costs were .84 and .88 cents per pound of dry milk. If physical data on fuel oil used had been available for these two larger plants, the effect of plant volume on fuel efficiency might have been more apparent between plants.

Plants Using Coal

The 1953 data for five spray process plants using coal for fuel indicate that an average of 1.77 pounds of coal was used for each pound of dry milk produced. (See table 7.) This figure varied for individual plants, ranging from 1.56

to 2.18 pounds of coal per pound of dry milk. As in the case of the plants using oil, the 1953 data reflect a considerable increase in efficiency over 1948. The weighted average coal consumption in 1948 was 2.24 pounds per pound of dry milk produced, which indicates a .47 pound or 20 per cent reduction, between 1948 and 1953. The seasonal variations in fuel efficiency for coal were quite similar to those for oil and have remained about the same over the period studied.

It may be noted from table 7 that plant no. 6 has a higher fuel cost than plant no. 7, even though no. 6 used less fuel. This is because coal for plant no. 6 must be shipped a greater distance and the higher freight rate increases the fuel cost. The amount of coal used in plant no. 10 is much larger than in any other plant. This is because of the lower volume of production and the resulting lower fuel efficiency in this plant.

Comparison between the costs of using coal or oil is difficult because of freight costs and differences in the individual plants. It may be noted, however, that of the 10 plants analyzed, the one with lowest fuel cost per pound of dry milk was a plant using coal (plant no. 7). This is a plant located relatively close to the coal docks, giving the advantage of low freight cost. Since coal is more bulky than oil it may be cheaper than oil for one plant and more expensive for another, depending on the distance it must be hauled.

No attempt was made in this study to analyze all of the cost differences arising out of the use of different fuels but it should be recognized that some differences do exist. Factors which should be considered in this connection include differences in cost of burners, the cost of fuel handling equipment, differences in amount of boiler room labor, and possibly even the ash handling or smoke nuisance problem. These factors are of special significance to plants planning conversion from one fuel to another and should not be overlooked in estimating the costs of such changes.

Plants Using Natural Gas

Only one plant included in this study was using natural gas for fuel in 1953.

Table 7. Pounds of Coal Used per Pound of Dry Milk Manufactured in Five Minnesota Milk Drying Plants, 1953

	Plant No. 6	Plant No. 7	Plant No. 8	Plant No. 9	Plant No. 10	Average for five plants*	
						1953	1948†
	pounds of coal						
Jan.-Feb.	1.607	1.739	2.069	1.988	2.502	1.91	2.57
March	1.438	1.533	2.345	1.842	2.788	1.81	2.22
April	2.143	1.846	1.952	1.764	1.721	1.91	2.28
May	1.214	1.416	1.593	1.779	1.579	1.50	1.88
June	1.591	1.747	1.593	1.795	2.270	1.73	1.94
July	1.294	1.483	1.543	1.657	1.847	1.51	2.35
August	1.328	1.682	2.400	2.319	3.009	1.95	2.36
September	1.559	1.857	2.030	2.716	.765	1.92	3.39
October	2.296	1.874	3.689	1.890	2.003	2.01	2.08
Nov.-Dec.	1.580	1.880	1.719	1.898	2.756	1.85	2.43
Annual average*	1.565	1.697	1.881	1.915	2.185	1.77	2.24
	cents						
Fuel cost per pound of dry milk	.96	.88	1.13	1.15	1.45	1.05	1.43

* Weighted averages.
† Plants compared in 1948 and 1953 are identical plants.

Even with substantial increases in the price of natural gas since 1947, it still was the cheapest fuel for drying milk. The contract with the suppliers was for surplus gas and the supply was cut off when the demand for gas from other users was heavy during the winter months. When the gas was cut off, the plant used standby oil burners.

Comparison on a cost basis indicates that natural gas is a lower cost fuel than either coal or oil, even with the cost of using standby oil for short periods. The fuel cost per pound of dry milk in the plant using natural gas was .59 cent as compared with a low of .84 cent for oil and .88 cent for coal. This would indicate that the low cost of natural gas more than compensates for the cost of standby oil provisions.

The use of natural gas is, of course, limited by access to a pipe line. A more recent development is the use of liquified propane, which may be transported by truck or rail and can be stored in tanks. Since 1953, some plants have been converted to this fuel. However, no data on costs were available at the time of this study. It is reported to be more expensive than natural gas, but it may compare favorably with coal or oil.

DEPRECIATION AND RENT EXPENSE

All depreciation and rent expenses for the individual plants were added together and treated as one cost com-

Table 8. Manufacturing Costs per Pound of Dry Milk Produced in 18 Minnesota Spray Drying Plants, 1947 and 1953

Expense item	Cost per pound 1947	1953
	cents	
Plant expense		
Labor	1.16	1.10
Payroll tax	.03	.02
Fuel	1.05	.91
Power, light, and water	.06	.05
Plant maintenance	.19	.24
Depreciation and rent	.55	.31
Other	.23	.22
Total	3.27	2.85
Administrative expense		
Office salaries	.07	.06
Office supplies	.01	.01
Telephone and telegraph	.01	.01
Other	.02	.02
Total	.11	.10
General expense		
Insurance	.04	.03
Interest	.03	.04
Taxes	.06	.08
Other	.04	.13
Total	.17	.28
Total manufacturing costs*	3.55	3.23
Range in costs	2.50 to 4.76	2.53 to 6.18
Median	3.51	3.14

* The cost of milk assembly and packaging supplies has been excluded from this total.

ponent. These expenses include depreciation on buildings and equipment and rent of plant or storage space. Depreciation on trucks used for milk assembly or product hauling was excluded.

There was a substantial reduction in the average depreciation and rent expense per pound of dry milk produced over the period 1947 to 1953. In 1953, the average cost of this item for 18 plants was .31 cent per pound of dry milk produced as compared with .55 cent in 1947. (See table 8.) Much of this reduction may be attributed to the increased volume which was processed without any substantial addition to plant and equipment.

At the 1947 level of production there was unused capacity. The increase in production between 1947 and 1953 meant fuller utilization of this capacity. This resulted in spreading the depreciation and rent expense over a larger output and lowering the per unit cost of production.

In some plants the total rent and depreciation expenses have fallen since 1947. Many of the plants were built during the war under a rental purchase agreement with the federal government. The fulfillment of these agreements by some of these plants between 1947 and 1953 reduced the amount of rent payments and depreciation allowances. It should be noted that the depreciation and rent data presented here represent the situation of the plants now in operation and are probably somewhat lower than might be expected for a new plant starting operations.

PLANT MAINTENANCE EXPENSE

The only plant expense component showing an increase on a per unit basis between 1947 and 1953 was plant maintenance. Maintenance cost per pound of dry milk produced rose from .19 cent in 1947 to .24 cent in 1953. (See table 8.)

There are several factors which contributed to increased maintenance costs over this period. The foremost of these factors was the aging of equipment and buildings. In 1947, most of the plants were relatively new and the equipment had not begun to wear out. By 1953, this situation had changed and many items of equipment were near the replacement stage. This aging coupled with increased rates of production led to greater repair expense. Also of major importance were rising prices of repair parts and services over this period. All of these factors would tend to increase the maintenance expense, though the extent to which each is responsible for the observed increase cannot be determined easily.

OTHER PLANT EXPENSE

This expense component includes primarily general supplies and those expense items not common to all plants, such as water treatment and equipment rental. Supplies used in cleaning the equipment make up a large portion of these expenses. No attempt was made to determine the relative importance of the factors included in this group.

The average per unit "other plant expenses" remained about the same from 1947 to 1953, declining only from .23 cent to .22 cent per pound of dry milk in this period. (See table 8.) While increased production would be expected to lower the average cost of such items as cleaning supplies on a per unit basis, it is likely that rising prices cancelled out some of the gain, resulting in the small change which was observed.

Administrative and General Expense

Administrative and general expenses combined made up only 12 per cent of the cost of manufacturing dry milk in the 18 plants studied. Administrative expenses in 1953 were .10 cent and general expenses amounted to .28 cent per pound of dry milk. (See table 8.)

Administrative expenses include office salaries, office supplies, telephone, and "other administrative expenses," which include postage, audit, bank charges, and depreciation on office equipment. General expenses include insurance, interest, taxes, and other general expenses. These "other general expenses" include small expense items such as subscriptions, donations, travel expenses, and others which are not uniform among plants and many items of minor significance.

The items included under administrative and general expense are generally of a fixed nature and the total expense does not vary much with production. This causes the per unit cost to vary as output changes and greater output will cause the average per unit cost to fall. This effect was observed in the plants studied in respect to both monthly changes in output and in comparison of large and small plants. Administrative costs per pound of dry milk produced were generally lower in the larger plants. For all plants, administrative costs were lowest during the heavy production months.

Packaging Costs

The costs of packaging the dried milk were excluded from the analysis in this study because of the diversity of the types of packages used and the influence of market outlets on choice of package. Two different types of bulk containers were used by the plants included in this study—the 225 pound fiber drum and 100 pound kraft paper bags. Most of the plants used both types of containers and all reported very nearly the same prices for the containers. The prices reported were 2.78 dollars for the fiber drums with liners and .40 to .44 cents for the 100 pound bags including liners.

The average packaging costs for those plants using only bulk packages ranged from .90 cent to 1.27 cents per pound of dry milk. This cost was dependent on the proportion of the output packed in drums and bags. In general, the fiber drums were used for sales to the government or where the dry milk was to be repackaged. For sales to commercial users, the paper bags were used. In some plants it was possible to reuse the fiber drums to a limited extent where the dry milk had been repackaged in small containers.

Only two plants included in the study packaged milk in small containers. One used 3½ ounce polyethylene consumer packages and the other packaged for government use in 4½ pound polyethylene lined fiber boxes. It was not possible to obtain costs of packaging in these containers since the equipment, supplies, and labor were not furnished by the plants in which the packaging was done. In these cases the purchaser of the dry milk reimbursed the plants for all of the expenses incurred in packaging.

Total Manufacturing Costs

The average total manufacturing cost for a pound of nonfat dry milk solids in the 18 plants studied was 3.23 cents in 1953. This is a .32 cent per pound reduction compared with 1947 when the previous study was made. (See table 8.) Nearly all of the cost reduction occurred in the major plant expense items such as labor, fuel, and depreciation. The reduction in the plant expense items since 1947 was .42 cent per pound of dry milk produced. There was an additional .01 cent reduction in administrative expense. The general expense items showed an increase of .11 cent a pound. This resulted in a reduction in total manufacturing costs of .32 cent.

Of the total cost of manufacturing dry milk, 88 per cent was for plant operating expenses in 1953 as compared with 92 per cent in 1947. No attempt was made to study the factors influencing costs in the administrative and general expense categories but it appeared that rising prices have offset any increases in efficiency in these categories.

A relationship between the annual volume of output and costs per pound of dry milk may be observed in the 1953 data for 17 plants. However, the relationship between volume and cost is not nearly as great in 1953 as it was in 1947. (See figure 4.) In 1947 there was a very evident relation between greater volume and lower costs in the 2 to 7 million pound annual volume range.

With most of the plants producing in excess of 5 million pounds of dry milk in 1953, some of the relatively smaller plants had achieved manufacturing costs just as low as plants having twice the volume. This would indicate that for the type of plants and equipment involved, the fixed cost components have been spread over a sufficiently large production to reduce the average fixed costs to a near minimum even in the smaller plants. Thus, any further expansion in output would incur costs roughly in proportion to the increase in volume with little effect on the average manufacturing cost per unit of output.

The data on the plants included in this study illustrate this point quite well. (See table 9.) The greatest reduction in manufacturing costs occurred in those plants which increased output from about 3 million pounds to about 5 million pounds during the interval from 1947 to 1953. Those plants which were in the 4 to 5 million pound output range in 1947 and increased to around 6 million pounds in 1953 showed only slight reductions in manufacturing costs.

The plants in the 5 to 6 million pound and 6 to 7 million pound ranges showed increased manufacturing costs. This indicates that, for this type and scale of plant, the greatest cost reduction through increased volume occurs at volumes under 6 million pounds per year. Beyond this output, cost reduction resulting from spreading fixed costs is slight and other methods of increasing efficiency are needed to achieve further cost reduction.

It may be noted from table 9 that the two plants producing over 7 million

Table 9. Relationship Between Changes in Volume from 1947 to 1953 and Changes in Manufacturing Costs for 17 Drying Plants

1947 annual output	Average output in 1953	Number of plants	Change in manufacturing costs
million pounds			cents
Under 4	5.9	5	—1.04
4 to 5	6.0	4	— .46
5 to 6	8.1	2	+ .08
6 to 7	8.1	4	+ .32
Over 7	12.9	2	— .50

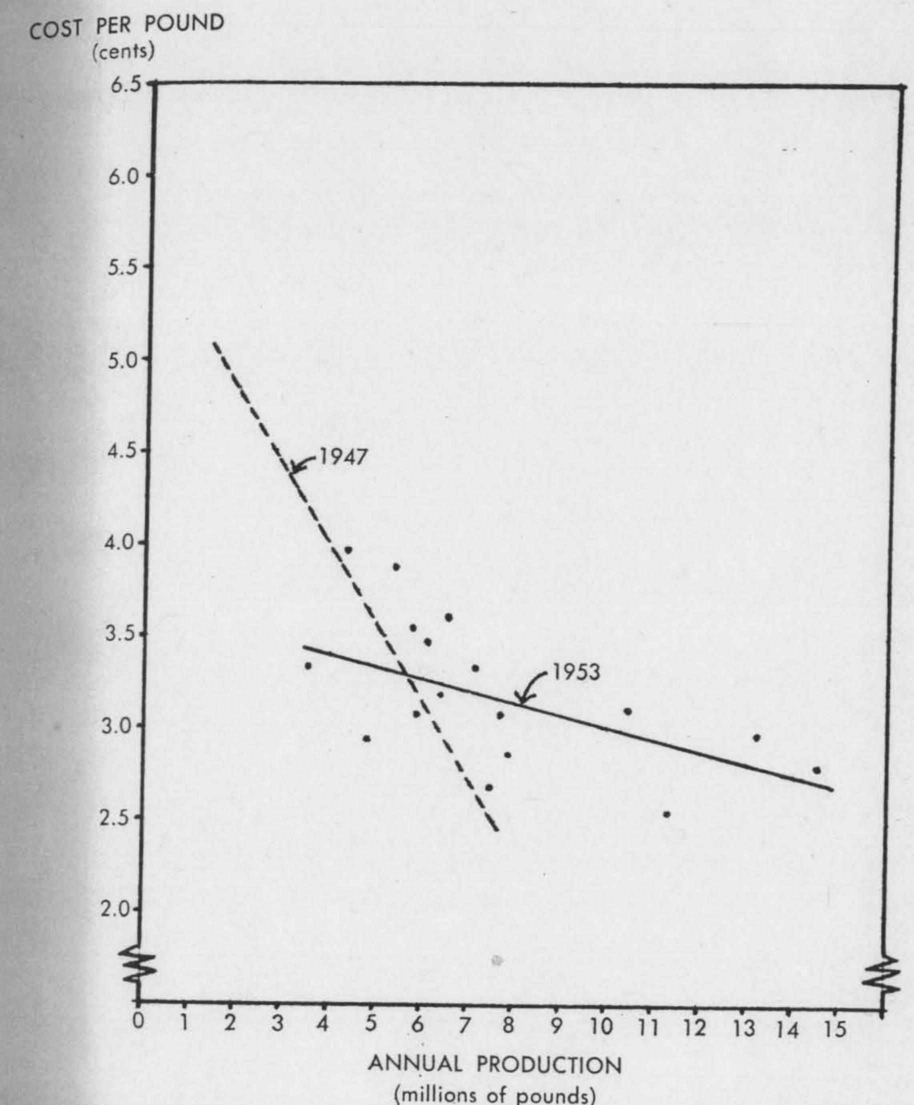

Fig. 4. Relationship between volume of dry milk produced and average manufacturing cost per pound, 17 Minnesota spray drying plants, 1947 and 1953. Each dot represents the 1953 production of dry milk and the 1953 manufacturing cost per pound of a given plant.

pounds of dry milk in 1947 did achieve lower costs, possibly through increased volume, in 1953. These two plants do not prove an exception to the relationship being illustrated. They are basically larger plants and should have an optimum capacity somewhat greater than that of the other 15 plants represented.

Effect of Seasonal Production on Costs

The seasonal pattern of milk production is one of the most difficult problems encountered by plant managers trying to achieve low manufacturing costs. In a milk drying plant it is not possible to set up an efficient combination of production factors and operate through the year without change. The level of production is constantly changing and in order to keep costs as low as possible, the manager must keep adjusting his supply of labor and other variable factors to the changing level of production.

The 1953 seasonal pattern shows little or no significant change over that observed in 1948. (See figure 6.) Figure 6 shows the changes in level of production and manufacturing costs by months for both 1948 and 1953. It can be seen that manufacturing costs and level of production vary inversely throughout the year and also that the extent of these variations is quite significant. In

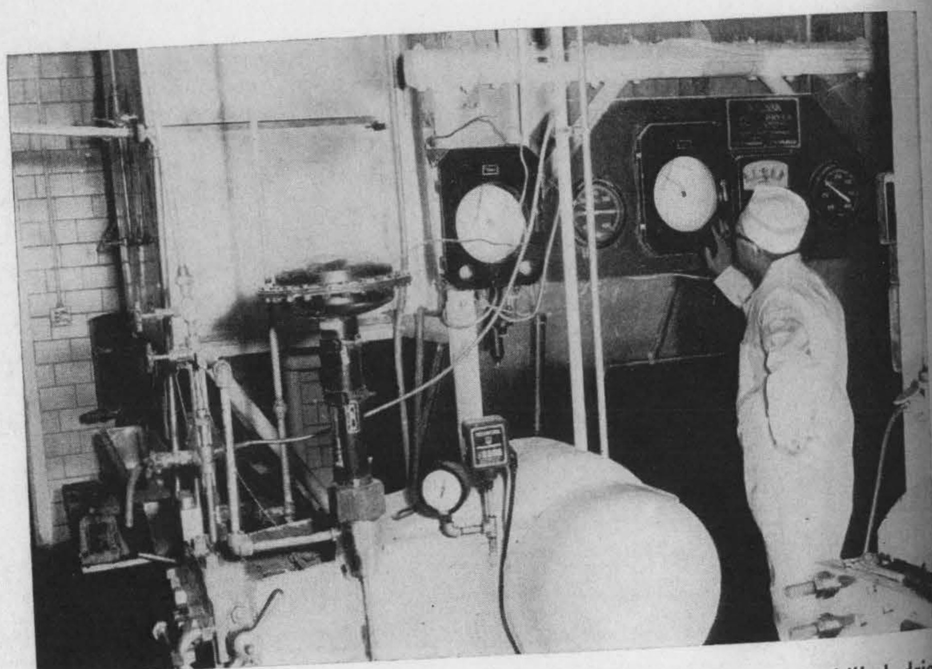

Fig. 5. Product quality and operating efficiency are dependent on skilled drier operation.

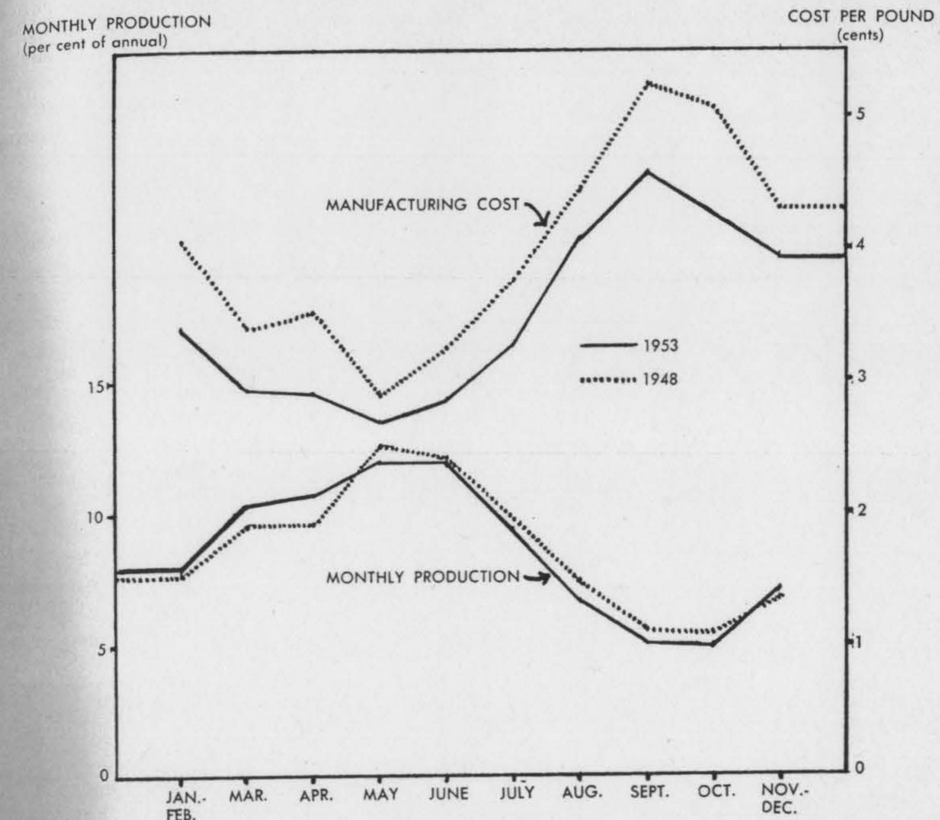

Fig. 6. Relationship between changes in production and changes in manufacturing costs by months, for 14 Minnesota spray drying plants, 1948 and 1953.

1953, production in different months ranged from less than 5 to more than 12 per cent of the total annual production and with considerable change between almost any two months.

Costs likewise showed large variations between different months, ranging from a low of 2.67 cents per pound in May to 5.25 cents per pound in September. The primary factors causing these cost variations were noted under earlier discussions of the effect of changes in volume on the per unit costs of labor, fuel, and fixed factors. In all cases it is primarily the effect of spreading fixed portions of cost over varying levels of production.

The problem of seasonality may be attacked in two ways: (1) by close adjustment of labor, fuel, and other inputs to the seasonal production pattern, and (2) by efforts to reduce the seasonality of milk production on farms.

The first of these two methods requires the experience and knowledge of a capable plant manager. The manager must be aware of those factors which may be adjusted to seasonality and know what combinations of factors will yield the greatest amount of product at least cost with varying levels of production. This knowledge can only come from training in techniques of cost reduction and experience in plant operation.

Knowledge of dairy science is essential in plant management. However, business management ability is not to be overlooked. Today most business organizations keep accounting records, but many which keep them do not utilize them to the best advantage. In adjusting for seasonal variations in production, good accounting records of day to day operations are the most valuable tool a plant manager can have. In recognition of this fact many plants have employed accountants to aid the managers in preparing and utilizing records.

The ways and means of reducing the seasonality in milk production are not as direct or as positive as the methods of adjusting to seasonality. The method most commonly advanced is that of a price incentive paid for producing milk during the normal slack season in the hope that farmers will shift their production to sell more milk at the higher price. This would reduce the amount of milk in the peak months and reduce the capacity needed in the plant.

This, of course, is not an immediate solution to a given plant with facilities geared to the present peak production volume. In order to decrease costs in these plants, there must be an increase in total production in order to stabilize production at the most efficient level.

The leveling out of seasonality must be accomplished not by shifting the production and lowering the peak but rather by increasing production during the slack months to something near that of the peak period. This would require a price incentive to the farmer large enough to cause him to increase production in a similar manner. With a given return on the finished product

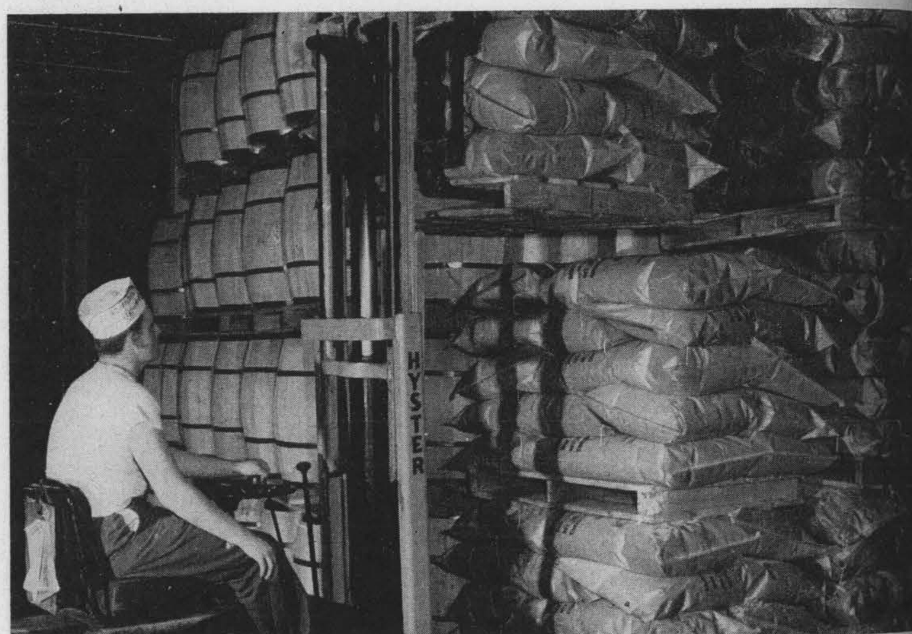

Fig. 7. The use of product handling equipment can reduce labor costs and speed warehouse operations.

to be marketed, the incentive payment could not exceed the cost reduction achieved.

The position of the farmer in the seasonal production of milk must also be considered. Though exact figures are difficult to construct, farm management people suggest that shifting from the present seasonal milk production pattern to a less seasonal one would increase the farmers' costs to some extent. Since most of the milk drying plants concerned are farmer owned co-operatives, it would be in the members' interests to shift to a less seasonal production pattern only if the manufacturing cost reduction were greater than the increase in farm milk production costs.

This would indicate that the best policy in respect to dealing with seasonality is probably continued improvement in managerial techniques. The progress made from 1947 to 1953 indicates that those plants which have invested in good managers have made considerable progress in reducing costs. The fact that labor cost was one of the largest variants between plants suggests that the quality of management is a major determining factor in a plant's costs.

The higher wages demanded by managers of exceptional ability are often, in fact, very low when viewed on a per unit basis and compared to the cost reductions that can be achieved. Even in the smaller plants, managerial wages account for only about .1 cent per pound of dry milk produced while variations in labor cost due to labor management may be twice this amount. Economizing on managerial costs by accepting less capable management is a false economy.

Large economies can also be achieved in many cases by the adoption of new types of equipment or new techniques which improve labor or fuel efficiency. Advances in both processing and product handling equipment have been quite rapid in recent years and plant managers should stand ready to appraise and adopt any advance which can improve their plant efficiency and reduce costs.

Summary and Conclusions

The average cost of manufacturing dry milk in 18 Minnesota spray drying plants has decreased since 1947. Data from these 18 plants indicate a total manufacturing cost of 3.23 cents per pound of nonfat dry milk solids produced in 1953, which is a reduction of .32 cent from the 3.55 cents reported in 1947.

A major contributing factor to this cost reduction was the increase in the volume of dry milk produced over this period of time. With greater volume, more intensive use was made of the fixed cost factors of production, resulting in greater efficiency in general. The two most important cost factors were labor and fuel, which represented 34 and 28 per cent of the total manufacturing costs respectively. Even with substantial increases in wage rates, increases in labor efficiency were large enough to cause a reduction in the per unit labor cost.

The output of dried milk per hour of plant labor varied considerably from plant to plant. In general the larger plants were more efficient in the utilization of labor although there were large variations between plants of nearly the same output. These plant to plant variations indicate that management, as well as volume, plays an important role in maintaining labor efficiency.

Differences in management were apparent in data showing the adjustment of labor to seasonal changes in output. The plants having the lowest labor cost for the year were those in which labor efficiency was high during the heavy production period.

Comparison of 1947 and 1953 fuel usage indicated that greater volume led to increased fuel efficiency in plants using both coal and oil. Seasonal variations in volume of output also had considerable effect on fuel efficiency. The average amount of fuel used per pound of dry milk produced was much lower during the heavy production months than during the slack period. Cost comparisons between coal and oil could not be made because of transportation charges included in the fuel expense. Only one plant used natural gas and this was found to be the cheapest fuel used.

Depreciation and rent costs were also lower in 1953 than in 1947. This was due to both greater volume and as a result of fulfilling the original lend-lease agreements with the government.

Little change was observed in the seasonal variations in production from 1947 to 1953. Manufacturing costs varied inversely with monthly changes in the level of production. Average manufacturing costs varied from 2.67 cents per pound of dry milk in May to 5.25 cents in September. Greater management skill is needed if further progress is to be made in reducing the magnitude of seasonal variations in manufacturing costs.

There was a relation between large volume and lower costs in the 1953 data. However, the relationship was not as apparent as in 1947. In general, the larger plants showed lower costs than small plants though some relatively small plants achieved costs lower than some of the largest plants. Comparison of the 1947 and 1953 data indicates that most of the plants included in the study have reached near optimum output with the existing seasonal production.

Further cost reduction may be effected by managerial efforts to achieve greater labor efficiency and the adoption of improved equipment and techniques. Substantial improvements have been made in processing and handling equipment in recent years and any improvement which is applicable should be evaluated as a possible means of reducing costs.

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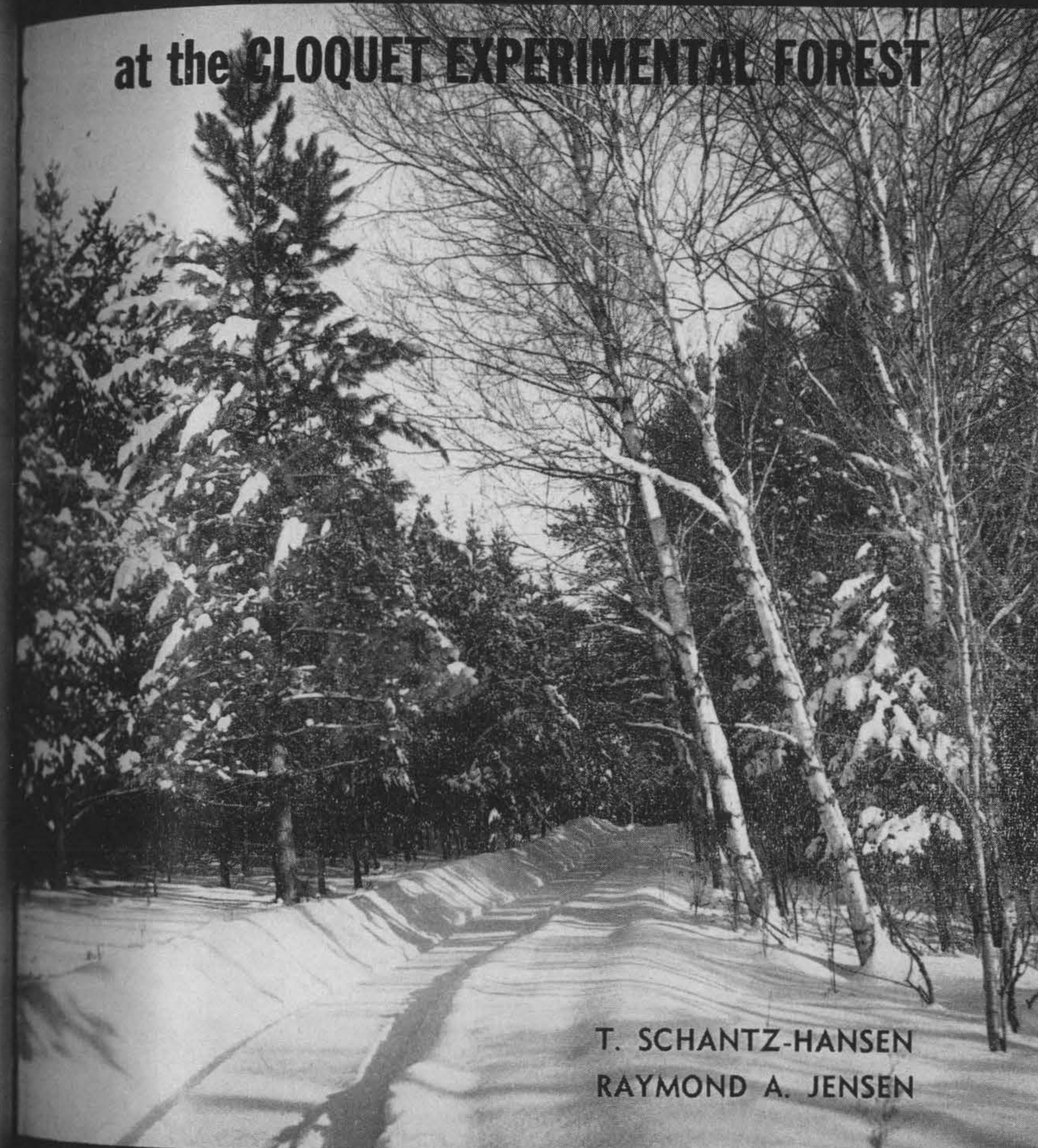

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