MANUFACTURING COSTS:

WHOLE MILK CREAMERIES

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Dairying in Iowa has been an essential part of most farm operations. The skimmilk resulting from farm separation of the cream has been a useful supplement to corn in the swine feeding operations which constitute the most important single phase of Iowa agriculture. Because of this relationship between dairying and hog farming, the dairy processing industry in Iowa has been based primarily on one product, butter, and most of this has been manufactured in creameries receiving only farm-separated cream. Many of these creameries were established 50-60 years ago when the roads and transportation facilities of the time dictated the need for many local plants which tended to remain small. Over the years this system of dairy marketing has persisted in Iowa. In other important dairy sections of the United States, there has been a trend to concentrate dairy processing in larger plants manufacturing a number of different products.

Despite research and experience which indicate that small creameries necessarily operate with high unit costs, the small local creameries in Iowa have prevailed. This may be due partly to lack of concern among producer-members, partly to local pride and partly to the determination of the operators to keep the plants going despite obvious evidence of their inadequacies as processing and marketing units. Consequently, a fierce and sometimes destructive competition for the available butterfat volume has developed. Costly overlapping and duplication of cream routes is apparent in many areas, and the struggle for volume has often resulted in pricing policies which left inadequate financial resources for replacement and expansion of plant facilities.

The project of which the present study is a part was initiated to find rational solutions to this dairy marketing problem. As a first contribution, Frazer, Nielsen and Nord (5) published an analysis of the butter manufacturing costs in farm-separated cream plants. They demonstrated clearly the cost reduction benefits which might be derived from consolidating small creameries. Later the results were applied to proposed consolidation schemes in specific areas in Iowa.

In recent years, changes in livestock feeding practices on many Iowa farms have made increasing quantities of skimmilk available. Simultaneously, a price situation favorable to the nonfat solids in milk has developed. These and other factors have created interest in changing the traditional farm-separated cream operations to whole milk operations. Naturally, questions have arisen concerning the advisability of effecting possible creamery consolidations simultaneously with the conversion to whole milk plants. The present study proposes to answer some of the questions concerning cost-volume relationships in whole milk plants.

PURPOSE OF THIS STUDY

The extent to which it would be profitable to shift from gathered cream operations to whole milk operations depends, to a large degree, upon the following:

(1) the efficiency of separation on the farm compared with the efficiency of separation at the creamery;

(2) the market value of the skimmilk solids;

(3) the value of the skimmilk to the farmer for feeding purposes;

(4) the cost of hauling whole milk compared with the cost of hauling cream; and

(5) the cost of manufacturing butter from whole milk compared with the cost of manufacturing butter from cream.

In this particular study, the relationship between costs of manufacturing butter from whole milk and volume of production are analyzed. Specifically, costs are determined for the various operations beginning with the receipt of the whole milk through the manufacturing and packaging operations which prepare the product for sale as bulk butter. In addition, costs are determined for the processing of the skimmilk into storage for sale as such, or for further manufacturing operations.

Other studies are being made to determine the costs of hauling both cream and whole milk for various volumes of production, the costs of drying the skimmilk into nonfat dry milk solids and the returns that may be secured. Compilation of the results of

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these studies should help to provide answers to questions concerning the profitability of changing from gathered cream to whole milk operations and the volumes of production desirable from a cost viewpoint in a whole milk creamery.

REVIEW OF LITERATURE

In the earlier studies of costs in dairy plant operations, costs were estimated from plant records. In 1935, Tinley and others (12) examined the records of 20 whole milk creameries in California which had annual volumes ranging from ½ million to 7 million pounds of butter. These were, for the most part, whole milk creameries with the manufacture of butter as the primary enterprise. Secondary activities were the drying of skimmilk and buttermilk or the manufacture of casein. The manufacture of butter was charged with all expenses which would have been incurred if only butter were made, while the by-products were charged only with the additional expenses which could be attributed directly to their manufacture. Tinley found that labor costs, excluding hauling, butter printing and wrapping, ranged from $7.45 to $17.55 per 1,000 pounds of butter manufactured. Labor costs declined rapidly as volume increased from ½ million to 1½ million pounds of butter annually and somewhat less rapidly from 1½ million to 2½ million pounds. These studies indicated that the optimum size with respect to labor utilization would be about 3½ million pounds of butter annually.

Recently, more intensive studies have been made of dairy plant operations. In June 1948, Henry, Bressler and Frick (8) published a study on economies of scale in market-milk plants. In their study model plants were constructed on paper and assigned outputs equal to their respective capacities. These capacities were estimated from technical data. Inasmuch as each plant operated at its respective capacity, the economies indicated by the results were considered to be the true economies of scale for this type of operation.

In 1952, Bartlett and Gothard (1) studied two plants they believed to be efficient. These plants were processing 3,250 and 12,750 gallons of milk per day, respectively. The labor, space, equipment, electric power and steam power used in the plants were studied in detail.

French (6), in 1952, described the research procedure used in evaluating the milk-receiving labor in Indiana. The use of motion and time study techniques was described, and time standards for receiving operations were established.

Hall (7), in 1953, published a talk given in 1952 in which receiving room efficiency and the causes of inefficiencies were discussed in detail. Hall also established time standards for receiving operations.

In 1952, Frazer, Nielsen and Nord (5) published a study of butter manufacturing costs in gathered cream creameries. Costs in sample plants were analyzed and compared with costs determined from plants constructed on paper. Close agreement was found between the manufacturing costs in the sample plants and the budgeted plants.

Walker, Preston and Nelson (14) examined the manufacturing costs in specialized butter-nonfat dry milk plants. Their study was based on the observation of 12 plants located in Washington, Oregon and Idaho. The data observed were applied to 12 hypothetical plants, five of which were assumed to make nonfat dry milk by the roller process while the other seven were assumed to use the spray process. In the former, the total manufacturing costs per 100 pounds of milk declined from 71.1 cents in the smallest plant processing a maximum of 60,900 pounds of milk daily to 42.2 cents in the largest plant processing a maximum of 152,000 pounds of milk daily. In the spray drying plants the costs ranged from 63.0 cents to 42.3 cents as the maximum daily volumes increased from 60,900 pounds in the smallest plant to 324,800 pounds in the largest. The authors pointed out that the decline in unit costs decreases progressively from a high rate among small scale plants to a low rate among the larger plants. The data from this study were later applied by Nelson (9,10) to an analysis of the input-output relationships in specialized butter-powder and cheese plants.

METHOD OF PROCEDURE

The procedure followed in gathering the data for this study was based primarily on the experience accumulated in a previous study of 13 gathered cream creameries (5). All available data from these sample plants applicable to the present study were used, and some of the standards appearing in this study were first developed for and published in that work.

Sample Plants

In addition to the data obtained from the published study of 13 gathered cream creameries, 10 whole milk plants were visited, and their operations were analyzed for this study. These 10 plants performed a variety of operations in addition to the specific type of operation considered here. Consequently, data on the costs in these sample plants would have little meaning here. Furthermore, it was not possible to locate a sufficient number of plants performing only the desired functions and covering the desired volume range to permit the selection of a sample of plants.

However, sufficient information was secured in the 10 sample plants to develop four hypothetical plants capable of performing the desired functions. Frazer *et al.* (5) illustrated that plants developed in this manner provide cost figures which closely approximate the average cost figures of existing sample plants and, in many cases, provide more and better information than is available from existing sample plants. The hypothetical plants cover the desired volume range and have costs typical of those which could be achieved if such plants were actually constructed and efficiently managed.

Methods Used in Obtaining Data

To gather the information for this study and other studies forming a part of this project, a team of three or four men visited each of the sample plants. Although complete information was not available at each plant, the following methods were used to gather the data in most cases:

(1) The over-all operation was inspected to observe the integration of the work force, equipment and functions performed.

(2) Pertinent operations were timed with a stop watch.

(3) Pertinent equipment in the plant was listed and described as to type, capacity and function.

(4) Cost data were secured from the plant's records.

(5) Haulers were interviewed, and their problems were discussed.

(6) The plant manager, plant superintendent and key workers were interviewed, and the problems of each were discussed.

(7) Manufacturers of dairy equipment were consulted about prices of equipment installations.

An attempt was made to have all the people participating in the over-all project become aware of the general objectives of the study. This was done to provide group participation in making the basic assumptions necessary for determining certain costs.

Basic Assumptions

Because of a great many factors over which the individual plant managers have little or no control, some costs vary considerably among plants. In developing a comparative study of this sort, it is necessary to standardize some variables by selecting values typical of the industry as a whole so that attention can be focused on those variables that are subject to managerial decisions. Establishment of these standards involves making basic assumptions, the validity of which is difficult to prove. Therefore, all such basic assumptions have been made by the investigators as a group in an effort to minimize arbitrariness and to achieve conditions representative of typical situations. Other standards, such as time standards for various operations and equipment necessary for various functions, have been established on the basis of intensive research and are not classified as basic assumptions.

The following basic assumptions concern the operation of the hypothetical plants:

(1) Average butterfat test in the flush season .... 3.5 percent

(2) Average production of milk per day per producer .... 240 pounds

(3) Average number of cans per day per producer 3.5

(4) Average number of cans per load 123

(5) Average number of patrons per load 35

(6) Number of loads per churning 5

(7) Average overrun .... 21.5 percent

(8) Twice monthly testing of composite samples

(9) Production of butter per churning .... 1,800 pounds

(10) Operating days per week 7

(11) Peak month's production represents 11 percent annual production.

Methods of Determining Costs

Using the above standards, costs were developed for each of four plants. The combinations of building and equipment represented in Plants I, II, III and IV were selected as being the ones that give the lowest costs for producing the annual target volumes of 500,000, 1 million, 1½ million and 2 million pounds of butter, respectively. Daily production in the peak month amounts to one, two, three and four full churnings, respectively, when the plants are operating at these target volumes. Costs were calculated on an annual basis for several different volumes for each plant. Sufficient labor and equipment were assigned to each plant to handle the load in the peak month, and annual costs were assigned to this labor force and equipment.

With a given processing unit, expenditures on certain items remain the same from year to year regardless of volume. General administrative expense, office supplies, insurance, taxes, depreciation and interest on building and equipment belong to this category of fixed costs. General plant supplies are fixed throughout the volume ranges considered for each plant; however, they would decline slightly if volume became so small that every-other-day receiving or churning became feasible.

Expenditures for processing materials and packaging materials vary in exact proportion to output. Expenditures on fuel and electricity also vary as output varies. However, since some fuel and electricity is required for heating, cleaning and lighting regardless of volume, these do not vary in exact proportion to output. Total labor costs and payroll taxes also vary as output varies. Where labor is employed on an annual basis and no seasonal labor is hired, a firm will maintain the same labor force through wide ranges in annual volume. Hence, labor costs change sharply at those volumes at which the size of the labor force is increased or decreased.

LABOR COSTS

The amount and type of labor required by each plant was determined by setting time standards for various tasks. The time standards were based on time studies of all phases of plant operations. These time standards are typical of times taken to perform the operations in the plants studied and do not represent any particular optimum or desired standard. A complete list of the time standards is given in Appendix B.

Work organization charts have been developed for a day's production in the peak season for each plant.

The charts for the target volume for each plant are presented in Appendix C. These work organization charts itemize the work to be done during the day as part of the daily routine and, in addition, provide for such irregularly occurring duties as loading butter and unloading supplies which cannot be assigned a specific time on the work organization chart. Not shown on the charts are the work schedules of the manager, clerical help, testers or additional men needed to provide a day off each week for the operating personnel.

Most creameries employ their labor on an annual salary basis and, with few exceptions, keep a constant work force throughout the year. Thus, no seasonal employees have been provided for in this study. Rather, it has been assumed that the regular employees will perform such functions as painting buildings and equipment, installing new equipment, etc., during the slack season of the year.

Wage rates, therefore, have been established on an annual basis, and the following wage rates, typical of those being paid, have been established by group decision:

Manager (Plants I and II)	$6,500 per year
Manager (Plants III and IV)	$7,000 per year
Plant Superintendent	$4,500 per year
Buttermaker	$4,000 per year
Helper	$3,000 per year
Tester	$2,000 per year
Chief office clerk	$2,500 per year
Other office help	$2,000 per year

These rates do not constitute a recommended standard. Information concerning wage rates was obtained before the revised Minimum Wage and Hour Law became effective. Hence, some of the wage rates may be lower than those now in force for certain plants. These standard wage rates were applied to the employees of each plant, as determined by the work organization charts, to determine labor cost.

BUILDING COSTS

Building costs were assessed by determining the space requirements for each general function in the plant and determining the cost of providing that space. In every case, the space allocations provide enough room for efficient operation and easy cleaning. Space requirements are listed in Appendix Table A-5.

The cost of providing the necessary space was determined by calculating the present cost of constructing an adequate building. This cost was determined through the use of Boeckh's Manual of Appraisals (2) and the Boeckh Index Calculator Tables (3). A sample calculation of building replacement cost is given in Appendix Table A-6. The values listed are for single-story brick and concrete construction, adjusted by a Des Moines construction cost index of 2.444 to allow for the increase in prices since Boeckh's manual and tables were published. For each plant, the adjusted cost was increased by $11,000 as an allowance for special items in creamery construction, such as cold storage facilities and tiled walls.

The annual depreciation and maintenance cost was set at 4 percent of this construction cost.[3] The amount of money spent on maintenance materially affects the life and, therefore, the rate of depreciation of the building, with depreciation costs and maintenance costs tending to vary inversely. As no attempt has been made to evaluate how much money should be spent on maintenance, the depreciation and maintenance costs have been grouped as one. This is not presented as a generally applicable treatment of depreciation but only as a satisfactory one in this instance.

An annual interest cost of 5 percent of the average investment (considered to be half of the original investment) is charged. Thus, the annual cost of the building is the sum of the depreciation, maintenance and interest costs, or an amount equal to 6.5 percent (4 percent plus half of 5 percent) of the present cost.

EQUIPMENT COSTS

Equipment costs were determined in a manner similar to building costs. The necessary equipment to do the job efficiently and well was first determined. Present costs of the equipment were secured from manufacturers and suppliers of dairy equipment. A complete list of equipment installations and costs may be obtained from the Department of Dairy Industry, Iowa State College, Ames, Iowa.

Depreciation and maintenance costs were grouped as one percentage, with the percentage applied to the original cost of the individual piece of equipment. These two costs have been grouped following the same reasoning as discussed in determining building costs. The choice of the percentage charge for depreciation and maintenance comes from estimates of the life of the equipment and of the maintenance cost of that equipment. The selection of appropriate depreciation and maintenance rates was considered a basic decision and, as such, represents the consensus of opinion of the group working on this study. Bulletin "F" of the U. S. Treasury Department, Bureau of Internal Revenue, entitled "Income Tax, Depreciation and Obsolescence, Estimated Useful Lives and Depreciation Rates" (13), *The Market-Milk Industry* by C. L. Roadhouse and J. L. Henderson (11), and *Dairy Engineering* by A. W. Farral (4), were used as references.

Interest is charged at 5 percent of the average investment (half of the original investment) in equipment. Thus, the annual cost of the equipment is the sum of the depreciation, maintenance and interest costs, all calculated as a percentage of the investment in equipment. Appendix Table A-4 lists the total investment in building and equipment for each of the plants.

OTHER COSTS

Labor, building and equipment are responsible for a major portion of the total cost involved in the type of plant studied here. These costs have, therefore,

[3] This is the figure used by Frazer et al. (5).

received a large share of the attention in developing costs for this study. Some items of cost, such as packaging materials, are easy to determine for various sized plants, whereas others, such as power, vary considerably, depending on local conditions. In general, the costs of fuel, power, materials used in processing, packaging materials, general plant supplies, office supplies and general administrative expense were determined by using the figures available from both the 10 plants visited for this study and the 13 sample plants studied by Frazer *et al.* (5). In most cases, it was necessary to alter the actual figures of the plants to fit the functions of the plants developed here, and an average of these values was then selected. All of these calculations were considered basic decisions and subjected to the scrutiny of the entire group. While these figures are subject to greater percentage error than the others, the absolute error is not large enough to affect the conclusions reached.

The costs of insurance, local taxes and payroll taxes were computed for each plant at standardized rates. Insurance was computed at $1.35 per $100 of coverage on the building and $1.45 per $100 of coverage on the contents of the building. These rates were furnished by the Iowa Inspection Bureau, Des Moines, Iowa, as representative rates for the insurance of butter plants. The rates were applied to a coverage representing 80 percent of average investment. Local taxes were charged at the rate of 30 mills per dollar of average investment. Payroll taxes were charged at a rate of 2 percent of the wages paid.

RESULTS

Using the methods discussed in the preceding section, costs have been established for Plants I, II, III and IV as 9.42, 7.18, 6.26 and 5.62 cents per pound of butter manufactured at annual volumes of 500,000, 1 million, 1.5 million and 2 million pounds, respectively. A summary of total costs in these plants is given in Appendix Table A-2. These figures represent the plant costs of receiving the whole milk, separating, pasteurizing, churning the cream into butter, packaging the butter for sale in bulk and storing the bulk butter for shipment. In addition, the costs of cooling and storing the skimmilk are included.

Plant I

Plant I, with a target volume of 500,000 pounds of butter per year, has a unit cost of 9.42 cents per pound at this volume. Table 1 shows the unit costs in cents per pound of butter manufactured for Plant I. In this and later tables, two figures are presented for labor costs at those volumes at which changes in the labor force are possible. Daily production in the peak season is 1,800 pounds of butter, requiring that the plant receive 42,300 pounds of 3.5-percent milk. The 42,300 pounds of milk is separated into approximately 4,300 pounds of cream and 38,000 pounds of skimmilk.

Milk is received in Plant I by one person at the rate of 20,000 pounds per hour. The milk is pumped from the receiving room to the separators through 2-inch sanitary pipe by a 3-horsepower centrifugal pump.

TABLE 1. UNIT COSTS FOR PLANT I IN CENTS PER POUND OF BUTTER MANUFACTURED AT VARIOUS ANNUAL VOLUMES.

Item	200,000 lbs.	300,000 lbs.	400,000 lbs.	500,000 lbs.
Labor	5.37-7.62	5.08-5.42	4.06	3.25
Fuel	1.12	0.89	0.77	0.70
Power	0.52	0.48	0.46	0.45
Processing materials	0.05	0.05	0.05	0.05
Packaging materials	0.23	0.23	0.23	0.23
Building	1.73	1.15	0.87	0.69
Equipment	6.57	4.38	3.29	2.63
Insurance	0.45	0.30	0.23	0.18
Taxes	1.21	0.80	0.60	0.48
Payroll taxes	0.11-0.16	0.11-0.16	0.08	0.07
General plant supplies	0.87	0.58	0.44	0.35
Office supplies	0.12	0.08	0.06	0.05
General administrative expense	0.72	0.48	0.36	0.29
Total cost per pound	19.07-21.37	14.61-15.00	11.50	9.42

The milk is stored before separation in a 2,000-gallon surge tank. From here the milk is pumped through a preheater, heating it to 100° F., before separation in two separators, each having a capacity of 11,000 pounds per hour. The cream then goes to one of two 600-gallon round processors for pasteurizing, cooling and overnight storage. This cream is churned into butter the following morning in one 2,000-pound churn. Following separation, the skimmilk is cooled from 100° F. to 40° F. in a plate cooler having a capacity of 20,000 pounds per hour and then is stored in a 5,000-gallon cold-wall storage tank.

The capacities of the various pieces of equipment have been selected so that the products may be handled without delays which are uneconomical or detrimental to quality. Likewise, labor-saving equipment such as a printomatic weight recorder and an automatic sampler was used wherever feasible. Though these devices may not speed up the processing rate appreciably, they do facilitate some of the tasks and usually make for greater accuracy and therefore justify their annual cost.

The labor force in Plant I consists of a manager, a combination buttermaker-plant superintendent, one helper, one half-time tester and one half-time office clerk. This results in a total annual labor cost of $16,250. It is assumed that the half-time tester and the half-time office clerk will be female employees. Observation in the field indicates that half-time female help is generally available, whereas, half-time male help is not. At an annual volume of 300,000 pounds, the tester can be dispensed with. When volume drops to 200,000 pounds, a labor force consisting of a manager-buttermaker, full-time helper and half-time office clerk is sufficient.

The work organization chart for Plant I shows the daily duties of the buttermaker and the helper when the plant is operating at its target volume. The duties of the manager, the half-time tester and the half-time office clerk are not shown. The duties of the manager encompass a great many functions, some of which may require him to be absent from the creamery at various times. Therefore, the manager has not been assigned any specific plant duties on a daily basis. However, in a plant of this size, the management functions are not as complex as in the larger plants, and the manager is expected to relieve the buttermaker and the helper on their days off. Thus the manager is expected to work 2 days a week in the plant, thereby keeping the plant operating 7 days a week, with no employee working more than 6 days a week.

The work organization chart of Plant I makes no provision for such irregular duties as receiving supplies and loading butter. These duties are not as time consuming in a plant of this size as they are in the larger plants, and it is anticipated that the manager will be available to perform such functions at least part of the time. If not, the length of the working day for the buttermaker and helper would have to be increased, although it is not anticipated that a working day of more than 8 hours would often be necessary.

Plant II

Plant II produces 1 million pounds of butter per year at a unit cost of 7.18 cents per pound. Table 2 shows the costs in cents per pound of butter manufactured for Plant II. The chief reasons for the reduction in cost of 2.24 cents per pound from the target volume of Plant I to that of Plant II lie in the reduction of labor, building and equipment costs by 0.60 cent, 0.30 cent and 0.87 cent, respectively.

In the peak season, Plant II manufactures 3,600 pounds of butter daily, requiring that it receive 84,600 pounds of 3.5-percent milk. The 84,600 pounds of milk is separated into approximately 8,600 pounds of cream and 76,000 pounds of skimmilk.

In Plant II, two men receive milk at the rate of 33,000 pounds per hour. The milk is stored before separation in a 3,000-gallon surge tank. From here the milk is pumped through a preheater, heating it to 100° F., before separation in three separators, each having a capacity of 11,000 pounds per hour. The cream then goes to two of three 600-gallon round processors for pasteurizing and cooling and overnight storage. This cream is churned into butter the following morning in one 2,000-pound churn. Following separation, the skimmilk is cooled from 100° F. to 40° F. in a plate cooler having a capacity of 33,000 pounds per hour, and then is stored in two 5,000-gallon coldwall storage tanks.

At volumes above 600,000 pounds the labor force consists of a manager, a plant superintendent, a buttermaker, two helpers, a combination helper-tester and a full-time office clerk. This results in a total annual labor cost of $26,500. At annual volumes of less than 600,000 pounds only one helper is needed.

The work organization chart for Plant II shows the daily duties of the buttermaker, the plant superintendent and two helpers but not the duties of the manager, the combination helper-tester and the office clerk. The manager in this plant is not expected to perform any plant duties. The combination helper-tester is used 4 days a week providing a day off for the other four men and, in addition, does the testing for 4 days every 2 weeks. The work organization chart schedules each man for approximately a 7-hour day. An 8-hour day would make considerable time available for miscellaneous duties.

TABLE 2. UNIT COSTS FOR PLANT II IN CENTS PER POUND OF BUTTER MANUFACTURED AT VARIOUS ANNUAL VOLUMES.

Item	500,000 lbs.	600,000 lbs.	700,000 lbs.	800,000 lbs.	900,000 lbs.	1,000,000 lbs.
Labor	4.70	3.92-4.42	3.79	3.31	2.94	2.65
Fuel	0.73	0.67	0.63	0.60	0.57	0.55
Power	0.50	0.48	0.47	0.46	0.46	0.45
Processing materials	0.05	0.05	0.05	0.05	0.05	0.05
Packaging materials	0.23	0.23	0.23	0.23	0.23	0.23
Building	0.80	0.66	0.57	0.49	0.44	0.39
Equipment	3.52	2.93	2.50	2.19	1.95	1.76
Insurance	0.24	0.20	0.17	0.15	0.13	0.12
Taxes	0.62	0.52	0.44	0.39	0.34	0.31
Payroll taxes	0.09	0.08-0.09	0.08	0.07	0.06	0.05
General plant supplies	0.75	0.58	0.50	0.44	0.39	0.35
Office supplies	0.09	0.08	0.07	0.06	0.05	0.05
General administrative expense	0.43	0.36	0.31	0.27	0.24	0.22
Total cost per lb.	12.75	10.76-11.27	9.81	8.71	7.85	7.18

Plant III

Plant III produces 1.5 million pounds of butter per year at a unit cost of 6.26 cents per pound. Table 3 shows the unit costs for Plant III. The chief reasons for the reduction in cost of 0.92 cent between the target volumes of Plant II and Plant III are lower equipment and labor costs. Equipment costs are reduced 0.40 cent, mainly because relatively little extra equipment is needed in Plant III. Labor costs are reduced 0.25 cent because the additional employees are all in the lower wage brackets.

On every peak day, Plant III manufactures 5,400 pounds of butter, requiring that it receive 126,900 pounds of 3.5-percent milk. This 126,900 pounds of milk is separated into approximately 12,900 pounds of cream and 114,000 pounds of skimmilk. The receiving facilities and method of operation in Plant III are the same as those in Plant II. The principal additional pieces of equipment in Plant III are an additional round processor, more storage capacity, another churn and more refrigeration and steam capacity.

At volumes above 1.4 million pounds, the labor force in Plant III consists of a manager, a plant superintendent, a buttermaker, five helpers, a tester, one full-time and one half-time office clerk. This results in a total annual labor cost of $36,000. At volumes between 1 million and 1.4 million pounds, the tester is not needed. Below 1 million pounds, four helpers are enough if a tester is used.

The work organization chart for Plant III shows the daily duties of the buttermaker, the plant superintendent and four helpers. The duties of the manager, the office help, the tester and one helper are not shown. The manager in this plant is not expected to perform any plant duties. The tester will be kept busy 6 days every 2 weeks. The extra helper works 6 days a week providing a day off for the other six men. Considerable time is available for miscellaneous duties and no one works more than an 8-hour day.

Plant IV

Plant IV produces 2 million pounds of butter per

TABLE 3. UNIT COSTS FOR PLANT III IN CENTS PER POUND OF BUTTER MANUFACTURED AT VARIOUS ANNUAL VOLUMES.

Item	1,000,000 lbs.	1,100,000 lbs.	1,200,000 lbs.	1,300,000 lbs.	1,400,000 lbs.	1,500,000 lbs.
Labor	3.30-3.40	3.09	2.83	2.62	2.43-2.57	2.40
Fuel	0.57	0.55	0.54	0.52	0.51	0.50
Power	0.48	0.47	0.46	0.46	0.45	0.45
Processing materials	0.05	0.05	0.05	0.05	0.05	0.05
Packaging materials	0.23	0.23	0.23	0.23	0.23	0.23
Building	0.46	0.41	0.38	0.35	0.33	0.30
Equipment	2.03	1.85	1.70	1.57	1.45	1.36
Insurance	0.14	0.12	0.11	0.10	0.10	0.09
Taxes	0.36	0.33	0.30	0.28	0.26	0.24
Payroll taxes	0.07	0.06	0.06	0.05	0.05	0.05
General plant supplies	0.52	0.47	0.43	0.40	0.37	0.35
Office supplies	0.07	0.06	0.06	0.05	0.05	0.05
General administrative expense	0.29	0.26	0.24	0.22	0.21	0.19
Total cost per pound	8.57-8.67	7.95	7.39	6.90	6.49-6.63	6.26

year at a unit cost of 5.62 cents per pound. Table 4 shows the unit costs for Plant IV. The cost reduction of 0.64 cent is the smallest difference between plants found in this study and is composed chiefly of a 0.25-cent reduction in labor cost and a 0.22-cent reduction in equipment cost. Labor costs are reduced chiefly because of the economies in work organization realized by hiring a special clean-up crew and because all additional employees are in the lower wage bracket. Some expensive additional equipment is required in Plant IV. However, a production increase of 33 percent over Plant III accompanied by a total equipment cost increase of 12 percent permits some equipment cost reduction per unit of output.

On every peak day, Plant IV manufactures 7,200 pounds of butter, requiring that it receive 169,200 pounds of 3.5-percent milk. The 169,200 pounds of milk is separated into approximately 17,200 pounds of cream and 152,000 pounds of skimmilk. The receiving facilities and method of operation in Plant IV are the same as those in plants II and III. Pasteurizing and cooling of cream in Plant IV is done in a short-time, high-temperature pasteurizer, rather than in round processors. This method of pasteurization could have been used in Plant III at little additional cost; it is a more economical method of performing this function in Plant IV. Other major items of additional equipment in Plant IV are more storage and refrigeration capacity and a composition control unit for the buttermaking process.

The labor force in Plant IV consists of a manager, a plant superintendent, a buttermaker, seven helpers, a tester and two full-time office clerks. This results in a total annual labor cost of $43,000. At volumes below 1.5 million pounds, one helper less is needed and overtime must be paid if annual output rises above 2 million pounds.

The work organization chart for Plant IV shows the daily duties of the buttermaker, the plant superintendent and four helpers. The duties of the manager, the office help, the tester and three helpers are not shown. The manager in this plant is not expected to perform any plant duties. The tester will be kept busy 8 days every 2 weeks. One of the extra helpers is available to provide 1 day off a week for the other men. The other two helpers are clean-up men who do the cleaning for the entire plant after the day's operations are completed. This cleaning requires a total of 10½ man-hours per day. Night clean-up crews are used in some plants and are necessary in a plant of this size unless two separate receiving lines are set up.

The three helpers not shown on the work organizaion chart split up the functions of receiving and performing miscellaneous plant duties. In this plant, except for the 12:30 to 1:30 lunch hour, one man is always available for irregular duties of a general nature.

DISCUSSION

The results obtained in this study show minimum costs of 9.42, 7.18, 6.26 and 5.21 cents per pound of butter manufactured for whole milk creameries producing 500,000, 1 million, 1.5 million and 2.2 million pounds, respectively. These figures represent the costs that could be attained under the stated conditions if new plants were constructed and equipped for whole milk operation and provided with able managers. In general, it is felt that the conditions imposed in developing the costs are typical of those prevalent in the dairy industry and that the estimated costs are representative of the costs that can be atained by plants of this type.

Because of the large seasonal variation present in the production of milk, the maximum annual volumes possible for these four plants are 524,000, 1,048,000,

TABLE 4. UNIT COSTS FOR PLANT IV IN CENTS PER POUND OF BUTTER MANUFACTURED AT VARIOUS ANNUAL VOLUMES.

Item	1,500,000 lbs.	1,600,000 lbs.	1,700,000 lbs.	1,800,000 lbs.	1,900,000 lbs.	2,000,000 lbs.	2,200,000 lbs.
Labor	2.67-2.87	2.69	2.53	2.39	2.26	2.15	1.97
Fuel	0.52	0.51	0.50	0.49	0.48	0.47	0.46
Power	0.47	0.46	0.46	0.46	0.45	0.45	0.44
Processing materials	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Packaging materials	0.23	0.23	0.23	0.23	0.23	0.23	0.23
Building	0.31	0.29	0.28	0.26	0.25	0.24	0.21
Equipment	1.52	1.42	1.34	1.26	1.20	1.14	1.03
Insurance	0.10	0.09	0.09	0.08	0.08	0.07	0.07
Taxes	0.26	0.25	0.23	0.22	0.21	0.20	0.18
Payroll taxes	0.05-0.06	0.05	0.05	0.05	0.05	0.04	0.04
General plant supplies	0.46	0.44	0.41	0.39	0.37	0.35	0.32
Office supplies	0.06	0.06	0.06	0.05	0.05	0.05	0.04
General administrative expense	0.24	0.23	0.21	0.20	0.19	0.18	0.17
Total cost per pound	6.94-7.15	6.77	6.44	6.13	5.87	5.62	5.21

1,500,000 and 2,200,000 pounds of butter, respectively. At these annual volumes, the daily skimmilk storage capacity is completely used during the peak month. The production of larger volumes of butter requires the installation of more storage capacity, a change in the procedure for disposing of the skimmilk or a change in the seasonal pattern of production to maintain volume in the peak month and increase volume in the other months. Plants I and II can increase their production slightly above the largest volumes studied here, but no plant can increase its annual volume above the preceding capacity figures without encountering increasing unit costs.

Unit costs decrease continuously at a decreasing rate throughout the volume range of this study, both within each plant and between the low cost points of successive plants. The realization that costs decrease with volume within a given plant is the source of the fierce competition that sometimes develops for the farmer's cream or whole milk. Decreasing costs between plants are one reason for the trend in the dairy industry toward the elimination of small processing units and the establishment of large ones.

The lowest unit costs are found at an annual volume of 2.2 million pounds, which represents the largest volume analyzed. Larger volumes have not been studied for several reasons. One reason is that the cost curve begins to level out and the rate of decline in cost will not be as great at larger volumes. A second reason is that the cost figures for relatively small plants are of more value to this study because changes to whole milk operations in Iowa are more likely to occur at small volumes. Another reason is that it would not be possible to attain a greater volume without materially changing the method of operation. Either the milk would have to be received for a longer period than normal (requiring a change in hauling practices), or additional receiving lines would have to be set up either in the plant or at another location. The duplication of facilities and change in the method of operation might result in higher unit costs at volumes slightly above 2.2 million pounds. However, a plant operating at volumes substantially above this level might expect lower unit costs than a plant operating at this volume.

The cost figures that have been tabulated in tables 1, 2, 3 and 4 are shown graphically in fig. 1. The curve ABCDE represents the costs per pound of butter for various annual volumes in Plant I; FGHI, Plant II; JKLMN, Plant III and OPQ, Plant IV. Each of these is an intra-plant cost curve; it compares unit costs of producing various annual volumes of butter within a given plant. The segment of each curve showing a plant's costs at and above the previously mentioned maximum possible annual volume is not plotted. At this capacity output, each plant's cost curve would turn sharply upward.

Only these four model plants were analyzed; however, intermediate plants could be constructed by varying the sizes and combinations of building, equipment and labor. If this were done and the lowest cost points for all plants were connected, the curve EINQ would be obtained. At each volume of output, this curve shows which plant has the lowest unit

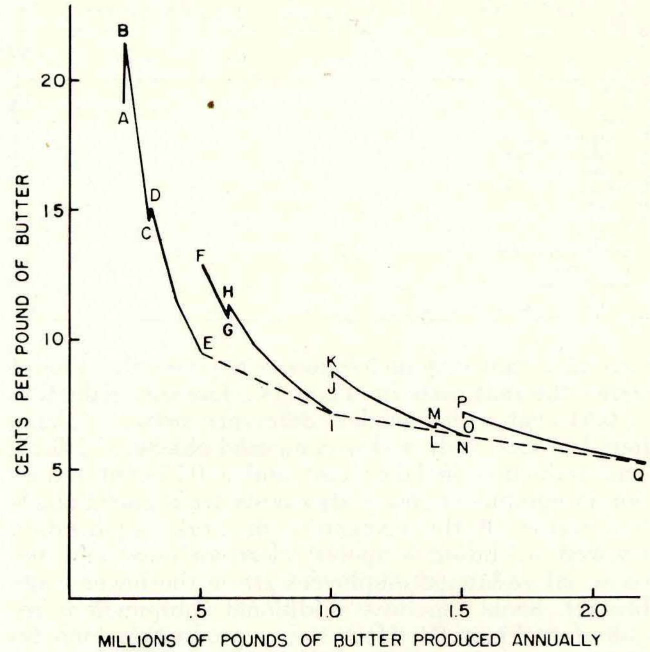

Fig. 1. Inter-plant and intra-plant unit cost curves.

costs. This inter-plant cost curve shows how unit costs vary as annual output varies from the lowest cost output of one plant to the lowest cost output of another.

When an operator is planning a new plant, he may use the inter-plant cost curve to determine which one of the possible combinations of building, equipment and labor has the lowest unit cost at the annual volumes he expects. After the plant is constructed, the intra-plant cost curve is the curve relevant to his decision-making as it shows what unit costs he will encounter at various annual volumes in that particular plant. Before the plant is built, he can select any combination represented on the inter-plant curve. After the plant is constructed, he is restricted to operating on the intra-plant curve corresponding to that plant. He cannot achieve the unit costs given for other plants but can only achieve the unit costs on the intra-plant curve representing his combination of building, equipment and labor.

For example, if an operator expects an annual volume of 1.5 million pounds, he will select Plant III. After the building is constructed and the machinery installed, his costs of producing various annual volumes are given by curve JKLMN. If his volume declines to 1 million pounds, he can produce at 8.57 cents per pound but not at 7.18 cents. To produce at the latter figure, he would need to have Plant II.

Each combination of building and equipment gives rise to a different cost curve. The cost curve facing a particular plant shifts upward or downward as the prices it must pay for inputs rise or fall. Thus, the position of a firm's cost curve changes in response to two different sets of forces: (1) changes in the building, equipment and labor used and (2) changes in the prices it must pay to hire or buy resources.

These curves emphasize the importance of estimating future volumes accurately when planning a new plant. If an operator underestimates future volume production, he will find himself unable to handle all of the milk available to him because of his limited facilities. When this increased volume appears, the plant will have to be remodeled or producers will have to look elsewhere for a market. On the other hand, if he overestimates his future volume, his unit costs will be unnecessarily high by the amount that the intra-plant cost curve exceeds the inter-plant cost curve at that reduced volume. Overestimating future volume is less costly to the large plant than to the small one since the amount by which the unit cost at any fraction of capacity output exceeds the cost on the inter-plant curve is less in the large than in the small plants. In addition, as shown in table 5, the amount by which the unit costs at less than capacity exceed the unit costs at capacity is less for the large than for the small plants.

These results demonstrate the cost advantages of the large plant: (1) It has lower unit processing costs at its capacity volume; (2) overestimating future volume is less costly; (3) the provision of extra processing facilities against unforeseen increases in the volume of whole milk is less costly.

These cost advantages can be converted into net revenue advantages, and it is instructive to look at these plants from the standpoint of net revenues. Total net revenue is total revenue minus processing costs minus the expenditure on butterfat. Suppose the average net price per pound of butter (gross price plus premium minus transportation charge) is 62 cents during some year and the weighted average butterfat price is 65 cents a pound. Table 6 tabulates the net revenues at selected volumes. Two cost and two net revenue figures are shown at those volumes at which changes in the labor force are possible.

With fixed prices for butterfat and butter, the nearer a plant's output approaches capacity the greater is its net revenue or the less its net loss. A larger plant operated at capacity has greater net revenue or smaller net losses than a smaller plant operated at its capacity. A price structure that allows profits to a larger plant can mean losses to a smaller plant. For example, in table 6, Plant IV is earning a profit at both volumes while Plant I shows only losses. Plants II and III sustain losses at small outputs while they earn profits at optimum output.

These revenue figures demonstrate the substantial increases in returns to farmers that would be made possible by the consolidation of small whole milk plants. For example, if four plants producing 500,000 pounds of butter each were to consolidate into one large creamery, such as Plant IV, producing 2 million pounds, their net revenue would increase by $75,381 (from minus $18,280 to $57,551). This increase would be sufficient to pay for the new creamery in 3½ years. Consolidation into larger units would permit greater net savings.

Tables 1, 2, 3 and 4 show the per-unit processing costs at various volumes. For a plant to break even or make a profit, the net price per pound of butter minus the cost of the butterfat in a pound of butter must equal or exceed the processing cost. When this difference is less than the processing cost, the plant loses money. If we know the net price a plant receives for butter, we can compute the break-even price it can pay for butterfat from this formula:

$$P_F = 1.215\ (P_B - C_u)$$

where P_F = price per pound of butterfat f.o.b. plant
P_B = net price per pound of butter
C_u = processing cost per pound of butter
1.215 = pounds of butter made from 1 pound of butterfat

Table 7 shows the break-even butterfat price for selected volumes with a net butter price of 65 cents a

TABLE 5. COMPARISON OF UNIT COSTS AT CAPACITY AND SPECIFIED PERCENTAGES OF CAPACITY.

Plant	Capacity		70 percent of capacity			90 percent of capacity		
	Volume (pounds)	Unit costs (cents)	Volume (pounds)	Unit costs (cents)	Excess over capacity unit costs (cents)	Volume (pounds)	Unit costs (cents)	Excess over capacity unit costs (cents)
I	500,000	9.42	350,000	13.25	3.83	450,000	10.46	1.04
II	1,000,000	7.18	700,000	9.81	2.63	900,000	7.85	0.67
III	1,500,000	6.26	1,050,000	8.31	2.05	1,350,000	6.70	0.44
IV	2,200,000	5.21	1,540,000	7.00	1.79	1,980,000	5.67	0.46

TABLE 6. ANNUAL NET REVENUE AT SELECTED VOLUMES.

	Annual volume (thousands of pounds)							
	Plant I		Plant II		Plant III		Plant IV	
	200	500	500	1,000	1,000	1,500	1,500	2,200
Processing cost	$ 38,140 to 42,740	$ 47,080	$ 63,750	$ 71,796	$ 85,700 to 86,700	$ 93,870	$104,100 to 107,250	$ 114,620
Butterfat cost	106,996	267,490	267,490	534,979	534,979	802,469	802,468	1,176,954
Total cost	145,136 to 149,736	314,570	331,240	606,775	620,679 to 621,679	896,339	906,558 to 909,718	1,291,574
Revenue	124,000	310,000	310,000	620,000	620,000	930,000	930,000	1,364,000
Net revenue*	–21,136 to –25,736	–4,570	–21,240	13,225	– 679 to –1,679	33,661	23,442 to 20,282	72,426
Ratios:								
Net revenue to total investment				6.4%		14.1%	8.9% to 7.7%	27.4%
Net revenue to total revenue				2.1%		3.6%	2.5% to 2.2%	5.3%

* Total revenue minus total cost.

TABLE 7. BREAK-EVEN BUTTERFAT PRICES AT SELECTED VOLUMES.

Annual volume (thousands of pounds)							
Plant I		Plant II		Plant III		Plant IV	
200	**500**	500	1,000	1,000	1,500	1,500	2,200
$0.558-0.530	**$0.645**	$0.635	$0.703	$0.686-0.684	$0.714	$0.705-0.703	$0.726

pound. At lower butterfat prices the firms would make positive net revenues and at higher prices they would undergo losses at these volumes.

The plants developed in this study manufacture both butter and skimmilk, but costs have been computed in terms of cents per pound of butter manufactured. These costs can also be expressed in cents per hundred pounds of whole milk received, and a summary of costs in this unit is given in Appendix Table A-1. They may be of value in comparing these costs with those of other whole milk operations. However, the unit of cents per pound of butter manufactured has been used to permit comparison of these figures with those developed for creameries producing butter from gathered cream.

It should be recognized that in calculating costs in terms of cents per pound of butter manufactured, all of the costs have been charged against the butter and none allocated to the skimmilk. The butter and the skimmilk are joint products, and an allocation of costs between the two on any physical basis would necessarily be arbitrary since much of the cost is incurred before the two are separated. The pertinent costs here are the extra costs of manufacturing butter from whole milk as compared with manufacturing butter from gathered cream. These costs expressed as cents per pound of butter can realistically be charged to the skimmilk and compared with the revenue received for the skimmilk (expressed in cents per pounds of butter) in deciding whether a change to whole milk would be advisable.

Frazer *et al.* (5) showed the costs of manufacturing butter from gathered cream to be from 3 to 5 cents per pound of butter manufactured in reasonably efficient plants, with the costs varying with volume of production. Some adjustment of these figures should be made to allow for price level changes from the time they were developed until now, but it is not expected that such changes would increase the costs by more than 0.5 cent per pound. At an annual production of 2 million pounds of butter, the extra costs in the whole milk plants as compared with the gathered cream plants amount to approximately 2 cents per pound of butter. With an annual production of 1 million pounds of butter, the extra costs are approximately 3 cents per pound of butter. A cost difference of 3 cents per pound of butter is equivalent to a cost of 14.22 cents per hundred pounds of skimmilk. The skimmilk must be of sufficient value to absorb these costs if a change to whole milk operations is to be advisable.

The methods used in this study are considered to be the best methods available for the determination of cost-volume relationships. In addition, the study provides other information which may be of value to the dairy industry. The equipment installation in Plants I-IV might be used by plant managers for comparison with the equipment they are now using. Situations have been observed where inadequate equipment resulted in unnecessary costs because it made an operation slower or required additional employees. Study of the time standards and the work organization charts should also provide information for comparing operations in individual plants.

In summary, this study provides partial answers to the questions of how large an efficient whole milk creamery should be and whether a change to whole milk from gathered cream would be advisable. Adding these figures to those applying to hauling costs and drying costs (if the skimmilk is to be dried) will provide a basis for determining the most economical size for a whole milk creamery. Comparison of these costs with those in gathered cream operations will provide the cost data necessary for an evaluation of the advisability of changing to whole milk.

LIMITATIONS

The purpose of this study has been to determine the unit costs of butter manufacturing in whole milk creameries operating with various annual volumes. The costs were evaluated assuming the operating conditions prevailing in typical Iowa plants. The work organization, for example, was based on a constant labor force throughout the year paid on an annual salary basis. Plant managers should consider the possibility of lowering costs by using a seasonally variable labor force consisting of (1) a permanent staff sufficient to handle production plus plant and equipment maintenance and repair during the low volume season and (2) employees hired only for the flush season. Some plant managers have found it possible to lower labor costs by paying supervisory personnel on an annual basis and other employees at an hourly wage rate with a guaranteed minimum work week and provision for overtime pay during the flush seasons.

Another possible cost-reducing scheme not applied in this study is the use of in-place cleaning of sanitary pipes, fittings and certain pieces of equipment. This technique had not yet been widely introduced at the time the cost study was made. Since plant clean-up requires a considerable share of the total man-hours paid for, it is reasonable to expect that significant savings could be realized by using in-place cleaning methods where possible. Part of this saving would accrue from less wear and tear on pipes and fittings. On the other hand, greater expenditures would be required for detergents and hot water.

There are certain other restrictions on the results in addition to those arising from the use of typical practices in Iowa creameries. In a multi-product plant, labor economies may be realized by the use of an integrated labor force. The labor costs of producing two or more products independently may be more than the labor costs involved in producing those same products in an integrated plant. For example, time that would be idle time in a single product plant can be devoted to other products in a multi-product plant.

In an integrated plant certain equipment such as a pasteurizer or cooler may be operated for a longer time with no increase in cleaning costs. Such potential labor savings would appear to be greater in larger plants.

Average equipment prices have been used in this study. Because of differences in bargaining power, some managers may be able to obtain lower prices than others. Also, differences in local conditions over which the manager has no control cause variations in the other prices a manager must pay.

It is conceded that some plant operators, through skillful practice, might well achieve lower unit costs than those presented here. By the same token there may be others who will find themselves spending more. The data presented will, however, serve as basis for comparison so long as the assumed conditions are kept in mind.

SUMMARY

In recent years changes in livestock feeding practices on many Iowa farms have made increasing quantities of skimmilk available for manufacturing purposes. Simultaneously, a price situation favorable to the nonfat solids in milk has developed. These and other factors have created a need for changing the traditional farm-separated cream operations in Iowa creameries to whole milk operations. This study endeavors to analyze the economics of the latter and presents the butter manufacturing costs encountered in four hypothetical whole milk plants—Plants I, II, III and IV. The annual target volumes for these four plants are 500,000, 1 million, 1.5 million and 2 million pounds of butter, respectively. Each plant consists of that combination of building and equipment which gives the lowest cost of producing its respective annual target volume. The hypothetical plants were developed after an intensive study of the operations of 13 gathered cream creameries and 10 whole milk plants. Costs are determined for the various operations from whole milk receipt through the manufacturing and bulk packaging operations to the storage of the skimmilk. In another phase of this project, the costs of skimmilk drying have been studied.

Unit costs of butter manufacturing decline rapidly between ½ and 1 million pounds—from 9.42 cents per pound in Plant I to 7.18 cents per pound in Plant II. They continue to decline, but at a slower rate, up to annual volumes of 2.2 million pounds, reaching 6.26 cents per pound at 1.5 million pounds and 5.21 cents per pound at 2.2 million pounds. The largest plant can produce 4 times as much butter as the smallest while paying only 2.4 times as much for the processing operations.

The reduction in costs of 2.24 cents per pound between ½ million and 1 million pounds is largely accounted for by the reductions in labor, building and equipment costs of 0.60 cent, 0.30 cent and 0.87 cent, respectively. Costs decline by 0.92 cent between 1 and 1.5 million pounds, mainly because of a 0.40-cent reduction in equipment cost and a 0.25-cent decrease in labor cost. The cost reduction of 1.05 cents per pound between 1.5 and 2.2 million pounds is chiefly composed of a 0.33-cent decline in equipment cost and a 0.43-cent reduction in labor cost.

Not only do unit costs decrease as output increases from one plant to another, but they also decline as output rises within a given processing unit. In Plant I, unit costs decline from 21.37 cents at 200,000 pounds to 9.42 cents at 500,000 pounds. In Plant II, they fall from 12.75 cents at 500,000 pounds to 7.18 cents at 1 million pounds; in Plant III, from 8.67 cents at 1 million to 6.26 cents at 1.5 million; in Plant IV, from 7.15 cents at 1.5 million to 5.21 at 2.2 million pounds.

These figures, of course, present only part of the picture. Assembling costs may increase rapidly enough with increasing volume to offset part of this saving in processing costs. Another study is currently underway to determine the relationship between volume of whole milk handled and assembling costs.

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APPENDIX A

A-1. UNIT COSTS IN FOUR WHOLE MILK PLANTS.

Item	Plant I 500,000 pounds	Plant II 1,000,000 pounds	Plant III 1,500,000 pounds	Plant IV 2,000,000 pounds
	(cents per cwt. of milk)			
Labor	13.85	11.29	10.21	9.16
Fuel	2.98	2.34	2.13	2.02
Power	1.92	1.92	1.92	1.92
Materials used in processing	0.22	0.22	0.22	0.22
Packaging materials	0.98	0.98	0.98	0.98
Building cost	2.95	1.69	1.30	1.00
Equipment cost	11.20	7.50	5.77	4.84
Insurance	0.78	0.50	0.38	0.32
Taxes	2.05	1.32	1.02	0.85
Payroll taxes	0.28	0.23	0.20	0.18
General plant supplies	1.48	1.48	1.48	1.48
Office supplies	0.20	0.20	0.20	0.20
General administrative expense	1.23	0.93	0.83	0.78
Total	40.12	30.60	26.64	23.95

A-2. TOTAL ANNUAL COSTS FOR FOUR WHOLE MILK PLANTS.

Item	Plant I 500,000 pounds	Plant II 1,000,000 pounds	Plant III 1,500,000 pounds	Plant IV 2,000,000 pounds
	(dollars)			
Labor	16,250	26,500	36,000	43,000
Fuel	3,500	5,500	7,500	9,500
Power	2,250	4,500	6,750	9,000
Materials used in processing	258	515	772	1,030
Packaging materials	1,150	2,302	3,455	4,610
Building cost	3,464	3,965	4,556	4,712
Equipment cost	13,147	17,583	20,347	22,756
Insurance	912	1,178	1,358	1,507
Taxes	2,410	3,100	3,580	3,970
Payroll taxes	325	530	720	860
General plant supplies	1,740	3,480	5,220	6,960
Office supplies	234	468	702	936
General administrative expense	1,440	2,170	2,910	3,650
Total	47,080	71,796	93,870	112,491

A-3. TOTAL INVESTMENT IN AND ANNUAL COSTS OF EQUIPMENT BY FUNCTIONS IN FOUR WHOLE MILK PLANTS.[*]

Function	Plant I		Plant II		Plant III		Plant IV	
	Total investment (dollars)	Annual cost (dollars)	Total investment (dollars)	Annual cost (dollars)	Total investment (dollars)	Annual cost (dollars)	Total investment (dollars)	Annual cost (dollars)
Administration	1,400	175	1,800	225	2,000	250	5,600	700
Receiving and testing	21,360	2,812	21,580	2,840	21,580	2,840	21,580	2,840
Separation, pasteurization and cooling	50,870	6,162	79,050	9,491	87,740	10,498	99,750	11,649
Churning	5,510	878	5,610	888	9,620	1,579	10,320	1,641
General plant (refrigeration)	11,050	1,182	17,380	1,846	24,030	2,545	30,440	3,218
General plant (steam and water, etc.)	17,600	1,938	20,900	2,298	23,950	2,635	24,550	2,708
Total	107,790	13,147	146,320	17,588	168,920	20,347	192,240	22,756

[*] An itemized list of the equipment installations may be obtained from the Department of Dairy Industry, Iowa State College.

APPENDIX A (cont'd.)

A-4. TOTAL INVESTMENTS IN BUILDING AND EQUIPMENT IN FOUR WHOLE MILK PLANTS.

Plant	Building (dollars)	Equipment (dollars)	Total (dollars)
I	53,300	107,790	161,090
II	61,000	146,320	207,320
III	70,100	168,920	239,020
IV	72,500	192,240	264,740

A-5. FLOOR AREA REQUIREMENTS.

	Plant I	Plant II	Plant III	Plant IV
	(square feet)			
Administration	240	240	336	336
Receiving	700	700	700	700
Testing	225	225	225	225
Pasteurizing, etc.	1,600	2,500	3,000	3,000
Churning	420	420	900	900
Refrigeration	300	400	500	600
Steam and water	800	920	1,000	1,000
Supplies	800	1,000	1,200	1,400
Cooler	256	288	320	360
Rest rooms, etc.	100	150	200	200
Total	5,441	6,843	8,381	8,721

A-6. SAMPLE CALCULATION OF REPLACEMENT COST OF CREAMERY BUILDING (PLANT I)

Perimeter of building	300 ft.
Area of building	5,441 sq. ft.
Base price per square foot of ground area	$3.18
Adjusted base price per square foot of ground area $3.18 × 2.444	$7.78
Estimate of replacement cost 5,441 × $7.78	$42,300
Adjustment for additional facilities	$11,000
Total estimate of replacement cost	$53,300

APPENDIX B

TIME STANDARDS FOR CREAMERY OPERATIONS

CHURNING

Rinse churn	5 min.
Run cream into churn	15 min.
Run churn	45 min.
Drain buttermilk	10 min.
Wash butter	10 min.
Drain wash water	10 min.
Add salt and run churn	5 min.
Run test, add water, run churn	15 min.
After rinsing churn, one man would be substantially free for next hour, busy 15 of the next 30 minutes, and fully occupied the next 20 minutes.	
Tub 1,800 lbs. butter (1 man)	20 min.
Tub 1,800 lbs. butter (2 men)	10 min.
Weigh, package and remove 1,800 lbs. of butter (1 man)	25 min.
Weigh, package and remove 1,800 lbs. of butter (2 men)	15 min.
Make boxes for 1,800 lbs. of butter (1 man)	10 min.
Line boxes for 1,800 lbs. of butter (1 man)	15 min.
Clean churn	60 min.
Time required of 1 man on cleaning churn	10 min.
Make records	15 min. per churning

RECEIVING

Receiving rate (1 man)	5 cans per min.
Receiving rate (2 men)	8 cans per min.
(Allow 5 minutes between loads)	
Time receiving line is in operation (Plant I)	143 min.
Time receiving line is in operation (Plant II)	199 min.
Time receiving line is in operation (Plant III)	300 min.
Time receiving line is in operation (Plant IV)	403 min.
Prepare receiving room	10 min.

PASTEURIZING, SEPARATING AND COOLING

Although not kept busy 100 percent of the time, when a plant is producing its target volume the full-time attention of one man is required to supervise the operation of the equipment used in separating the whole milk and preparing the cream for churning and the skimmilk for storage.

CLEANING

	Plant I	Plant II	Plant III	Plant IV
	(minutes)			
Clean receiving room	60	60	60	60
Clean separators (45 min. each)	90	135	135	135
Clean storage vats (30 min. each)	60	90	90	150
Clean round processors (30 min. each)	30	60	90	30
Clean plate cooler	30	45	45	45
Clean pipes	30	30	30	45
General plant cleanup	60	90	90	120
Clean cream pasteurizer & cooler				45
Total man-min. cleaning time	360	510	540	630

APPENDIX C

WORK ORGANIZATION, PLANT I

Time	Buttermaker	Helper
7:00 A.M.	Rinse churn; Attend boiler; Make boxes	
7:30 A.M.	Clean round processor	
8:00 A.M.	Line boxes; Operate churn	
8:30 A.M.	M.D.* 15 min.; Operate churn	
9:00 A.M.	Tub butter; Weigh butter	Tub butter; Weigh butter; Prepare receiving room
9:30 A.M.	M.D. 40 min.; Eat	M.D. 30 min.
10:00 A.M.	Assemble pipes	
10:30 A.M.		
11:00 A.M.	Tend pasteurization, separation, etc.	Receive
11:30 A.M.		
12:00 Noon		Receive

Time	Buttermaker	Helper
12:30 P.M.	Tend pasteurization, separation, etc.	
1:00 P.M.		Eat
1:30 P.M.	Eat	
2:00 P.M.		Clean receiving room
2:30 P.M.	Clean two separators	Clean plate cooler
3:00 P.M.		Clean pipes
3:30 P.M.	Records	Clean storage vat
4:00 P.M.		Clean storage vat (skim)
4:30 P.M.		General plant cleanup
5:00 P.M.		
5:30 P.M.		

* Miscellaneous duties.

Time	Buttermaker	Plant Superintendent	Helper	Helper
7:00 A.M.				
	Rinse churn			
	Attend boiler			
	Make boxes			
7:30 A.M.	Clean round processor			
8:00 A.M.	Line boxes			
	Operate churn			
8:30 A.M.	M.D. 15 min.			
	Operate churn			
9:00 A.M.	Tub butter	Assemble pipes	Prepare receiving room	Prepare receiving room
	Weigh butter			
9:30 A.M.		M.D. 45 min.	M.D. 50 min.	M.D. 50 min.
	Make boxes			
10:00 A.M.	Line boxes			
	M.D. 10 min.			
	Operate churn			
10:30 A.M.				
	M.D. 15 min.			
	Operate churn	Tend pasteurization, separation, etc.	Receive	Receive
11:00 A.M.				
	Tub butter			
11:30 A.M.				
	Weigh butter			
12:00 Noon	M.D. 10 min.			

Time	Buttermaker	Plant Superintendent	Helper	Helper
	M.D. 60 min.			
12:30 P.M.	Eat			
			Receive	Receive
		Tend pasteurization, separation, etc.		
1:00 P.M.				
	Clean churns			
1:30 P.M.	Clean round processor			
			Eat	Eat
2:00 P.M.	M.D. 50 min.			
2:30 P.M.		M.D. 60 min.		
		Eat		
	General plant cleanup		Clean storage vat	
3:00 P.M.				Clean receiving room
	Records		Clean pipes	
3:30 P.M.		Clean two separators		
			Clean plate cooler	Clean separator
4:00 P.M.				
4:30 P.M.			Clean storage vat (skim)	Clean storage vat (skim)
		General plant cleanup		
5:00 P.M.			General plant cleanup	General plant cleanup
5:30 P.M.				

WORK ORGANIZATION, PLANT III.

Time	Buttermaker	Helper	Plant Superintendent	Helper	Helper	Helper
7:00 A.M.	Rinse churn Attend boiler Make boxes					
7:30 A.M.	Line boxes M.D. 25 min.					
8:00 A.M.	Rinse churn Operate churn	Clean round processor				
8:30 A.M.	M.D. 15 min. Operate churn	Make boxes M.D. 15 min.				
9:00 A.M.	Tub butter Operate churn and weigh butter	Tub butter Weigh butter	Assemble pipes	Prepare receiving room	Prepare receiving room	Clean round processor
9:30 A.M.	Operate churn	Line boxes M.D. 20 min.	M.D. 40 min.	M.D. 50 min.	M.D. 50 min.	M.D. 25 min.
10:00 A.M.	M.D. 10 min. Operate churn	Tub butter Weigh butter				Tub butter Weigh butter
10:30 A.M.	M.D. 15 min. Operate churn	Make boxes Line boxes M.D. 10 min.	Tend pasteurization, separation, etc.	Receive	Receive	Clean round processor M.D. 5 min.
11:00 A.M.	M.D. 65 min.	Tub butter Weigh butter				Tub butter Weigh butter
11:30 A.M.	Eat	M.D. 40 min.				M.D. 40 min.
12:00 Noon						

Time	Buttermaker	Helper	Plant Superintendent	Helper	Helper	Helper
12:30 P.M.	Tend pasteurization, separation, etc.	M.D. 60 min. Eat	M.D. 60 min. Eat	M.D. 60 min. Eat	Receive	Receive
1:00 P.M.	Clean churns					
1:30 P.M.	M.D. 50 min.	Receive			M.D. 60 min. Eat	M.D. 60 min. Eat
2:00 P.M.			Tend pasteurization, separation, etc.	Receive		
2:30 P.M.	General plant cleanup	M.D. 90 min.			Receive	M.D. 90 min.
3:00 P.M.	Records					
3:30 P.M.				Clean receiving room M.D. 30 min.	Clean receiving room M.D. 30 min.	Clean separator
4:00 P.M.		Clean two separators	Records			
4:30 P.M.				Clean pipes	Clean storage vat	Clean plate cooler
5:00 P.M.			General plant cleanup	Clean storage vat (skim) General plant cleanup	Clean storage vat (skim) General plant cleanup	General plant cleanup
5:30 P.M.						

Time	Buttermaker	Helper	Plant Superintendent	Helper	Helper	Helper
6:00 A.M.		Rinse churn Make boxes Line boxes				
6:30 A.M.		Make boxes Line boxes				
7:00 A.M.		M.D. 5 min. Rinse churn Operate churn				
7:30 A.M.	Operate churn	M.D. 15 min. Make boxes M.D. 10 min.				
8:00 A.M.	Tub butter Operate churn and weigh butter	Tub butter Weigh butter				
8:30 A.M.	Operate churn Tub butter	Line boxes M.D. 20 min. Tub butter				
9:00 A.M.	Operate churn and weigh butter	Weigh butter Make boxes	Assemble pipes	Prepare receiving room	Prepare receiving room	M.D. 210 min. General plant duties
9:30 A.M.	Operate churn Tub butter	Line boxes M.D. 10 min. Tub butter	M.D. 35 min.	M.D. 50 min.	M.D. 50 min.	
10:00 A.M.	Operate churn and weigh butter	Weigh butter M.D. 35 min.	Tend pasteurization, separation, etc.	Receive	Receive	
10:30 A.M.	Operate churn Tub butter	Tub butter				
11:00 A.M.	Weigh butter	Weigh butter				
11:30 A.M.	M.D. 70 min. Eat	M.D. 70 min. Eat				

WORK ORGANIZATION, PLANT IV. (cont'd.)

Time	Buttermaker	Helper	Plant Super-intendent	Helper	Helper	Helper
12:00 Noon	M.D. 70 min. Eat	M.D. 70 min. Eat	Tend pasteurization, separation, etc.			M.D. 210 min. General plant duties
12:30 P.M.	Tend pasteurization, separation, etc.	Receive	M.D. 60 min. Eat	M.D. 60 min Eat	Receive	M.D. 60 min. Eat
1:00 P.M.						
1:30 P.M.	Clean churns	M.D. 60 min.	Tend pasteurization, separation, etc.	Receive	M.D. 60 min. Eat	Receive
2:00 P.M.	Records					
2:30 P.M.					M.D. 150 min. General plant duties	
3:00 P.M.	General plant cleanup					
3:30 P.M.						
4:00 P.M.						
4:30 P.M.						
5:00 P.M.						
5:30 P.M.						