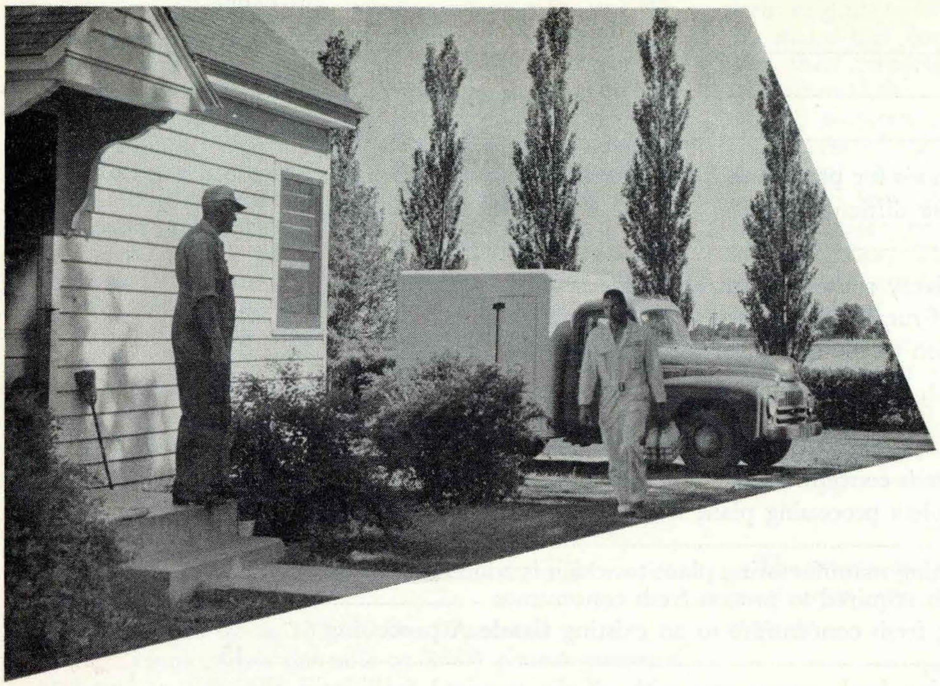
METHODS AND COSTS OF PROCESSING AND DELIVERING FRESH CONCENTRATED MILK IN RURAL AREAS



By K. L. Utter, W. S. Rosenberger, H. Homme and Geoffrey Shepherd

Department of Dairy Industry
Department of Economics and Sociology

SPECIAL REPORT NO. 14

Agricultural Experiment Station—Iowa State College

Ames, Iowa—November, 1955

CONTENTS

FOREWORD

This project, based on field studies in Iowa and Illinois, evaluates a development which is of potential application throughout the North Central states. It is an Iowa contribution to the work of the North Central Regional Committee on Dairy Marketing Research (NCM-12). In considerable measure, the project has been financed by regional funds and carried out under the general supervision of the regional technical committee. The project is one of a series of studies of new developments in milk distribution. The studies were made in the region by a subcommittee of the regional technical committee which has been known as the "fluid milk distribution subcommittee."

SUMMARY

The Department of Dairy Industry of Iowa State College started marketing fresh concentrated milk in rural areas in July, 1951. Five experimental rural delivery routes were established within a four-county area around Ames. The concentrate was sold to a vendor who delivered it to rural customers on a one-delivery-per-week basis. Soon after the process was perfected at Iowa State College, Prairie Farms Creamery adapted it to facilities at their Henry, Ill., plant. Prairie Farms added fresh concentrate to previously established country cream pickup routes in a 13-county area.

The processing procedures and sales experiences in these rural markets in central Iowa and central Illinois are the basis for the present study. The study attempts to (1) outline the methods for processing fresh concentrate, (2) discover something about the characteristics of fresh concentrate customers, (3) estimate costs for delivering fresh concentrate to rural areas and (4) estimate the costs of processing fresh concentrate.

PROCESSING

The following procedure for processing fresh concentrate is recommended:

(1) Clarify and standardize Grade A milk to 3.5 percent butterfat.

(2) Pasteurize at 180° F. for 16 seconds.

(3) Homogenize the milk at 2,500 pounds pressure and cool to 125-130° F.

(4) Condense to slightly over a 3:1 concentration in a stainless steel vacuum pan.

(5) Pasteurize the concentrate at 180° F. for 20 to 25 seconds and cool to 40° F.

(6) Add pasteurized water to reduce the concentrate to exactly 10.5 percent butterfat.

RURAL CUSTOMERS

A questionnaire survey was made in the Iowa area to determine the characteristics of the 340 customers and to discover some factors which affect the sales of fresh concentrate in rural areas. Three factors were chosen as most likely to explain the variation in sales. These factors were: (1) the number of dairy cows on the farm, (2) size of the household and (3) size of the farm. The number of dairy cows on the farm showed an inverse relation to sales. The size of the household and the size of the farm showed a direct relation to sales. But the three factors together explained only 20 percent of the variation in sales.

Another study was made to determine whether or not the characteristics of the customers differed from their neighbors who weren't buying fresh concentrate. To make this comparison, customers were compared with their respective county averages, as listed in the 1953 annual farm census report for Iowa. The characteristics compared included size of the farm, acres of corn, acres of hay and the number of milk cows, beef cattle and hogs per farm. The concentrate customers seemed to have slightly larger households, more acres of corn, more beef cattle and fewer dairy cows than their neighbors. Thus, it would seem that sales of fresh concentrate are more likely to be successful in non-dairying areas.

To test the findings in the Iowa studies, a similar study was made of the rural delivery routes in central Illinois. In comparing the results of the two studies, no significant differences were found. It seems, therefore, that the characteristics found in the Iowa survey would apply to other similar market areas.

COSTS OF DELIVERY

The estimated costs of delivering fresh concentrate to rural areas were about 10.7 cents per quart of concentrate.

COSTS OF PROCESSING

The costs of processing fresh concentrate were estimated for four different plant situations or cases. The costs of processing fresh concentrate in a plant producing only fresh concentrate are considered as Case 1. In cases 2 and 3, the costs of processing are considered for adding fresh concentrate to an existing manufacturing plant and to an existing Grade A plant. Costs in a plant which already has all necessary processing equipment available are considered as Case 4.

The costs for each case were computed for nine levels of output, based on multiples of 750 quarts per week—the amount which one man was selling each week in central Iowa. Processing costs were found to be highest in Case 1, followed by Case 2. Next highest was Case 3. Processing costs were lowest for Case 4, where the product was added to a plant which has all the necessary processing facilities available. The costs in cases 1, 2 and 3 decrease as the output increases, but at a declining rate. The costs in Case 4 are not affected by volume.

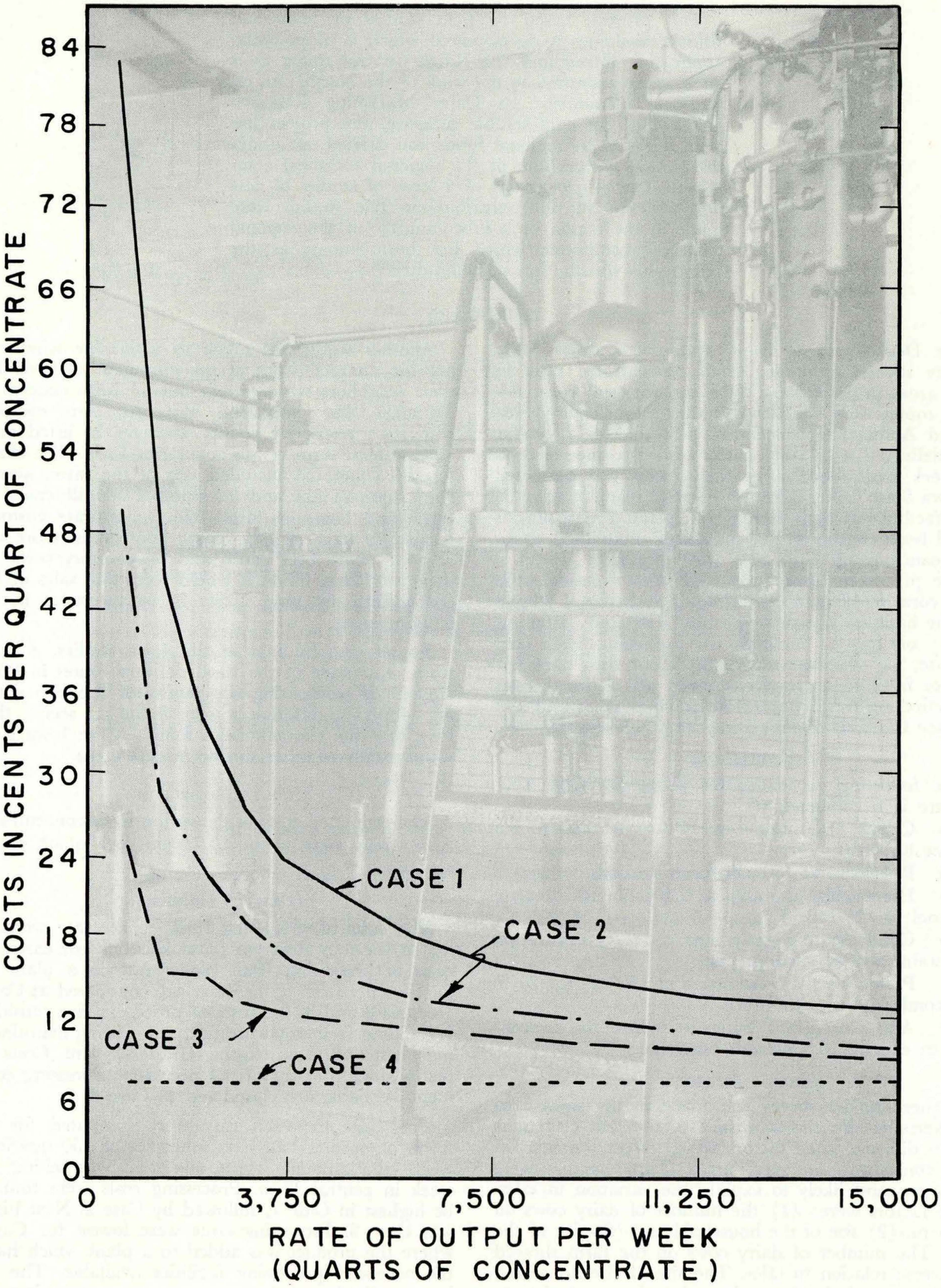


Fig. 1. Cost estimates for producing fresh concentrated milk at different rates of output for cases 1, 2, 3 and 4. (Case 1, single product plant; Case 2, concentrate equipment added to existing manufacturing plant; Case 3, concentrate equipment added to existing Grade A plant; Case 4, plant having all equipment.)

series of experiments was pasteurized at various temperatures by the vat and HTST systems, using split lots in a number of the comparisons. In these comparisons, the concentrate to be vat pasteurized was homogenized directly from the vacuum pan at 125° F., while the concentrate pasteurized in the HTST system was homogenized at 136° F. After the concentrated product was stored at 40° F. for 1, 2, 4, 10 and 15 days, each batch was reconstituted to 3.5 percent butterfat and scored for flavor by a judging panel of students and staff members. The flavor scoring standards were those which are used in the Collegiate Students International Contest in Judging Dairy Products. These standards are:

Excellent—40 and above
Good —37 to 40
Fair —34 to 37

With the first batch made in the 36-inch vacuum pan, the raw milk was pasteurized at 162° F. for 16 seconds, concentrated and standardized to 10.5 percent butterfat. The concentrate then was divided into five lots, each of which was subjected to different pasteurization treatments. The raw milk used in these test trials had a distinct "grassy" flavor and was given a flavor score of 37.5 after the first pasteurization.

The concentrate direct from the pan had a flavor criticized as "harsh cooked" and somewhat stale, leaving a distinctly unpleasant aftertaste in the mouth. However, when this concentrate was pasteurized at 180° F. for 16 seconds, the flavor of both the fresh and the stored concentrate was distinctly improved. Similar results were obtained by pasteurizing the concentrate at 150° to 155° F. for 30 minutes. The heat treatment at either of these two levels apparently covered up the original unpleasant flavor or destroyed the compounds which had been responsible for that flavor.

The flavor of this product after reconstitution resembled milk which had been produced under ideal conditions. It also was considered very mellow and rich. Treatment at 172° or 185° F. for 16 seconds was less successful, the former not causing the desired type of change and the latter giving an excessive cooked flavor to the product.

Further tests showed that the quality of the product was inferior when the concentrate was reconstituted to 3.5 percent butterfat before pasteurization.

Several additional batches were made in the 36-inch pan, using HTST pasteurization at 162° F. before concentrating and pasteurization at 180° F. after concentrating. The product seemed uniformly good in flavor as well as in keeping quality.

Results of these pasteurization experiments at Iowa State College indicate that it is possible to produce a product with desirable flavor by properly heat-treating the concentrate. Furthermore, vacuum temperatures below 120° F. are not needed to produce fresh concentrate of a desirable flavor.

SEVERAL PROCESSING DIFFICULTIES

Five retail country routes were started at this stage of the processing experiments. However, several processing difficulties were experienced. A brief discussion of these problems might prove helpful.

During the second week of retail delivery, the first major processing difficulty developed. A batch of milk had been processed in the usual manner, but when a concentrate of about 2 to 1 was reached the product started to thicken in the pan. Within about 5 minutes a gel was formed which would barely drain from the pan. The product continued to thicken to such an extent that it was discarded. The acidity of the milk was normal.

A series of test runs were made to discover the cause of this thickening condition. A similar run made the same day from the same source of raw milk also thickened in the pan. A 30-gallon batch made from the same source of raw milk was processed with sodium citrate added at the rate of 4 ounces per 1,000 pounds 3:1 concentrate. Again the product thickened.

Satisfactory results were obtained with another 30-gallon lot of this same milk which was pasteurized at 180° F. by the HTST process before concentration. Although the problem was eliminated, there was no definite explanation for the coagulation of the batches during concentration. However, there apparently was an unstable condition in the milk which was corrected by using a pasteurization temperature of 180° F. before concentration. No further difficulty of this type has been experienced since the temperature for both pasteurizations has been kept at 180° F.

Another processing difficulty occurred occasionally in the final pasteurization and cooling stages of the concentrate. In some of the batches, there was trouble with foam in the bottled product. The foam was not apparent when the concentrate was bottled, but after several hours, the milk level in the bottle had dropped. This trouble was caused by the incorporation of air into the concentrate as it passed through the suction side of the HTST pasteurizer. Because the concentrate is very thick, a high vacuum is created when it passes through this part of the system. Because of the high vacuum, air was incorporated into the fresh concentrate through defective or improperly seated gaskets. During homogenization, the air cells were reduced in size, and it was impossible to detect foam or air in the concentrate immediately after it was bottled. However, during storage for a number of hours, the trapped air would rise to the surface resulting in "short-filled" bottles. This difficulty occurred only occasionally but always required refilling the bottles—thus increasing the chance for post-processing contamination.

Another situation which increased the possibility of "short-filled" bottles was the fact that the final product could not be cooled below 50° F. by the pasteurization arrangement used. The concentrate temperature was approximately 125° F. when it was withdrawn from the vacuum pan. Then it was pumped to the pasteurizer at this temperature to avoid cooling to 40° F. before final pasteurization. However, the HTST pasteurizer is so designed that, in order to take advantage of the regenerator section, milk at about 40° F. must be introduced into the raw milk side of the regenerator. Since concentrate at a temperature of 125° F. was introduced into the pasteurizer, full advantage of the regenerator section was not obtained. When the bottled concentrate was cooled to 38° F. in the cold storage room, the volume of the milk was reduced due to shrinkage. This shrinkage resulted in "short-filled" bottles.

To correct this difficulty, certain modifications were made in the second pasteurization procedure. The raw milk float tank was placed adjacent to the inlet side of the timing pump where only a short sanitary elbow and tube were needed to connect it to the pump. By this arrangement, the concentrate was pumped directly to the homogenizer, then through the pasteurizer. The concentrate by-passed the suction side of the pasteurizer, and the chances for the incorporation of air were practically eliminated. The temperature of the concentrate was adjusted to 130° F. in the vacuum pan. This temperature was adequate for proper homogenization.

To cool the concentrate properly, cold water was circulated through the raw milk side of the regenerator, and the concentrate was cooled to 40° F. following pasteurization. This treatment, together with the modified pasteurization arrangement, corrected the difficulty and resulted in properly filled bottles.

Results have been favorable when fresh concentrate has been served at various meetings in Iowa. The usual procedure is to reconstitute a sample of the product with cold water before the meeting. The reconstituted product then is offered for comparison with regular homogenized milk of the same butterfat content. The group is asked to taste each product identified by code.

While no actual figures were kept on the results of these trials, the majority of the people on each occasion preferred the milk prepared from the fresh concentrate. Some individuals could tell no difference in the two types of milk, and a few preferred the regular homogenized milk. The reason given by most individuals who preferred the fresh concentrated milk was that it tasted richer. The rich flavor is attributed to the pasteurization treatment used on the concentrated product.

KEEPING QUALITY

There has been considerable discussion of the keeping quality of fresh concentrate. Some people have suggested that the product has unusual keeping qualities because of the degree of concentration employed. To obtain more information on this point, samples processed in different ways were stored under conditions which might be encountered in general use of the product. Changes in the microbial populations were tabulated. The methods outlined in "Standard Methods for the Examination of Dairy Products"[2] were followed in making bacterial counts. Coliform counts were determined on violet red bile agar. The plates for all counts were incubated at 37° C.

Samples were stored at 35°, 40° and 50° F. for periods up to 30 days. A few samples were held at 70° F. but both the concentrate and the reconstituted product became unusable so quickly that holding at this temperature was discontinued. The data obtained are too extensive to be presented in detail, so only representative results will be given.

Nearly all samples of the finished concentrate were negative for coliform bacteria in milliliter quantities, indicating considerable success in the protection of the product from post-processing contamination. This fact must be kept in mind in interpreting the results on keeping quality, since one sample, which the coliform test showed to be contaminated, had a much poorer keeping quality than was characteristic of most samples.

Although there was some variation in the heat treatments received by the various batches of concentrate, the counts on the fresh product always were low; the highest was 3,200 per milliliter and the lowest 50 per ml., with most of the counts below 1,000 per ml. There seemed to be no relationship between the count on the raw milk and the count on the finished product but this would be expected since most of the raw milk was of good bacteriological quality.

Most of the samples stored at 35° F. remained satisfactory in both flavor and bacterial count over a 30-day period. However, there were two exceptions—two samples pasteurized at 162° F. for 16 seconds had a pronounced stale flavor and a count exceeding 30,000,000 per ml. after 30 days of storage at 35° F. Most of the samples showed a slight decline in count during the first few days and then a small subsequent increase.

With the samples held at 40° F., the total count usually increased slowly for about the first 2 weeks, and the concentrate became unsatisfactory from both organoleptic and bacteriological standpoints some time between the fifteenth and the twentieth days of holding. Since many household electric refrigerators are set at about this temperature, or just a little higher, these results would indicate good keeping quality under home storage conditions.

Storage at 50° F. noticeably decreased the keeping quality of the product. The usual sample remained low in count for 2 days at this temperature but considerable growth was evident by 4 days; the counts became very high, and objectionable flavors developed soon after 4 days at 50° F. Since poorer household refrigerators are commonly set at about 50° F., the keeping quality of the concentrated product under such conditions would not be very good.

A number of samples were held in both concentrated and reconstituted forms at the various temperatures. Sterile distilled water and sterile equipment were used in reconstituting the product. Reconstitution had no effect on the changes in bacterial counts during holding, and differences observed were attributed to the reduction in numbers resulting from the dilution involved. There was a slight tendency for the reconstituted product to develop a stale flavor sooner than the concentrate but this tendency was not pronounced.

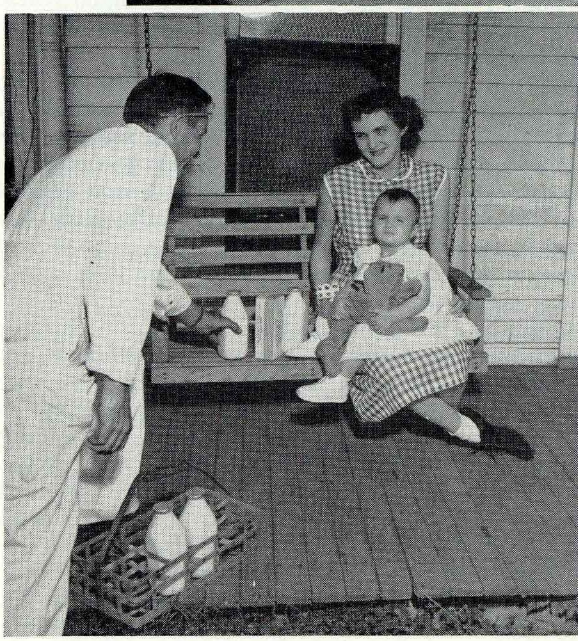
The results of the keeping quality tests indicate that the comparatively good storage life of the product is not because of the increased concentration of milk solids in the concentrate. The combination of relatively high pasteurization temperatures, double pasteurization and low holding temperatures is responsible for this good keeping quality.

If the product becomes contaminated after pasteurization, even good refrigeration will not prevent extensive bacterial development. One of the latter lots which became contaminated, as shown by a coliform count of 30 per ml. on the fresh product, illustrates this point. After this lot was held at 40° F. for a week, a distinct off-flavor developed and the total count ex-

[2]Standard Methods for the Examination of Dairy Products. 9th Ed. American Public Health Association, New York. 1948.

1. Bulk tank trucks such as this one pick up the raw milk from the producer and deliver it to the plant where it's processed in vacuum equipment.

2. The fresh concentrated milk is delivered to rural customers by a private vendor. The reduced bulk of the fresh concentrate makes it possible to use small, lightweight trucks.

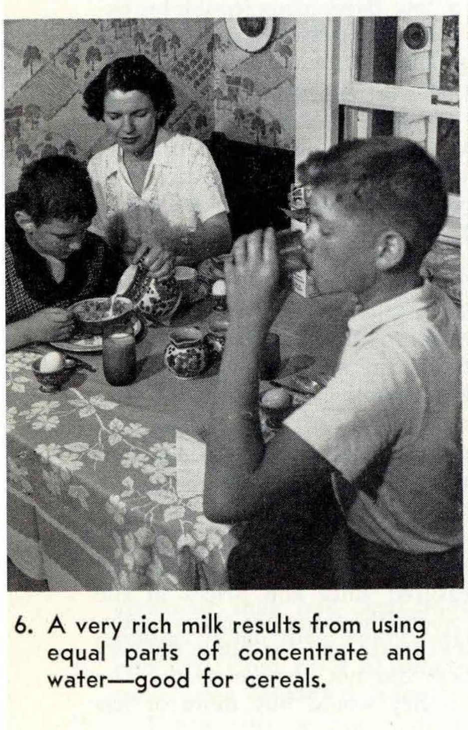


3. Fresh concentrate is delivered once a week to each family on the route. Besides the fresh concentrated milk, ice cream, butter and cheese also are available.

4. Families find it easy to dilute the fresh concentrate. They simply add 2 quarts of water to each quart of concentrate; each quart of concentrate makes 3 quarts of milk.

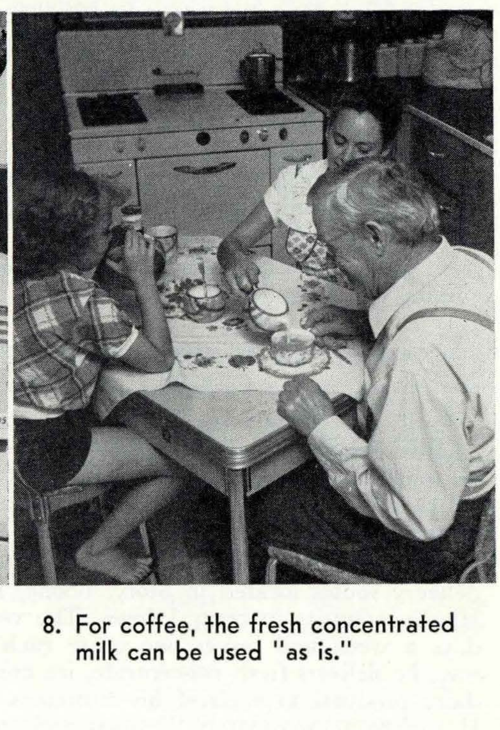
5. Diluted fresh concentrate makes an excellent drinking milk; it has a clean, rich flavor.

FRESH CONCENTRATED MILK is a relatively new product. It's produced in essentially the same way as the more familiar condensed or evaporated milk. Taste, however, is not affected. Much of the water is removed which reduces bulk in handling the product. The reduced bulk makes door-to-door delivery possible in rural areas. Keeping quality of the fresh concentrate is good, and once-a-week delivery is all that's needed.



6. A very rich milk results from using equal parts of concentrate and water—good for cereals.

7. Use the water in which vegetables are cooked to dilute the milk in creaming vegetables—don't lose those vitamins.



8. For coffee, the fresh concentrated milk can be used "as is."

ceeded 300,000 per ml., with the coliform count exceeding 30,000 per ml.

The keeping quality tests indicated that attributing any remarkable keeping qualities to the product would not be justified. However, if properly protected from contamination and properly refrigerated, fresh concentrate will keep as well as good, pasteurized milk and possibly a little better because of the more drastic heat treatment which the concentrate receives during pasteurization. The vacuum treatment apparently has no effect on microbial keeping quality.

The results of the work on fresh concentrate at Iowa State College may be summarized as follows:

(1) High quality milk must be used to prepare this product.

(2) A pre-heating or pasteurizing treatment is necessary before condensing.

(3) Experience with the single stage homogenizer indicates that the product must be homogenized both before and after condensing to prevent a cream layer formation after storage for 7 to 10 days. However, one homogenization might suffice when other types of homogenizers are used.

(4) An acceptable product can be produced by condensing at the usual vacuum pan temperatures of 125° to 135° F. However, condensing at these temperatures will produce varying degrees of a flavor which we have called "harsh cooked" and "stale." This flavor can be changed to a pleasing mellow-cooked, rich flavor by pasteurizing at 180° F. for 16 seconds after concentration.

(5) Most people agree that the reconstituted product has a fresh milk flavor and is relatively free from volatile feed and grass flavors.

(6) Experience has shown that any major deviation in the processing procedure will be reflected in the flavor score of the finished product.

(7) The relatively good keeping quality of the product is because of pasteurization at high temperatures, double pasteurization and low holding temperatures. The concentration of milk solids is not sufficient to inhibit bacterial growth, and the vacuum treatment does not have any demonstrable effect on the bacterial population during storage.

The present recommended methods of processing fresh concentrate are given in the summary at the beginning of this bulletin.

ANALYSIS OF RURAL DELIVERY ROUTES IN CENTRAL IOWA

Fresh concentrate and other milk products are distributed for the Iowa State College dairy by a vendor. He picks up the milk at the milk plant loading dock, delivers with his own truck and returns the empty bottles to the plant.

At the present time, he maintains five experimental delivery routes located in Story, Boone, Hamilton and Hardin counties in central Iowa. The vendor works 5 days a week and serves one route each day. In this way, he delivers fresh concentrate, ice cream and other dairy products to each of his customers once a week. He drives approximately 92 miles and serves about 71 customers each day. He sells approximately 750 quarts of fresh concentrate in a 5-day week, or an average of 150 quarts each day. In addition, he sells about 300 quarts of ice cream and 42 units of miscellaneous dairy products each week.

The operations on these experimental routes are analyzed below to provide information about the rural market for fresh concentrate. This information may prove helpful to anyone considering the rural distribution of fresh concentrate as a commercial venture.

CHARACTERISTICS OF RURAL CONSUMERS OF FRESH CONCENTRATE

A survey was made to determine the characteristics of the customers in central Iowa. Each customer was given a questionnaire which was collected 2 days later by a college representative. To minimize the number of nonrespondents, call-backs were made where necessary.

Three factors were selected as guides to determine the characteristics of the consumers and to explain the variation in sales within the five routes. These factors were (1) the number of dairy cows on the farm, (2) the number of people in each household and (3) the number of acres in the farm.

The number of dairy cows was included to obtain a measure of the type of farming practiced by the customer. Size of the household was used on the basis of previous urban studies which showed that this factor was related to family milk consumption. The number of acres in the farm was included to obtain an estimate of income. Because of the difficulty of obtaining reliable responses, customers were not asked their income directly.

The number of cows showed an inverse relationship with sales of concentrate, while the size of the household and the number of acres in the farm were directly (positively) related to sales. In other words, a large farm family with only a few dairy cows could be expected to be a better customer than a small family milking a relatively large number of cows.

These three factors, however, explained only 20 percent of the variation in sales. Accordingly, another analytical approach was tried to uncover more information. It was thought that the characteristics of the customers might differ from those of their neighbors who weren't buying concentrated milk. To determine what these differences might be, the characteristics of customers on the rural delivery routes were compared with the averages for their respective counties, as shown in the 1953 annual farm census for Iowa.[3] The characteristics compared were the size of the farm, acres of corn, acres of hay, and the number of milk cows, beef cattle and hogs per farm.

This comparison showed that a typical customer had a slightly larger household and slightly more corn, hay and beef cattle than the average for his respective county. The differences, however, were small.

The effects of changes in the price of concentrated milk could not be measured since the prices in the Ames area were kept at about the same per-quart equivalent as the prices in local stores and for home delivery in towns, and these prices did not change much. The customers were asked if they would buy more or less

[3]Iowa Department of Agriculture, Division of Agricultural Statistics. Annual farm census, 1953. State of Iowa. Bul. 92-01954.

TABLE 1. OPINIONS EXPRESSED ABOUT FRESH CONCENTRATED MILK BY MEMBERS OF FIVE RURAL DELIVERY ROUTES IN CENTRAL IOWA, 1954.

	Opinions mentioned first		Opinions mentioned second	
	Nonfarm*	Farm	Nonfarm*	Farm
	(percent of those expressing opinions†)			
Good	17.6	25.7	0	5.4
Very good	35.3	35.3	0	1.8
Excellent	3.9	15.0	5.0	1.8
Better than other milk	11.8	3.6	5.0	1.8
Good keeping quality	2.0	4.8	15.0	17.9
Convenience	5.9	2.4	20.0	33.9
Can't tell difference	7.8	1.8	15.0	8.9
Can use as both cream and milk	3.9	1.2	20.0	5.4
Adverse comments	11.8	10.2	20.0	23.2

*Nonfarm people were those living in the rural market area but not receiving their major income from farming.

†Of 340 route members interviewed, 32 percent of the nonfarm people and 37 percent of the farm people expressed no comment.

concentrate if prices were lowered or raised 1, 2 or 3 cents per quart equivalent. About half said yes, and the other half said no.

CONSUMER REACTION TO THE QUALITY OF FRESH CONCENTRATE

The vendor's customers also were asked to "please comment on the quality of fresh concentrated milk." Replies to this question were grouped into nine categories which are shown in table 1.

It was found that most respondents, as a first opinion, praised the product. Of the people commenting adversely in their first opinion, almost half were not buying fresh concentrate but were buying other products from the vendor. Respondents expressing second opinions were more inclined to say why they liked the product or why they didn't like it. This analysis would seem to indicate that customers think first of either liking or disliking the product. Then they consider the reasons why they think what they do about fresh concentrated milk.

RURAL DELIVERY OF FRESH CONCENTRATE IN CENTRAL ILLINOIS

To test the findings of the central Iowa survey, additional studies were made in central Illinois where Prairie Farms Creamery was experimentally distributing fresh concentrate to rural areas. These areas covered 13 counties around Bloomington and Henry, Ill. Prairie Farms adapted the process to its Henry, Ill., plant and started to process fresh concentrate soon after the processing methods were perfected at Iowa State College. The product was introduced to customers on previously established country pick-up routes. Over a period of years, other products including ice cream, butter and chocolate milk had been added to the existing cream routes. When these studies were made, six routes were operated from each of these locations, and each customer was contacted twice a week.

The results of the study of the Illinois area were similar to the results of the Iowa area. This indicates that similar results might be expected in other areas having the same characteristics, such as topography, type of farming and density of population.

ESTIMATING THE COSTS OF RURAL DELIVERY OF FRESH CONCENTRATE

To estimate the cost of delivering fresh concentrate on a rural basis, a situation was assumed similar to that existing in central Iowa. The vendor in Iowa serves five routes and drives approximately 92 miles a day—or 460 miles in 5 days. At the time this study was made, he was selling approximately 750 quarts of fresh concentrate each week to approximately 340 customers. Roughly, about every fourth household on this route was a customer. At this rate—assuming conditions similar to the central Iowa sales area—1,360 households would have to comprise a sales territory to sell 750 quarts of fresh concentrate each week. About 300 quarts of ice cream and 42 units of miscellaneous dairy products also were delivered each week by the vendor.

The delivery costs under these conditions were estimated on the basis of information obtained from this central Iowa area. They are shown in table 2.

Running costs per mile were obtained from data supplied by a local truck dealer. The license fee was for the 5-ton maximum load limit in Iowa. To estimate the cost of insurance, agents of six different companies were contacted. The rate used in the study was the average of the rates quoted for "10-30" coverage ($10,000 maximum payment to any person—$30,000 maximum payment for any one accident). A ½-ton chassis which could be traded in every 3 years for approximately half of the original purchase value was the basis for determining the depreciation schedule of the truck. The truck body, assumed to depreciate over a period of 8 years, was figured to be of magnesium construction and included a small compressor for refrigeration. The interest charge was computed at 5 percent of the average investment. In computing the driver's wages, it was assumed he was paid at the rate of 2½ cents for each unit of sales. This approximates the rate of payment for urban milk deliverymen in the Des Moines, Iowa, area. A quart of fresh concentrate was figured equal to 3 units; 1 quart of ice cream equal to 2½ units; and 20 cents in miscellaneous sales equal to 1 sales unit.

TABLE 2. ESTIMATED RURAL DELIVERY COSTS FOR FRESH CONCENTRATED MILK.

Type of cost	Cost per mile	Total cost per year	Cost per unit of sale
Running costs per mile	$ 0.0261	$ 625	$ 0.00390
License	0.0017	40	0.00025
Insurance	0.0038	90	0.00057
Depreciation			
Truck	0.0118	283	0.00180
Body	0.0146	350	0.00224
Interest	0.0053	126	0.00080
Driver's wages	0.1645	3,935	0.02500
Payroll, taxes and insurance*	0.0066	157	0.00100
Total cost	$ 0.2344	$ 5,606	$ 0.0356

*Kolmer, Lee. Spray drying costs in low-volume milk plants. Unpublished Ph. D. thesis. Iowa State College Library, Ames, Iowa. 1954.

These costs add up to 3.56 cents per quart milk equivalent—that is, to 10.68 cents per quart of concentrated milk. Delivery costs in areas not relatively flat and open, like the central Iowa market area, would differ from these. The costs would also differ in other areas where density of population is greater or less than in Iowa. In addition, insurance and license costs may differ from year to year and from area to area. Such considerations should be taken into account in computing the costs for other areas.

COSTS OF PROCESSING FRESH CONCENTRATE

If study of an area indicates that a potential market for fresh concentrate exists, a processor considering the marketing of the product would want to know something about the costs of processing fresh concentrate. To estimate such costs, four different plant situations were considered. The processing costs were budgeted for each of the following cases:

Case 1—A new plant built to process fresh concentrate.

Case 2—An existing manufacturing plant to which is added the equipment required to process fresh concentrate.

Case 3—An existing Grade A plant to which is added the equipment required to process fresh concentrate.

Case 4—A plant which has the equipment necessary to process fresh concentrate.

For each of these cases, costs were calculated at nine different levels of output. The levels selected were multiples of 750 quarts of concentrate—the amount which the vendor in the Iowa area was selling each week. The highest output considered was 15,000 quarts a week. Based on the present rate of consumption in the Iowa area, this output would supply enough fresh concentrate for about half the state.

As in any cost study, many assumptions must be made—not only about the allocation of costs to the various enterprises, but also about the basis for original costs. For example, all equipment costs were based on current list prices for new equipment minus the usual trade discounts, rather than on costs for used equipment. They could not be based on used equipment prices because they vary considerably over a period of time, and a person who is at the right place at the right time may buy dairy plant equipment for a fraction of the cost the same equipment might cost at some other time. Other basic assumptions made in this cost study are: that latest techniques and equipment would be used to produce at the lowest long run cost; that the building is the minimum size necessary for practical operation; and that ground for expansion is available.

Costs of processing in this study were divided into two classes—fixed costs and variable costs. Costs were regarded as fixed if they did not change as output varied, or if the change in processing costs was assumed to be extremely small and difficult to estimate. All other costs were treated as variable costs.

CASE 1—A COMPLETE PROCESSING PLANT WHERE ONLY FRESH CONCENTRATE IS PRODUCED.

To estimate the cost of materials for a building to house this processing plant, a rough appraisal method was used. The value of the basic structure was obtained by multiplying the total number of square feet in the building by the estimated cost of constructing each square foot.

Estimated construction costs were obtained from Boeckh's Manual of Appraisals and corrected to April, 1954.[4] Facilities included in addition to the basic structure were: (1) nonslip tile floor; (2) hollow wall tile in the rooms where the milk was processed; (3) plastered ceilings in the milk handling rooms; (4) heating and plumbing; (5) a 38° F. cold storage room and (6) refrigeration equipment. For these facilities, the quantities and cost of materials and labor were obtained by using builders' handbooks and by contacting contractors in the field. Processing equipment for the plant included those facilities most likely included in a new building built specifically for a Grade A dairy plant. The capacity of the various pieces of equipment selected was normally the smallest size in general commercial use. Table 3 lists the processing equipment assumed necessary for the plant.

An attempt was made to provide equipment of similar capacities throughout the plant. However, since an effort was made to duplicate the present Iowa State College method of processing, the high-temperature, short-time (HTST) pasteurization method was used. This method uses equipment which provides large capacity at a minimum of additional expense and requires very little floor space. In addition, a paper bottler was provided. This was done because of lower equipment costs and savings in labor which paper permits and because experiments showed that the quality of the product was not affected by using paper containers.

The evaporator selected was a single effect type which allows either batch or continuous operation. An oil-gas burner was provided for the boiler. Although coal may be more economical, the oil-gas burner was selected because it is cleaner and affords a greater degree of automatic control. Fuel oil was chosen over gas since gas is not available in all areas. However, if a plant can take advantage of cheaper off-hours gas rates, this burner could be converted at a minimum expense.

[4]Boeckh, E. H. Boeckh's manual of appraisals. 4th ed. Rough Notes Co., Inc., Indianapolis. 1945.

TABLE 3. EQUIPMENT ASSUMED NECESSARY FOR PROCESSING FRESH CONCENTRATE

Receiving room	Pasteurizing and packaging
Milk pump	HTST pasteurizer (5,000 lbs. per hr.)
Scale	Homogenizer (5,000 lbs. per hr.)
2,000 gallon storage vat	500 gal. round pasteurizer (2)
Weigh tank (750 lbs.)	Milk pumps (2)
Plate milk cooler	Paper bottler (112 qt. per minute)
Receiving vat (1,000 lbs.)	Movable case conveyors
Can washer (6 cans per minute)	Sanitary piping and accessories
Testing equipment	Wash tank, racks, etc.
Sanitary piping	Sweet water pump
Conveyor	Timing pump
Evaporation	Miscellaneous facilities
Evaporator	Water softener
Installation	Office facilities
Sanitary piping	Lockers
	Other equipment (2 percent of equipment investment)

Separate rooms were provided for each of the following operations: receiving, processing, evaporation, boiler and service. The evaporator was placed in a separate room to comply with many milk ordinances. This also made it possible to assign a fair share of the building cost to the evaporator. The boiler and refrigeration charges were included in the building costs rather than in the equipment costs because of the dual purpose this equipment serves. In addition to the part they play in processing, this equipment can be used to heat the building or, in the case of refrigeration equipment, to cool the building. Adequate artificial lighting throughout the plant was provided for, and appropriate charges were included for insurance and taxes.

Other fixed costs included expenses for office and locker facilities, heating the building, bookkeeping and managerial operations. The heating of the building was considered a fixed expense since this cost is independent of the rate of output. Heating requirements were calculated by estimating heat loss of the plant for a heating season of 9 months. The BTU requirements thus obtained were converted to pounds of oil. It is assumed that the boiler was 70 percent efficient.[5]

The bookkeeping charge was calculated on the assumption that a combination bookkeeper-secretary could be hired to work half time at the rate of $25.00 per week. Such costs as a yearly audit, any incidental supervision which might be given by a professional management firm and the value of the plant superintendent's time as a manager are included in expenses for managerial operations. The managerial charge was estimated to be $1,500 per year.

Variable costs included such items as fuel for the processing equipment, electricity for refrigeration and other equipment, labor, containers for fresh concentrate and expenses for miscellaneous supplies.

Fuel requirements for operating the can washer, the HTST pasteurizer, the evaporator and the paper carton filler were calculated by finding the steam requirements and converting this value into the equivalent pounds of oil. Costs of refrigeration were estimated by calculating the necessary number of tons of refrigeration, converting this into horsepower hours and then into kilowatt-hours. Other electricity costs were computed by finding the KWH used by all motors plus an allowance for lighting.

The labor requirement was estimated from a time study of the two plants (Iowa State College Dairy and Prairie Farms Creamery, Henry, Ill.) processing fresh concentrate. Since all employees were assumed to work a 40-hour week, labor was added in 40-hour units. Provision also was made for a working supervisor because certain operations—such as evaporation—require only intermittent attention. He was allowed 10 hours a week for strictly supervisory duties, and he never worked over 30 hours a week as a regular employee. The next ranking employee was assumed to be an operator—all other employees were helpers.

Expenses for supplies included costs for such items as chlorine, washing powder and stationery. Supply expenses for the nine levels of output were estimated from the amount spent for these items at the Iowa State College processing plant. An allowance of 2 percent of the total equipment cost was made at each output for miscellaneous expenses, such as for containers. The interest rate was considered to be 5 percent—the assumed rate of earnings for alternative investments.

For a plant operating under the conditions described in Case 1, the estimated fixed, variable and average total costs of processing fresh concentrate at nine levels of output are shown in table 4. These costs are expressed in cents per quart of concentrate in table 5.

At each of the outputs, the average total cost per quart of concentrate decreased. Therefore, a processor wishing to minimize his costs would produce at the highest output consistent with his sales. Even at the highest output considered (15,000 quarts a week), the plant would be relatively small compared with the capacity of most Grade A dairy plants.

[5]McGinnis, C. H., Des Moines, Iowa. Information on boiler costs for a dairy plant. (private communication) 1954.

TABLE 4. TOTAL COSTS OF PROCESSING FRESH CONCENTRATE WHERE A COMPLETELY NEW PLANT IS BUILT TO PROCESS THE PRODUCT—CASE 1.

	Number of quarts of concentrate processed per week								
Cost item	750	1,500	2,250	3,000	3,750	6,000	7,500	11,250	15,000
Fixed Costs									
Equipment/week	$269.06	269.06	269.06	269.06	269.06	269.06	269.06	269.06	269.06
Building	119.00	119.00	119.00	119.00	119.00	119.00	119.00	119.00	119.00
Office expense	6.39	6.39	6.39	6.39	6.39	6.39	6.39	6.39	6.39
Heating of building	31.00	31.00	31.00	31.00	31.00	31.00	31.00	31.00	31.00
½ time bookkeeper	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00
Managerial charge	29.00	29.00	29.00	29.00	29.00	29.00	29.00	29.00	29.00
Total fixed costs	479.45	479.45	479.45	479.45	479.45	479.45	479.45	479.45	479.45
Variable costs									
Dumping	10.32	18.65	26.73	34.61	42.43	63.69	77.92	112.86	145.88
Concentrating	9.51	16.57	26.07	33.13	42.64	66.27	82.76	124.98	164.21
Processing and packaging	11.16	15.54	23.42	27.80	35.68	52.32	64.58	96.48	124.88
Boiler	3.81	4.67	5.94	6.95	8.23	11.07	13.36	18.34	23.06
Plant loss*	14.17	28.38	42.55	56.76	70.93	113.53	141.86	212.84	283.77
Labor	80.00	80.00	130.00	130.00	130.00	190.00	240.00	290.00	350.00
Container ($0.021 each)	15.75	31.50	47.25	63.00	78.75	126.00	157.50	236.25	315.00
Total variable costs	144.72	195.31	301.96	352.25	408.66	622.88	777.98	1,091.85	1,406.80
Total costs	624.17	674.76	781.41	831.70	888.11	1,102.33	1,257.43	1,571.20	1,886.26

*Plant loss calculated at 6 percent of raw milk dumped; priced at $4.60 per hundredweight which is the price Iowa State College paid for Class I milk during 1953.

TABLE 5. COST PER QUART OF PROCESSING FRESH CONCENTRATED MILK AT NINE LEVELS OF OUTPUT.

Sales per week (quarts)	Fixed cost per quart of concentrate	Variable cost per quart of concentrate	Average total cost per quart of concentrate
750	$ 0.6393	$ 0.1930	$ 0.8322
1,500	0.3196	0.1302	0.4498
2,250	0.2131	0.1342	0.3473
3,000	0.1598	0.1174	0.2772
3,750	0.1279	0.1090	0.2368
6,000	0.0799	0.1038	0.1837
7,500	0.0639	0.1037	0.1676
11,250	0.0426	0.0970	0.1397
15,000	0.0320	0.0937	0.1258

It is unlikely that a processor would build a completely new plant and start processing fresh concentrate. A processor would be more likely, at least until after the product was well established, to add fresh concentrate to an existing milk processing business. Cases 2, 3 and 4 are the possible situations considered in this study in which a processor might wish to add fresh concentrate. The processing costs for these cases were calculated by varying the basic calculations considered in Case 1. No allowance was made for increased maintenance costs resulting from additional use of the equipment in the existing plants. Such costs are unpredictable and difficult to calculate. However, they would be small, and omitting them should not significantly affect the comparison with Case 1.

TABLE 6. COST OF PROCESSING FRESH CONCENTRATED MILK ASSUMING EQUIPMENT FOR FRESH CONCENTRATE ADDED TO EXISTING MANUFACTURING PLANT—NINE OUTPUT LEVELS CONSIDERED.

Sales per week (quarts)	Fixed cost per quart of concentrate	Variable cost per quart of concentrate	Average total cost per quart of concentrate
750	$0.3161	$0.1828	$0.4989
1,500	0.1580	0.1214	0.2794
2,250	0.1054	0.1259	0.2313
3,000	0.0790	0.1095	0.1885
3,750	0.0632	0.1012	0.1645
6,000	0.0395	0.0968	0.1363
7,500	0.0316	0.0969	0.1285
11,250	0.0211	0.0906	0.1117
15,000	0.0158	0.0876	0.1034

CASE 2—AN EXISTING MANUFACTURING PLANT TO WHICH IS ADDED THE NECESSARY EQUIPMENT REQUIRED TO PROCESS FRESH CONCENTRATE.

In Case 2, it was assumed that a manufacturing plant having the facilities to process regular milk and other dairy products was in operation. The plant was assumed to have an evaporator. The fresh concentrate would be run through the evaporator ahead of the day's regular run in order to meet Grade A standards.

To add fresh concentrate to an existing manufacturing plant, the following costs were considered fixed costs. It was assumed that a processing room and a refrigeration room would have to be built and that a larger boiler (54 HP) would be needed. The cost of lining the processing and refrigeration rooms with hollow tile was calculated so that facilities could be similar in all four cases. The cost of adding extra space was calculated by using the estimated building costs in Case 1 and subtracting the part of the building which a manufacturing plant might normally have. It was assumed that a receiving room was already a part of the plant. Other fixed costs included expenses for the additional processing equipment needed and for heating the extra space. Additional processing equipment assumed necessary included the processing equipment listed in table 4 for Case 1, except for the following items: evaporator and sanitary piping, single can washer and the conveyor system. The receiving room equipment was added to facilitate complete mechanical handling of the milk and to comply with the standards for processing Grade A milk. The costs of additional maintenance facilities included the 2-percent cost of the equipment investment for miscellaneous equipment. Except for the cost of concentrating, variable costs were considered to be the same as in Case 1. The processing costs are shown in cents per quart in table 6. They are shown in detail in table 7.

TABLE 7. TOTAL COSTS OF PROCESSING FRESH CONCENTRATE WHERE THE PRODUCT IS ADDED TO AN EXISTING MANUFACTURING PLANT—CASE 2.

	Number of quarts of concentrate processed per week								
Cost item	750	1,500	2,250	3,000	3,750	6,000	7,500	11,250	15,000
Fixed costs									
Added building costs	$ 27.88	$ 27.88	$ 27.88	$ 27.88	$ 27.88	$ 27.88	$ 27.88	$ 27.88	$ 27.88
Added equipment costs	190.96	190.96	190.96	190.96	190.96	190.96	190.96	190.96	190.96
Heating of added building	18.23	18.23	18.23	18.23	18.23	18.23	18.23	18.23	18.23
Total added fixed costs	$ 237.07	$ 237.07	$ 237.07	$ 237.07	$ 237.07	$ 237.07	$ 237.07	$ 237.07	$ 237.07
Variable costs									
Concentrating costs:									
Value fuel oil at $0.0175/lb.	$ 1.59	3.18	4.77	6.36	7.95	12.72	15.90	23.85	31.80
Cost of water & sewage	$ 0.80	1.60	2.40	3.20	4.00	6.40	8.00	12.00	16.00
Electricity	$ 0.064	0.128	0.192	0.256	0.320	0.512	0.640	0.960	1.28
Labor	$ 0.23	0.46	0.69	0.92	1.15	1.84	2.30	3.45	4.60
Total concentrating cost	$ 2.68	5.37	8.05	10.74	13.42	21.47	26.84	40.26	53.68
Other variable costs (Same as Case 1)	$ 134.40	176.66	275.23	317.64	366.23	559.19	700.06	978.89	1,260.92
Total variable costs	$ 137.08	182.03	283.28	328.38	379.65	580.66	726.90	1,019.15	1,314.60
Total costs	$ 374.15	$ 419.10	$ 520.35	$ 565.45	$ 616.72	$ 817.73	$ 963.97	$ 1,256.22	$ 1,551.67

TABLE 8. ADDITIONAL COSTS OF PROCESSING FRESH CONCENTRATE WHERE THE PRODUCT IS ADDED TO AN EXISTING GRADE A PLANT—CASE 3.

	Quarts of concentrate processed per week								
	750	1,500	2,250	3,000	3,750	6,000	7,500	11,250	15,000
Fixed costs:									
Added building expense per week	$ 9.52	9.52	9.52	9.52	9.52	9.52	9.52	9.52	9.52
Added equipment expense per week	$ 31.96	31.96	31.96	31.96	31.96	31.96	31.96	31.96	31.96
Total fixed costs	$ 41.48	41.48	41.48	41.48	41.48	41.48	41.48	41.48	41.48
Total variable costs (same as Case 1)	$ 144.72	195.31	301.96	352.25	408.66	622.88	777.98	1,091.75	1,406.80
Total added costs	$ 186.20	236.79	343.44	393.73	450.14	664.36	819.46	1,133.23	1,448.28

CASE 3—ADDING FRESH CONCENTRATE TO AN EXISTING GRADE A PROCESSING PLANT

In Case 3, it was assumed that fresh concentrate was added to an existing Grade A plant. Most of the costs created by adding the new product would be variable costs—those which a processor would have in addition to his present operating costs. The variable costs were considered to be the same as in Case 1.

To add fresh concentrate to an existing Grade A plant, it was assumed necessary to add an extra room for the evaporator and to provide a larger boiler and boiler room. To estimate the cost of constructing this extra room, the replacement cost of the building without the necessary enlargements was calculated. The difference between this calculated replacement cost and the building cost in Case 1 constituted the building cost incurred by adding fresh concentrate to the plant. In practice, a processor might not actually add the extra space; he might be able to use existing space more efficiently. However, for the purposes of this study, it was necessary to assume that the extra space required would have to be added to the plant.

TABLE 9. COST OF PROCESSING FRESH CONCENTRATED MILK ASSUMING FRESH CONCENTRATE OPERATIONS ADDED TO AN EXISTING MARKET MILK PLANT—NINE OUTPUT LEVELS CONSIDERED.

Sales per week (quarts)	Fixed cost per quart of concentrate	Variable cost per quart of concentrate	Average total cost per quart of concentrate
750	$0.0579	$0.1930	$0.2508
1,500	0.0289	0.1302	0.1592
2,250	0.0193	0.1342	0.1535
3,000	0.0145	0.1174	0.1319
3,750	0.0116	0.1090	0.1206
6,000	0.0072	0.1038	0.1110
7,500	0.0058	0.1037	0.1095
11,250	0.0039	0.0970	0.1009
15,000	0.0029	0.0938	0.0967

Expenses for the additional processing equipment needed and for heating the extra space were treated as fixed costs. The only new equipment considered necessary was the evaporator and sanitary piping. The cost of heating the added space was assumed proportional to the total area of the plant plus heat escape through the windows.

The estimated processing costs for Case 3 are shown in detail in table 8. They are given in cents per quart in table 9. In Case 3, as in cases 1 and 2, the total processing cost per quart of concentrate decreased as the output increased; the higher the output, the lower the cost. However, at outputs over 6,000 quarts per week, the cost decreased only slightly. The cost per quart at an output of 15,000 quarts per week was only 1.43 cents less than the cost per quart at an output of 6,000 quarts.

CASE 4—PROCESSING FRESH CONCENTRATE WITH ALL THE REQUIRED FACILITIES AVAILABLE.

Case 4 was intended to cover two situations: (1) the plant with receiving, processing and evaporation facilities and (2) the arrangement by which one plant might concentrate the milk on a custom basis for another plant to distribute.

Processing costs for Case 4, shown in table 10, are additional costs since it is assumed the plant has all the facilities required to process fresh concentrate. For the situation where one plant may process fresh concentrate on a custom basis and bulk plant pick-up is used, the costs are calculated in table 11.

COMPARISON OF COSTS FOR CASES 1, 2, 3 AND 4.

On the basis of this study, the costs for processing fresh concentrate were highest in Case 1 where a new plant is built to process the product. Next was Case 2

TABLE 10. PROCESSING COSTS FOR A PLANT ASSUMED TO HAVE THE NECESSARY PROCESSING FACILITIES—CASE 4.

	Quarts of concentrate processed per week								
Cost item	750	1,500	2,250	3,000	3,750	6,000	7,500	11,250	15,000
Evaporating cost	$ 2.68	5.37	8.05	10.74	13.42	21.47	26.84	40.26	53.68
Dumping cost	$ 7.25	14.50	21.75	29.00	36.25	58.00	72.50	108.75	145.00
Labor for dumping	$ 0.05	0.10	0.15	0.20	0.25	0.40	0.50	0.75	1.00
Processing and packaging	$ 6.24	12.48	18.72	24.96	31.20	49.92	62.40	93.60	124.80
Labor for processing	$ 6.00	12.00	18.00	24.00	30.00	48.00	60.00	90.00	120.00
Containers	$ 15.75	31.50	47.25	63.00	78.75	126.00	157.50	236.25	315.00
Water and electricity	$ 1.16	2.32	3.48	4.64	5.80	9.28	11.60	17.40	23.20
Total costs	$ 39.13	78.27	117.40	156.54	195.67	313.07	391.34	587.01	782.68

TABLE 11. ADDITIONAL COSTS OF PRODUCING FRESH CONCENTRATED MILK FOR THE SITUATION WHERE ONE PLANT MIGHT CONCENTRATE THE MILK ON A CUSTOM BASIS USING BULK TANK RURAL COLLECTION.

Nature of cost	Average cost per quart at any output level
Evaporating	$0.0036
Processing and packaging	0.0486
Plant loss*	0.0189
Total cost of processing	0.0711
Total cost of processing without considering dumping cost	0.0614
Estimated cost of transportation†	0.0210
Cost of processing fresh concentrate assuming custom evaporation and bulk tank rural collection	0.0824

*Plant loss calculated at 6 percent of the raw milk dumped. The milk is priced at the Iowa State College Class I price for 1953—$4.60 per cwt.
†Estimate of the cost of milk transportation for 20 miles within the municipality made by a local trucker.

where the product is added to an existing manufacturing plant, followed by Case 3, where the product is added to an existing Grade A plant. Lowest costs for processing fresh concentrate were found in Case 4 where the product was added to a plant having all the necessary processing equipment.

Under the cost considerations and plant situations assumed in this study, the processing costs for cases 1, 2 and 3 decreased as the output was increased up to as high as 15,000 quarts per week. However, processing costs might increase at some level of output under other circumstances or plant situations than those considered here. The processing costs for Case 4 remained constant at $0.0522 regardless of output.

The cost estimates for the four cases at different rates of output are summarized in fig. 1 (see p. 4).

The cost and other factors considered in this study would be important points to consider by anyone interested in rural distribution of fresh concentrate as a commercial venture. However, each firm should analyze its own market area and appraise its own processing cost position. This study indicates some methods which might be used to make these estimates and appraisals.