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A Cost Analysis of Fluid Milk Packaging Operations

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SUMMARY

THIS BULLETIN focuses attention on that phase of milk plant operation pertaining to the packaging of fluid milk products. An attempt was made to determine and evaluate packaging costs and some of the factors that were particularly significant in influencing such costs.

The data used in this study were obtained in 1958 from 12 fluid milk plants located in Southern Michigan. The plants were selected so as to have plant operations of various sizes represented and were considered to be representative of the fluid milk plants in operation throughout the state. On the basis of the information gained from the study, the following conclusions appear to be warranted:

Since plants having glass operations tend to have a relatively high proportion of total costs as fixed costs, utilization of plant at or near capacity and increases in volume are important considerations.

When the total packaging operation is considered, equipment charges, payroll expenses and packaging materials, constituted 90 percent of the total cost. In looking for ways to decrease packaging costs, it is logical to investigate these cost items.

Of the five plants having the lowest unit packaging costs, four of them used only one type of container. This would seem to indicate that the plants that had combined glass-paper operations had a cost disadvantage attributable perhaps to the fact they used both types of containers. However, plant K, a combined glass-paper operation had a lower unit packaging cost on a quart equivalent basis for its total operations than did plants B and H, each of which used only one type of container. Inasmuch as plant K had a larger volume than either B or H, the possibility is suggested that it is feasible for plants having a relatively large volume to have combined glass-paper operations, if desiring to do so and still be able to compete with smaller plants using only one type of container.

When the total cost of the packaging operation does not include the cost of packaging materials, a comparison of unit cost shows a very close relationship between unit costs of paper and glass operations. The lower unit cost of glass is largely a function of the lower cost of packaging materials.

Regardless of volume packaged in paper containers, the ratio of fixed costs to variable costs tended to remain about the same. All

plants, except plant L, using large automatic paper fillers had above average proportions of the total packaging costs as fixed costs. Plant L had a relatively low proportion of total costs as fixed costs due to the use of an unusually small amount of building area and to the large amount of expenditures for packaging materials necessitated by the relatively large volume.

Plants having a combined operation of glass and paper with the production of one far greater than the other, experienced higher unit costs for the smaller outputs. Where the volume of milk packaged in glass and in paper containers was approximately the same the cost per unit varied very little. (Table 12)

The percentage of product packaged in glass and in paper had no apparent relationship to the total volume handled by the plant. Instead the manner in which the total output was divided between glass and paper was probably a result of management's attempt to adapt the plants operation to the demand characteristics of the market in which it operated.

A COST ANALYSIS OF FLUID MILK PACKAGING OPERATIONS

By W. H. BLANCHARD, GLYNN McBRIDE, and A. L. RIPPEN[1, 2]

INTRODUCTION

THE IMPORTANCE of knowing unit costs in any business cannot be over emphasized. Yet, it is often difficult for the dairy plant operator to accurately determine costs. This situation prompted this study to determine and evaluate, with respect to fluid milk plants, costs of production and some of the factors that are particularly significant in influencing them.

Importance of the Packaging Operation

Though each phase of the total plant operation is important, this bulletin focuses attention on the packaging of fluid milk products. Its importance is indicated by the fact that, on the average, about 36 percent of the investment, about 45 percent of the building area and almost 48 percent of the total payroll expenses for the fluid milk portion of the plant operations studied were allocated to the packaging operations. Thus, any measures taken to lower packaging costs would have a significant effect on decreasing total plant costs. (Sales and distribution costs were not included).

Attention has been focused on the packaging operations for several additional reasons. First, the nature of the operation and the relatively large amount of labor required provide an environment within which excessive costs may easily prevail. Secondly, the packaging operation is generally considered to set the production pace of the entire plant and thus has a direct influence on its operating efficiency. Finally, many of the distribution problems are directly related to the type of package being used.

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[2] The authors acknowledge the cooperation and help provided by the managers of the plants included in the study and their personnel without whose help the study could not have been made. Help and advice of colleagues in the departments of agricultural economics, agricultural engineering, food science, and dairy are appreciated.

Packaging Operation Defined

The total fluid milk operation may be considered to consist of cost centers, each representing one specific operation or a group of closely related operations. A cost center may represent all plant operation pertaining to receiving raw milk, to processing, packaging or to the storage of finished products. Once each cost center has been defined, all costs associated with any one center can be charged to a product as it passes through that center.

For this study, the packaging cost center is defined to include all building space, equipment, labor, packaging materials, utilities and supplies used directly in packaging fluid milk products. In addition, the packaging cost center includes its proportionate share of the items that are required for the general operation of the total fluid milk plant.

Description of the Study

Data for this study were obtained in 1958 from 12 fluid milk plants located in Southern Michigan. Various sizes of plant operations were represented in the plants selected. All were similar in business structure, each being a locally owned proprietary or cooperative business.

Each plant was visited to obtain financial data from its accounting records and to determine the physical layout, amount and type of equipment, amount of supplies, amount of labor and the machine running time necessary to package the fluid milk products handled by the plant. Each plant was observed for a 2-day period in the summer and again for a similar period in the fall.[3] One exception to this was plant E where observations were made on only 3 days. The costs presented in this bulletin are an average of those incurred in the operation of each of the packaging cost centers on the days that each plant was observed.

Though various operating costs determined in this study have been computed primarily from the financial and engineering data obtained at each of the plants, some use of supplementary cost data was made in order to more realistically represent current conditions in the milk industry and to assure comparability of data. The following standards were used in computing operating costs for each of the plants:

[3] Ratio delay and accounting data were used.

A. The original building cost per square foot was computed at the rate of $15 for all areas pertaining to the packaging cost center except those used for housing steam and refrigeration equipment, maintenance facilities, and dry storage. The rate for these areas was $10.

B. The life expectancy of all buildings was considered to be 30 years. No salvage value was considered on the buildings in the computation of building charges.

C. The building maintenance cost per year was computed at 1½ percent of the original building cost.

D. The costs of the various pieces of equipment were based on prices quoted by dairy equipment manufacturers. Installation charges for all equipment, except steam and refrigeration equipment and small items that didn't need to be installed, were 20 percent of the original equipment cost. For steam and refrigeration equipment, 50 percent of the original cost was added for installation charges.

E. The life expectancy of all equipment was based on suggestions of the Milk Industry Foundation and International Association of Ice Cream Manufacturers Committee regarding equipment depreciation schedules. No salvage value was considered on the equipment in computing equipment charges.

F. The equipment repair cost per year was computed at 4 percent of the original equipment cost, which included installation charges and cost of leased equipment.

G. The yearly interest rate used was 5 percent of the average investment.

H. The fringe benefits for labor were computed at 15 percent of the total labor cost.

DESCRIPTION OF THE TOTAL FLUID MILK OPERATIONS STUDIED

The criterion of plant size used was the average daily volume of milk and non-milk products packaged, expressed in terms of quart equivalents.[4] This volume did not include milk that may have been

[4] During the period that the plants were observed, a number of them packaged one or two non-milk products such as orange drink, fruit punch, etc. The packaging of these products was treated in this study in the same manner as the packaging of milk products since the same packaging facilities and operating procedures were used. For purposes of this study, the use of the term "fluid milk products" shall be understood to include these non-milk products.

packaged in some type of bulk container such as 5-gallon dispenser cans. The average daily volume of products packaged in each of the 12 plants is shown in Table 1.

On the basis of average daily volume, the plants ranged in size from 2,460 to about 35,600 quarts. For analytical purposes, the plants were placed in three groups on the basis of size, (Tables 1 & 2).

The amount of investment in buildings, land, equipment and supplies for the total fluid milk operations ranged from $88,700 to $731,-700. The amounts of these investments, however, did not increase in all cases in a successive manner with successive increases in average daily volume. This was because of variations in the percentage of plant capacity being used.

The relationships of the investments for the packaging cost centers with respect to plant size followed the same general pattern as the investments for the total fluid milk operations. Investments for the packaging cost centers ranged from $27,500 to $279,400. For each plant, this represented between approximately 30 and 40 percent of the investment for the total fluid milk operation.

The floor space used for the total operation in each plant ranged from 2,611 to 30,521 square feet. Floor space allocated to the packag-

TABLE 1—Daily volume and average daily volume of products packaged in the 12 plants studied

Relative plant size	Plant	Daily volume packaged				Average daily volume
		1	2	3	4	
		(quarts)	(quarts)	(quarts)	(quarts)	(quarts)
	A	2,545	1,224	3,361	2,710	2,460
	B	2,338	2,475	3,606	2,011	2,608
Small	C	4,078	4,790	4,660	4,792	4,580
	D	6,192	6,762	6,098	5,754	6,202
	E	.....	9,059	9,526	8,371	8,985(*a*)
	F	11,291	10,797	13,309	16,231	12,907
Medium	G	13,821	12,059	14,940	13,874	13,674
	H	20,205	19,716	13,905	18,673	18,125
	I	19,789	20,768	20,248	20,450	20,314
	J	26,592	20,341	26,216	26,257	24,852
Large	K	29,801	31,165	29,461	34,410	31,209
	L	26,871	35,612	41,790	38,113	35,597

(*a*) Three-day average.

TABLE 2—Total investment in buildings, land, equipment, and supplies, amount of floor space used, and average daily payroll expenses for the total fluid milk operations and the packaging cost centers in the 12 plants studied

Plant	Total investment			Floor space used			Payroll expenses		
	Total fluid milk operation (1)	Packaging cost center (2)	Percentage col. 2 is of col. 1 (3)	Total fluid milk operation (4)	Packaging cost center (5)	Percentage col. 5 is of col. 4 (6)	Total fluid milk operation (7)	Packaging cost center (8)	Percentage col. 8 is of col. 7 (9)
	(dollars)	(dollars)	(percent)	(sq. ft.)	(sq. ft.)	(percent)	(dollars)	(dollars)	(percent)
A	88,705	27,477	31.0	2,611	595	22.8	73	31	42.5
B	100,477	30,039	29.9	3,075	1,752	57.0	73	27	37.0
C	126,497	50,680	40.1	2,984	1,250	41.9	104	52	50.0
D	115,546	41,571	36.0	3,230	1,808	56.0	96	54	56.2
E	159,770	51,591	32.3	5,725	1,887	33.0	161	78	48.4
F	250,596	95,422	38.1	10,466	5,223	49.9	177	85	48.0
G	337,218	128,727	38.2	12,511	5,648	45.1	324	155	47.8
H	249,391	101,660	40.8	10,038	5,774	57.5	336	169	50.3
I	423,775	166,012	39.2	14,284	6,410	44.9	353	141	39.9
J	501,318	192,893	38.5	16,470	7,557	45.9	481	250	52.0
K	731,720	279,422	38.2	30,521	11,919	39.0	367	201	54.8
L	261,015	89,819	34.4	6,585	3,499	53.1	416	186	44.7

ing cost center in each plant ranged from 595 to 11,919 square feet. This represented approximately 23 to 58 percent of the building area used for the total fluid milk operation.

The average daily payroll expenses for the total fluid milk operations ranged from $73 to $481. For the packaging cost center, the range was from $27 to $250, or about 37 to 56 percent of the daily payroll expenses for the total fluid milk operations.

Further characteristics of the plants have been compiled in Table 3. This table indicates the number of days per week on which the plants processed and packaged fluid milk products and the basic methods used in the various operations of receiving, processing, packaging and storing milk and milk products.

DESCRIPTION OF THE PACKAGING COST CENTERS

The information presented in Table 3 indicates that of the 12 plants, seven used both glass and paper containers for packaging fluid milk products. In describing the various data pertaining to the packaging operation, it is beneficial to make a distinction between those data relating to the glass sections and those relating to the paper sections of the combined glass-paper operations. Thus, seven plants will be considered, for costing purposes, to have two separate packaging operations rather than one. The data presented in this bulletin will be shown and analyzed in a manner reflecting this idea.

TABLE 3—Selected miscellaneous information pertaining to the 12 plants studied

Plant	Days per week processing and packaging occurred	Type of receiving operation		Principle method of pasteurization		Type of container used for packaging		Principle method used for moving finished products to storage	
		Bulk	Can	Vat	HTST(a)	Glass	Paper	Dollies	Conveyor
A	4		X	X		X	X	X	
B	6		X		X	X		X	
C	6		X		X	X	X	X	
D	6		X	X		X	X	X	
E	5	X			X	X		X	
F	6	X			X	X	X	X	
G	7		X		X	X	X		X
H	5	X			X		X	X	
I	6	X			X	X			X
J	5	X			X	X	X		X
K	6	X	X		X	X	X		X
L	6	X	X		X		X		X

(a) High-temperature, short-time.

Daily Volume of Products Packaged

Table 4 shows the manner in which the average daily volume of products packaged by each plant was divided between glass and paper operations and the percent that each was of the total volume packaged. The percentage of product packaged in glass and in paper had no apparent relationship to the total volume handled by the plant. Instead, the manner in which the total output was divided between glass and paper was probably a result of management's attempt to adapt the operation of the plant to the characteristics of the market in which it operated.

TABLE 4—Average daily volume of products packaged in glass and in paper in the 12 plants

Plant	Average daily volume packaged				Average daily volume
	Glass		Paper		
	Quantity	Percentage of total	Quantity	Percentage of total	
	(quarts)	(percent)	(quarts)	(percent)	(quarts)
A	420	17.1	2,040	82.9	2,460
B	2,608	100.0	.....	....	2,608
C	2,889	63.1	1,691	36.9	4,580
D	4,519	72.9	1,683	27.1	6,202
E	8,985	100.0	.....	....	8,985
F	893	6.9	12,014	93.1	12,907
G	11,738	85.8	1,936	14.2	13,674
H	.....	....	18,125	100.0	18,125
I	20,314	100.0	.....	....	20,314
J	12,543	50.5	12,309	49.5	24,852
K	9,439	30.2	21,770	69.8	31,209
L	.....	....	35,597	100.0	35,597

The total investment in each packaging cost center and the allocation of this investment between those operations pertaining to glass and to paper in the applicable plants are shown in Table 5. It should be noted that plants A and K, though packaging the greater percentage of their volume of products in paper, had the greater percentage of their packaging cost center investment in the glass operation. This situation was contrary to that which prevailed in the other 10 plants.

TABLE 5—Total investment in buildings, land, equipment and supplies for the glass operations, the paper operations and the total packaging operations in the 12 plants

Plant	Investment				Total Investment
	Glass		Paper		
	Amount	Percentage of Total	Amount	Percentage of total	
	(dollars)	(percent)	(dollars)	(percent)	(dollars)
A	16,713	60.9	10,726	39.1	27,439
B	30,039	100.0	.....	....	.....
C	31,784	62.7	18,896	37.3	50,680
D	32,175	78.5	8,811	22.6	40,986
E	51,591	100.0	.....	....	51,591
F	35,369	37.1	60,053	62.9	95,422
G	95,023	73.8	33,704	26.2	128,727
H	.....	....	101,660	100.0	101,660
I	166,012	100.0	.....	....	166,012
J	137,461	71.3	55,422	28.7	192,883
K	161,400	57.8	118,022	42.2	279,422
L	.....	....	89,819	100.0	89,819

Total Floor Area Used

The total floor area included within each of the packaging cost centers and the allocation of this area between the glass and paper operations in the applicable plants is shown in Table 6. For all plants except plant A, there was a similar relationship between the manner in which the total volume packaged was divided between glass and paper and the manner in which the total floor area used in the packaging cost center was divided between the two types of operations.

Payroll Expenses

The average daily payroll expenses incurred by the packaging cost centers and the allocation of these expenses to the glass and paper packaging operations in the applicable plants are shown in Table 7. The percentage of these expenses allocated to the glass and to the paper operations in the applicable plants had a relatively close direct relationship to the volume of product packaged by the respective types of operations.

TABLE 6—Amount of floor area used for the glass operations, the paper operations and the total packaging operations in the 12 plants studied

Plant	Floor area used				Total floor area used
	Glass		Paper		
	Amount	Percentage of total	Amount	Percentage of total	
	(sq. ft.)	(percent)	(sq. ft.)	(percent)	(sq. ft.)
A	335	56.3	260	43.7	595
B	1,752	100.0	.....	....	1,752
C	960	76.8	290	23.2	1,250
D	1,060	58.6	748	41.4	1,808
E	1,887	100.0	.....	....	1,887
F	1,650	31.6	3,573	68.4	5,223
G	3,305	58.5	2,343	41.5	5,648
H	.....	....	5,774	100.0	5,774
I	6,410	100.0	.....	....	6,410
J	4,977	65.9	2,580	34.1	7,557
K	5,915	49.6	6,004	50.4	11,919
L	.....	....	3,499	100.0	3,499

TABLE 7—Average daily payroll expenses incurred by the glass operations, the paper operations and the total packaging operations in the 12 plants studied

Plant	Payroll expenses				Total payroll expenses
	Glass		Paper		
	Amount	Percentage of total	Amount	Percentage of total	
	(dollars)	(percent)	(dollars)	(percent)	(dollars)
A	9	29.0	22	71.0	31
B	27	100.0	...	....	27
C	33	63.5	19	36.5	52
D	33	61.1	21	38.9	54
E	78	100.0	...	....	78
F	16	18.8	69	81.2	85
G	119	76.8	36	23.2	155
H	...	....	169	100.0	169
I	141	100.0	...	....	141
J	158	63.2	92	36.8	250
K	99	49.2	102	50.8	201
L	...	....	186	100.0	186

Types of Packaging Equipment

The costs incurred by the packaging cost center are, in part, dependent upon the number and types of basic pieces of equipment used. This is true not only from the standpoint of the original equipment cost but also from the operational standpoint with respect to the speed of the flow of products which the equipment allows and with respect to the labor-saving potentialities. Table 8 shows the basic pieces of equipment found in the 12 plants that were used directly in packaging fluid milk products. The equipment in this table are the bottle washer, glass filler, paper filler and case washer. None of the plants studied used mechanical casers, case stackers or de-stackers.

Type and Quantity of Packages Used for Each Product

A detailed breakdown of the average number of units of each product packaged in glass and in paper and by size of container for each of the 12 plants is presented in Table 9. The data in this table represent an average of the number of units packaged on those days

TABLE 8—Basic pieces of equipment used by the packaging operations in the 12 plants studied

Item	Plant											
	A	B	C	D	E	F	G	H	I	J	K	L
Bottle washer												
4 wide	X											
6 wide		X	X	X	X	X					X	
8 wide							X					
10 wide											X	
12 wide									X	X		
Glass filler												
6 valve				X								
7 valve	X		X									
10 valve		X				X						
14 valve					X						X	
16 valve											X	
20 valve							X					
28 valve									X	X		
Paper filler												
Semi-automatic:												
(requires pre-formed cartons)												
Packages units of half-gallon size or smaller	X		X	X								
Packages units of quart size or smaller			X									
Automatic:												
Packages units of half-gallon size (27 units per minute)						X		X		X	X	X
Packages units of quart size or smaller (36 units per minute)								X			X	X
Packages units of quart size or smaller (20 units per minute)						X	X	X		X		
Case washer			X				X	X		X	X	X

by the 12 plants (a) (All columns in units)

Plant	Homogenized vitamin D milk					Homogenized multi-vitamin		Homogenized Guernsey milk		Regular Guernsey	Regular milk			Skim milk (plain)			
	Half-gallon	Quart	Pint	Third-quart	Half-pint	Half-gallon	Quart	Half-gallon	Quart	Quart	Half-gallon	Quart	Pint	Half-gallon	Quart	Pint	Half-pint
PRODUCTS PACKAGED IN GLASS																	
A	...	200	...	...	448	...	...	...	...	...	...	116	...	...	35	70	...
B	578	704	...	...	647	...	...	...	...	...	...	465	298	...	86	..	...
C	...	1,993	...	...	1,260	...	...	...	...	...	...	158	...	...	159	..	...
D(*b*)	908	812	...	...	1,732	...	...	81	...	78	...	678	...	...	...	..	...
E	...	5,564	...	...	2,208	...	...	...	...	...	...	2,046	...	...	371	..	...
F	...	360	...	...	604	...	...	...	...	...	...	312	...	...	...	..	...
G	1,289	3,236	86	...	1,537	...	1,713	...	...	...	...	1,707	...	...	455	..	...
I	576	5,707	277	549	4,014	...	...	2,181	672	441	...	3,309	...	...	850	..	...
J	1,380	4,839	...	394	7,567	...	...	...	...	...	...	2,447	175	...	1,201	..	125
K	1,343	2,643	...	...	1,450	443	705	...	...	...	99	1,050	...	...	540	..	...
PRODUCTS PACKAGED IN PAPER																	
A	963	153	...	...	...	...	...	...	...	...	...	...	...	...	...	..	...
C	727	297	...	...	88	...	...	...	...	...	...	...	...	...	...	..	...
D(*b*)	655	230	...	70	...	...	...	...	...	...	...	...	...	...	...	..	...
F	4,383	1,325	...	300	930	...	...	...	...	...	240	178	...	...	500	..	...
G	...	1,334	50	288	429	...	...	...	...	...	...	251	...	...	...	..	...
H	4,790	3,095	1,132	...	2,322	539	...	54	65	...	...	208	...	...	...	..	...
J	4,085	1,135	...	960	927	...	...	...	...	...	...	621	...	...	450	..	...
K	6,617	2,743	1,134	15	1,600	367	600	...	...	...	...	162	...	...	607	..	...
L	12,950	3,198	135	179	5,037	...	...	...	...	...	587	109	...	301	...	..	...

(*a*) The number of units listed for each product represents an average of only the number of days on which each particular type of unit was packaged rather than a straight 4-day average.
(*b*) Homogenized only.

TABLE 9—Continued (All columns in units)

Plant	Skim milk (fortified)			Chocolate milk				Enzylac	Eggnog	Buttermilk				Half and Half	
	Half-gallon	Quart	Half-pint	Quart	Pint	Third-quart	Half-pint	Quart	Quart	Quart	Pint	Third-quart	Half-pint	Quart	Pint
PRODUCTS PACKAGED IN GLASS															
A	...	...	...	13	...	...	116	...	...	...	...	...	...	...	47
B	...	182	...	150	...	...	987	...	...	144	...	...	...	72	110
C	...	...	...	240	...	...	748	...	...	61	...	...	...	...	193
D	...	348	...	173	...	...	1,180	...	...	99	...	...	...	...	258
E	...	...	...	216	...	...	1,262	...	...	272	...	...	...	...	102
F	...	...	...	359	...	...	560	...	...	...	..	...	...	...	...
G	...	485	...	362	74	...	899	...	...	274	...	...	...	417	413
I	...	711	287	413	251	...	2,159	...	...	665	...	...	256	526	481
J	...	...	...	...	...	211	2,940	...	...	197	...	65	210	...	...
K	...	...	...	...	...	...	528	...	...	...	...	...	...	...	...
PRODUCTS PACKAGED IN PAPER															
A	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
C	...	...	...	...	...	...	60	...	...	...	...	...	...	...	90
D	...	...	...	...	...	385	...	...	...	114	...	...	...	...	56
F	...	...	...	201	60	1,107	981	...	...	...	...	...	...	...	320
G	...	...	...	75	...	263	707	...	...	49	...	108	...	...	...
H	164	621	...	177	788	...	1,764	...	378	731	336	...	...	...	803
J	...	...	...	213	...	566	920	...	...	650	...	...	...	761	946
K	...	...	...	549	741	30	1,085	78	52	1,619	182	...	...	119	1,370
L	441	27	...	308	35	260	2,321	116	1,168	595	...	240	...	...	579

Plant	Coffee cream			Whipping cream			Orange drink				Grapefruit drink		Fruit punch		Cider
	Quart	Pint	Half-pint	Quart	Pint	Half-pint	Quart	Pint	Third-quart	Half-pint	Quart	Pint	Half-gallon	Half-pint	Half-pint
PRODUCTS PACKAGED IN GLASS															
A	4	17	30	..	12	34	...	...	...	...	...	...	...	...	...
B	8	...	69	..	..	64	100	...	...	240	...	...	42	600	...
C	18	...	...	..	70	...	...	...	...	...	...	...	...	...	...
D	47	...	184	..	..	150	...	...	...	...	...	...	...	...	...
E	57	...	343	7	..	...	...	...	...	...	...	...	...	...	424
F	...	...	...	..	..	...	...	...	...	...	...	...	...	...	...
G	84	105	543	13	..	176	268	...	...	...	...	...	...	...	...
I	265	...	670	..	..	298	...	...	...	...	...	...	...	...	...
J	54	...	209	..	..	...	...	...	...	...	...	...	...	...	...
K	96	...	410	24	..	...	504	...	...	400	...	...	...	...	...
PRODUCTS PACKAGED IN PAPER															
A	...	...	...	..	..	...	...	...	...	...	...	...	...	...	...
C	...	...	153	..	..	238	...	...	...	...	...	...	...	...	...
D	...	...	...	..	..	...	...	...	...	...	...	...	...	...	...
F	75	20	100	8	..	100	60	...	...	...	...	...	...	...	...
G	...	...	...	..	..	...	...	...	...	...	...	...	...	...	...
H	35	...	109	6	..	130	...	518	...	447	142	345	...	...	...
J	...	...	154	..	..	147	...	...	244	...	...	...	...	...	...
K	...	...	150	..	..	280	...	...	...	...	...	...	...	...	...
L	...	...	387	16	..	326	...	...	339	588	...	...	...	...	...

(of the 4 days the plants were observed) that the packaging of each particular type of unit occurred. Only in some cases can these figures be considered a 4-day average since some products were packaged on only one, two or three of the 4 days the plants were observed.

During the 4 days that they were under observation, the plants packaged a total of 18 different products. The number of fluid milk and non-milk products packaged in each of the plants ranged from seven in the smallest plant to 13 in two of the larger plants. The number of products that a plant packaged did not appear to be necessarily related to its total volume. Eight of the plants packaged at least one non-milk product during the period that the plants were observed.

On the basis of the number of plants packaging each of the various products, it is evident that only eight of these products were of major importance to all of the plants taken as a whole. Homogenized Vitamin D milk was the primary product packaged with chocolate milk ranking second in importance. Of somewhat lesser importance were regular milk, plain skim milk, buttermilk, half and half, coffee cream and whipping cream. Each of the remaining products was packaged by only a few of the plants. In the case of one non-milk product, the plant that packaged this item did so on a one-time basis only, the event occurring on one of the days that the plant was observed.

TOTAL DAILY COSTS INCURRED BY THE PACKAGING COST CENTERS

The average daily packaging costs incurred by each of the plants are presented in Table 10. The costs of the various items associated with the packaging cost center have been grouped under several categories. Of these, four are considered as fixed costs and four as variable costs.[5]

[5] Building charges represent those costs pertaining to depreciation, maintenance and rental costs of buildings. Equipment charges are those costs pertaining to depreciation and repairs of equipment and includes the cost of leasing equipment and the minimum production rental that must be paid by those plants using the large, automatic paper packaging machines. Taxes include the amounts assessed on land, buildings, and equipment, while the insurance costs are those incurred in insuring buildings and equipment. Interest charges reflect the charge that must be made against the capital invested in land, buildings, equipment and inventories of packaging materials and supplies.

Payroll expenses include the wages, salaries and fringe benefits paid to the plant workers, supervisors and clerical and administrative personnel. Packaging materials includes all items used for container purposes such as bottles, paper cartons, cases and associated items pertaining thereto. This cost item also includes that portion of the total production rental for the large, automatic paper packaging machines that is considered to be a variable cost, this amount being that which is in excess of the minimum production rental. Utilities include such items as steam, refrigeration, electricity, heat and water. Miscellaneous expenses are those items such as alkali for bottle washers and cleaning compounds necessary for normal plant operation.

TABLE 10—Average daily packaging costs by cost items for glass, paper and total operations for the 12 plants (All columns in dollars)

Cost item	Plant												
	A			B	C			D			E	F	
	Glass	Paper	Total	All-glass	Glass	Paper	Total	Glass	Paper	Total	All-glass	Glass	Paper	Total
Building charges.....	1.14	0.80	1.94	4.03	2.17	0.58	2.75	2.31	1.04	3.35	5.03	2.84	6.24	9.08
Equipment charges...	7.84	4.09	11.93	7.80	8.68	6.28	14.96	6.68	2.58	9.26	11.29	7.06	47.08	54.14
Taxes and insurance..	0.83	0.48	1.31	1.22	0.83	0.47	1.30	0.66	0.18	0.84	2.19	2.91	6.20	9.07
Interest charges.....	2.07	1.47	3.54	2.55	2.67	1.63	4.30	2.70	0.86	3.56	5.30	2.90	5.37	8.27
Total fixed cost.....	11.88	6.84	18.72	15.61	14.35	8.96	23.31	12.35	4.66	17.01	23.81	15.71	64.89	80.56
Payroll expenses.....	9.21	22.24	31.45	27.18	32.91	18.69	51.60	33.02	20.52	53.54	77.78	15.73	68.83	84.56
Packaging materials..	5.58	40.06	45.64	19.35	23.44	41.07	64.51	40.49	42.86	83.35	64.76	9.41	197.40	206.81
Utilities.....	1.03	1.78	2.81	1.98	2.84	0.62	3.46	3.47	0.44	3.91	6.69	2.23	7.48	9.71
Misc. expenses.....	0.22	0.49	0.71	1.23	1.41	0.40	1.81	1.81	0.39	2.20	3.73	0.44	2.34	2.78
Total variable cost....	16.04	64.57	80.61	49.74	60.60	60.78	121.38	78.79	64.21	143.00	152.96	27.81	276.05	303.86
Total cost—glass.....	27.92	.....	.....	65.34	74.95	.....	.....	91.14	.....	.....	176.77	43.52	.....	.....
Total cost—paper....	.....	71.41	.....	.....	.....	69.74	.....	.....	68.87	.....	.....	.....	340.94	.....
Total cost.....	.....	.....	99.33	65.34	.....	.....	144.69	.....	.....	160.01	176.77	.....	.....	384.46

TABLE 10—Continued (All columns in dollars)

Cost item	Plant											
	G			H	I	J			K			L
	Glass	Paper	Total	All-paper	All-glass	Glass	Paper	Total	Glass	Paper	Total	All-paper
Building charges.....	5.68	3.50	9.18	12.67	14.04	11.92	5.96	17.88	12.91	13.09	26.00	7.00
Equipment charges.....	18.24	13.37	31.61	81.85	31.16	39.43	60.84	100.27	34.53	60.74	95.27	63.10
Taxes and insurance.....	9.23	3.55	12.78	9.16	10.18	7.36	4.48	11.84	9.13	7.20	16.33	6.19
Interest charges.....	6.81	2.49	9.30	10.90	13.88	13.81	6.02	19.83	13.19	10.36	23.55	8.65
Total fixed cost.....	39.96	22.91	62.87	114.58	69.26	72.52	77.30	149.82	69.76	91.39	161.15	84.94
Payroll expenses.....	118.49	36.06	154.55	169.87	141.39	158.12	92.13	250.25	99.02	102.14	201.16	186.41
Packaging materials.....	81.22	41.29	122.51	304.44	132.95	114.15	202.33	316.48	58.16	336.15	394.31	565.82
Utilities.....	7.57	2.52	10.09	10.23	15.17	12.63	5.73	18.36	8.75	9.51	18.26	24.98
Miscellaneous expenses...	4.53	0.38	4.91	3.50	6.80	5.33	1.97	7.30	3.28	3.50	6.78	5.67
Total variable cost.....	211.81	80.25	292.06	488.04	296.31	290.23	302.16	592.39	169.21	451.30	620.51	782.88
Total cost—glass.....	251.77	.....	.....	.....	365.57	362.75	.....	.....	238.97	.....	.....	.....
Total cost—paper.....	.....	103.16	.....	602.62	.....	.....	379.46	.....	.....	542.69	.....	867.82
Total cost.....	.....	.....	354.93	602.62	365.57	.....	.....	742.21	.....	.....	781.66	867.82

The data in Table 11 show the proportions of the total daily packaging costs that are considered as fixed costs and as variable costs for paper and glass operations.

TABLE 11—Average percentage that each cost item is of the total average daily packaging costs for all plants, for all glass operations and for all paper operations in the 12 plants studied

Cost item	Average percentage		
	For all plants	For all glass operations	For all paper operations
	(percent)	(percent)	(percent)
Fixed costs:			
Building charges	2.7	4.0	1.7
Equipment charges	10.4	12.3	10.4
Taxes and insurance	1.7	2.7	1.3
Interest charges	2.7	4.3	1.8
Total	17.5	23.3	15.2
Variable costs:			
Payroll expenses	33.3	40.6	26.2
Packaging materials	45.2	30.8	56.2
Utilities	2.8	3.7	1.8
Miscellaneous expenses	1.2	1.6	0.6
Total	82.5	76.7	84.8
Total cost	100.0	100.0	100.0

UNIT COSTS INCURRED BY THE PACKAGING COST CENTERS

The determination on a unit basis of the various costs incurred by each of the packaging cost centers aids in measuring the state of technological efficiency prevailing in the plants. The term technological efficiency is used in this study to mean that condition where a given output is produced from the least possible amount of resources. The given output is represented by a unit of product by a plant, and the resources are represented by the itemized costs necessary to produce this unit of product. As the unit costs become lower, the state of technological efficiency becomes higher. On this basis, if the total packaging cost per unit of product is computed for all plants concerned, it can be determined which packaging opera-

tion has the highest state of technological efficiency. To go further, by investigating those cost items which tend to result in higher unit costs for one plant than for another, ways may be suggested for increasing the efficiency of packaging operations in the plant with higher costs by changing production methods.

Average Unit Costs Per Quart Equivalent of Product Packaged

Table 12 shows the average fixed, variable and total packaging costs per quart equivalent of product packaged for the glass, paper and total packaging operations in the 12 plants. The data in this table were computed by dividing the average daily packaging costs for the respective operations by the applicable average daily volume, expressed in quarts, packaged in each plant. In these computations, the average daily volume that was converted to a quart equivalent basis included the total amount of product packaged (excluding bulk milk) irrespective of the size of container in which the product was packaged. The unit costs thereby computed can be used to show the relative efficiency of each operation.

TABLE 12—Average fixed, variable and total packaging costs per quart equivalent of product packaged by glass, paper and total operations for the 12 plants(a) (All columns in cents)

Plant	Average cost per quart equivalent								
	Fixed cost			Variable cost			Total cost		
	Glass	Paper	Weighted average	Glass	Paper	Weighted average	Glass	Paper	Total
A	2.83	0.34	0.76	3.82	3.16	3.28	6.65	3.50	4.04
B	0.60	....	0.60	1.91	....	1.91	2.51	....	2.51
C	0.50	0.53	0.51	2.10	3.59	2.65	2.60	4.12	3.16
D	0.27	0.28	0.28	1.74	3.81	2.30	2.01	4.09	2.58
E	0.26	....	0.26	1.70	....	1.70	1.96	....	1.96
F	1.76	0.54	0.62	3.11	2.30	2.35	4.87	2.84	2.97
G	0.34	1.18	0.46	1.80	4.15	2.14	2.14	5.33	2.60
H	....	0.63	0.63	....	2.69	2.69	....	3.32	3.32
I	0.34	....	0.34	1.46	....	1.46	1.80	....	1.80
J	0.58	0.63	0.60	2.31	2.45	2.38	2.89	3.08	2.98
K	0.74	0.42	0.52	1.79	2.07	1.99	2.53	2.49	2.51
L	....	0.24	0.24	....	2.20	2.20	....	2.43	2.44

(a) The *total* fixed or variable cost per quart is a weighted average of the fixed or variable costs of glass and paper packages for each plant that has a combined operation.

For the total packaging operations in the plants studied, the total unit packaging cost per quart ranged from 1.80 cents to 4.04 cents. The total fixed cost per quart ranged from 0.24 cents to 0.76 cents while the total variable cost per quart ranged from 1.46 cents to 3.28 cents. The plants, when listed in the order of increasing total unit packaging costs per quart, fall in the following order: I, E, L, K, B, D, G, F, J, C, H, and A. Thus, plant I had the most efficient packaging operation while plant A had the least efficient. With the relative efficiency of the packaging operations determined, some of the more notable differences between these operations can be shown as based on the unit costs.

The relationship between the volume in quarts equivalent packaged by the 10 glass operations and the packaging cost per unit is shown in Fig. 1. Plant A with 420 quarts packaged in glass had the

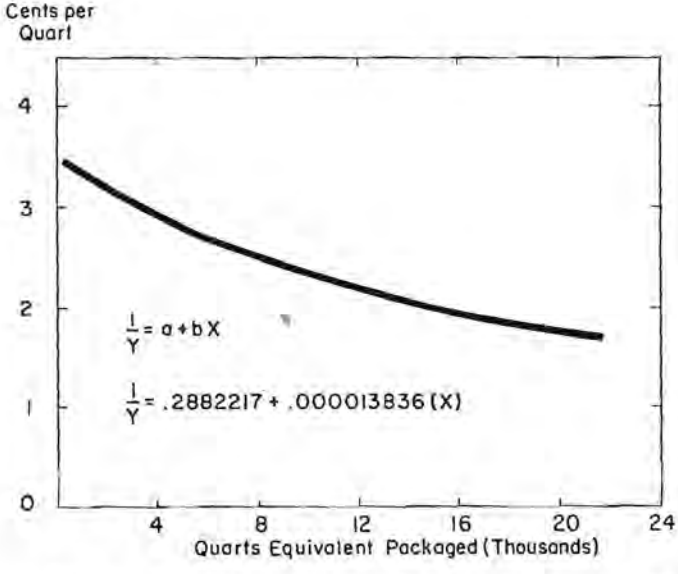


Fig. 1. Total cost-volume relationship in packaging milk in glass, quart equivalent, in 10 plants.

highest cost of 6.65 cents per quart equivalent. With 20,314 quarts packaged by plant I, the cost decreased to the lowest of the 10 plants with a cost of 1.80 cents. Similar results occurred in the plants with paper operations as shown in Fig. 2. Although the range between plant G, with a cost of 5.33 cents, and plant L, with a cost per quart

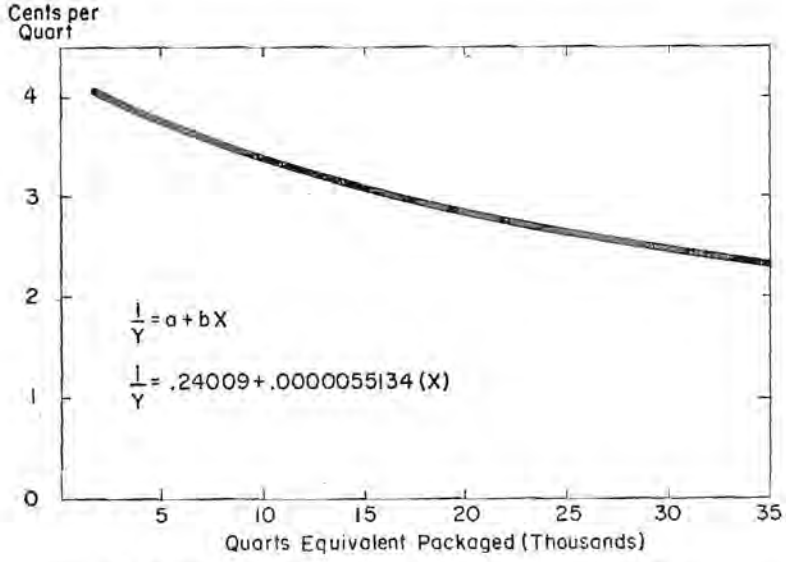


Fig. 2. Total cost-volume relationship in packaging milk in paper, per quart equivalent, in nine plants.

equivalent of 2.43 cents, is less than existed in the glass operations, there was a gradual decrease in cost with an increase in total volume. Plants A, C and D used preformed cartons. Plant G, with a relatively small volume in paper, employed an automatic machine which increased the unit cost.

Differences Between Packaging Operations Based On Costs Per Quart

Of the five plants having the lowest unit packaging costs, four used only one type of container. This would seem to indicate that combined glass-paper operations had a cost disadvantage.

Of significance is the fact that plant K, a combined glass-paper operation, had a lower unit packaging cost for its total operation than did plants B and H, each of which used only one type of container. Plant K had a larger volume than either plant B or plant H. This suggests that plants with combined glass-paper operations may still be able to compete cost-wise with smaller plants using only one type of container provided the volume of production is large enough. This makes greater flexibility for such plants as K because more sales outlets can be exploited.

Plants I, E and B, each having an all-glass operation and being among the five plants having the lowest unit packaging costs, were not the plants handling the largest volume of product. Having volumes smaller than the other plants studied apparently was not a handicap to these all-glass operations since they had unit costs lower than several of the larger plants.

Past studies have indicated that as plants become larger in size the average total unit costs decrease due to economies of scale. Although three of the four plants having the lowest packaging costs per quart were in the group of large-sized plants studied, evidence bearing on this question is not conclusive. This may be due, however, to the fact that some of the plants were not operating at their practical capacity or with a high degree of efficiency.

When the glass and paper operations are considered separately, much stronger support for such economies is found to exist. Of the 12 plants, plants B, E and I had all-glass operations and plants H and L had all-paper operations. Statistical analyses of these all-glass and all-paper operations indicate that as the volume of product packaged increased the average cost per quart packaged decreased.[6] The same trend was found to exist, though to a slightly lesser degree, for all of the glass operations and all of the paper operations in plants A, C, D, F, G, J and K which had combined glass-paper operations.

Average Unit Costs for Individual Products Packaged

One method of determining the relative efficiency of the packaging operations in the 12 plants was to determine the average total packaging cost per quart equivalent of product packaged. A second method used in this study is shown in Table 13. This table shows the average total unit packaging cost for each of the products packaged in each plant. The data have been broken down in a manner which shows the unit costs for those products packaged in glass and in paper and in each size of container used.

A cost-volume relationship for six plants packaging homogenized milk in glass half gallons is shown graphically in Fig. 3. The highest cost, 3.77 cents, occurred in one of the larger plants, plant K. Plants D and I, with a considerable difference in volume, nevertheless had the same cost of 2.30 cents. This is the result of combining, on a weighted average basis, the unit cost for homogenized vitamin D

[6] See Blanchard, W. H. (1960). A cost and efficiency analysis of packaging operations in selected fluid milk plants. Unpublished thesis, Mich. State Univ.

TABLE 13—Average total unit packaging cost for each product packaged in glass and in paper in various sizes of containers by the 12 plants studied (All columns in cents)

Plant	Homogenized vitamin D milk					Homogenized multi-vitamin		Homogenized Guernsey milk		Regular Guernsey	Regular milk			Skim milk (plain)			
	Half-gallon	Quart	Pint	Third-quart	Half-pint	Half-gallon	Quart	Half-gallon	Quart	Quart	Half-gallon	Quart	Pint	Half-gallon	Quart	Pint	Half-pint
PRODUCTS PACKAGED IN GLASS																	
A	....	3.11	....	....	2.71	....	....	....	....	....	....	2.84	....	....	8.98	3.96	....
B	3.26	1.59	....	....	1.49	....	....	....	....	....	....	2.02	1.76	....	5.00	....	....
C	....	1.99	....	....	1.27	....	....	....	....	....	....	2.82	....	....	2.25	....	....
D(*a*	2.20	1.44	....	....	1.37	....	....	3.41	....	2.15	....	1.90	....	....	....	....	....
E	....	1.48	....	....	1.62	....	....	....	....	....	....	1.60	....	....	1.74	....	....
F	....	3.48	....	....	2.59	....	....	....	....	....	....	2.88	....	....	....	....	....
G	2.82	1.70	5.14	....	1.81	....	1.72	....	....	....	....	1.67	....	....	2.17	....	....
I	2.82	1.27	2.82	1.49	1.31	....	....	2.16	1.75	1.91	....	1.37	....	....	1.54	....	....
J	3.00	1.76	....	2.85	1.56	....	....	....	....	....	....	1.90	3.78	....	2.28	....	3.34
K	3.77	2.12	....	....	1.50	3.69	1.91	....	....	....	4.64	2.33	....	....	2.82	....	....
Weighted Average per unit	3.02	1.66	3.37	2.06	1.55	3.69	1.78	2.20	1.75	1.95	4.64	1.77	2.51	....	2.24	3.96	3.34

(*a*) Homogenized only.

TABLE 13—Continued (All columns in cents)

Plant	Homogenized vitamin D milk					Homogenized multi-vitamin		Homogenized Guernsey milk		Regular Guernsey	Regular milk			Skim milk (plain)			
	Half-gallon	Quart	Pint	Third-quart	Half-pint	Half-gallon	Quart	Half-gallon	Quart	Quart	Half-gallon	Quart	Pint	Half-gallon	Quart	Pint	Half-pint
PRODUCTS PACKAGED IN PAPER																	
A	6.96	5.42	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
C	7.07	4.95	....	....	3.97	....	....	....	....	....	....	....	....	....	....	....	....
D(*a*)	6.72	4.67	....	5.90	....	....	....	....	....	....	....	....	....	....	....	....	....
F	4.40	2.94	....	2.42	2.31	....	....	....	....	....	4.93	3.61	....	....	3.19	....	....
G	....	3.98	3.59	2.87	2.86	....	....	....	....	....	....	4.00	....	....	....	....	....
H	4.80	2.80	4.77	....	2.31	5.40	....	9.22	3.73	....	....	4.14	....	....	....	....	....
J	4.59	2.87	....	2.54	2.53	....	....	....	....	....	....	3.12	....	....	3.31	....	....
K	4.14	2.44	2.03	15.25	1.78	4.31	2.44	....	....	....	....	2.60	....	....	2.89	....	....
L	3.84	2.75	3.53	3.60	1.70	....	....	....	....	....	4.28	3.38	....	4.71	....	....	....
Weighted average per unit	4.40	2.96	3.41	2.91	2.02	4.90	2.44	9.22	3.73	....	4.47	3.42	....	4.71	3.11	....	....

(*a*) Homogenized only.

TABLE 13—Continued (All columns in cents)

Plant	Skim milk (fortified)			Chocolate milk				Enzylac	Eggnog	Buttermilk				Half and half	
	Half-gallon	Quart	Half-pint	Quart	Pint	Third-quart	Half-pint	Quart	Quart	Quart	Pint	Third-quart	Half-pint	Quart	Pint
PRODUCTS PACKAGED IN GLASS															
A	....	....	....	15.71	....	....	3.56	....	....	....	....	....	....	....	7.09
B	....	2.65	....	3.12	....	....	1.43	....	....	2.59	....	....	....	2.51	2.73
C	....	....	....	2.23	....	....	1.30	....	....	5.94	....	....	....	....	2.48
D	....	1.46	....	2.84	....	....	1.35	....	....	4.35	....	....	....	....	2.11
E	....	....	....	1.86	....	....	1.65	....	....	3.25	....	....	....	....	4.55
F	....	....	....	....	....	....	2.36	....	....	....	....	....	....	....	....
G	....	2.32	....	2.97	4.32	....	2.22	....	....	5.41	....	....	....	2.20	2.00
I	....	1.58	2.39	2.39	2.34	....	1.46	....	....	1.58	....	....	1.69	2.02	1.68
J	....	....	....	3.32	....	2.50	1.70	....	....	4.22	....	4.80	2.29	....	....
K	....	....	....	....	....	....	3.53	....	....	....	....	....	....	....	....
Weighted average per unit	....	1.88	2.39	2.81	2.76	2.50	1.75	....	....	3.16	....	4.80	1.96	2.13	2.34
PRODUCTS PACKAGED IN PAPER															
A	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
C	....	....	....	....	....	....	3.17	....	....	....	....	....	....	....	4.30
D	....	....	....	....	....	3.99	....	....	....	5.70	....	....	....	....	6.14
F	....	....	....	3.26	3.54	2.73	3.74	....	....	....	....	....	....	....	2.62
G	....	....	....	5.24	....	2.90	2.62	....	....	6.14	....	2.82	....	....	....
H	6.27	3.09	....	4.21	2.63	....	2.44	....	4.86	4.19	2.58	....	....	....	2.57
J	....	....	....	3.59	....	2.86	2.54	....	....	3.12	....	....	....	3.09	2.51
K	....	....	....	2.91	2.06	4.75	2.53	4.97	11.13	2.92	3.24	....	....	3.54	2.03
L	4.30	7.54	....	2.84	4.31	2.67	1.68	6.37	3.03	2.94	....	2.20	....	....	2.33
Weighted average per unit	4.83	3.28	....	3.18	2.44	2.98	2.42	5.81	3.73	3.33	2.81	2.39	....	3.15	2.40

TABLE 13—Concluded (All columns in cents)

Plant	Coffee cream			Whipping cream			Orange drink				Grapefruit drink		Fruit punch		Cider
	Quart	Pint	Half-pint	Quart	Pint	Half-pint	Quart	Pint	Third-quart	Half-pint	Quart	Pint	Half-gallon	Half-pint	Half-pint
PRODUCTS PACKAGED IN GLASS															
A	38.85	6.31	3.97	....	13.48	5.80	....	....	....	....	....	....	....	....	....
B	19.11	....	3.47	....	....	5.55	2.21	....	....	1.56	....	....	5.81	1.72	....
C	12.16	....	....	....	11.74	....	....	....	....	....	....	....	....	....	....
D	4.01	....	1.68	....	....	2.01	....	....	....	....	....	....	....	....	....
E	7.10	....	1.96	31.49	....	....	....	....	....	....	....	....	....	....	2.60
F	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
G	4.15	2.43	1.79	36.56	....	3.76	2.19	....	....	....	....	....	....	....	....
I	2.56	....	1.93	....	....	2.09	....	....	....	....	....	....	....	....	....
J	8.98	....	2.74	20.90	....	....	....	....	....	....	....	....	....	....	....
K	....	....	....	....	....	....	1.92	....	....	1.36	....	....	....	....	....
Weighted average per unit	4.80	2.97	2.16	27.20	12.00	2.96	2.04	....	....	1.43	....	....	5.81	1.72	2.60
PRODUCTS PACKAGED IN PAPER															
A	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
C	....	....	3.77	....	....	3.76	....	....	....	....	....	....	....	....	....
D	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
F	4.12	5.05	2.93	8.61	....	2.16	3.53	....	....	....	....	....	....	....	....
G	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
H	6.26	....	5.18	44.54	....	3.93	....	3.11	....	3.46	4.23	3.16	....	....	....
J	....	....	2.61	....	....	3.33	....	....	4.38	....	....	....	....	....	....
K	....	....	3.21	....	....	4.39	....	....	....	....	....	....	....	....	....
L	....	....	2.01	3.02	....	2.28	....	....	2.11	2.04	....	....	....	....	....
Weighted average per unit	4.80	5.05	2.94	12.80	....	3.32	3.53	3.11	3.06	2.65	4.23	3.16	....	....	....

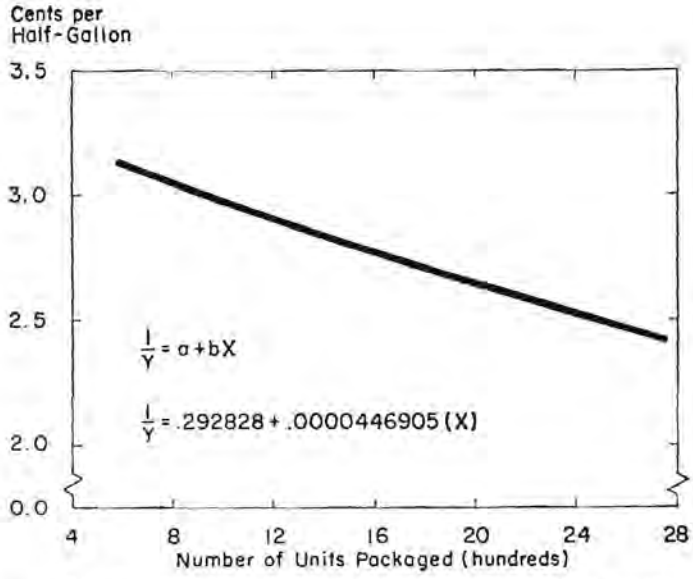


Fig. 3. Total cost-volume relationship in packaging homogenized milk in glass half-gallons in six plants.

milk and homogenized Guernsey milk in both plant D and plant I. A range from 2.30 to 3.77 cents existed between the six plants. When considering the cost-volume relationship of packaging homogenized milk in paper half-gallons in eight plants, the range in cost was from 3.84 to 7.07 cents as shown in Fig. 4. The effect of volume on the unit cost appeared to be quite pronounced in the paper operations.

Differences as Based on Unit Packaging Costs

Previous discussion has indicated that some plants were more efficient than others due to the larger volume of output which they packaged. Data in Table 13 tend to further bear this out. A statistical analysis to determine the cost-volume relationships for eight principal products packaged by these plants was made on the basis of the average total unit packaging costs for these products. The products considered were homogenized Vitamin D milk, chocolate milk, regular milk, plain skim milk, buttermilk, half and half, coffee cream and whipping cream. Statistical computations were made for these products for each type and size of container that was used in practically all cases by at least one-half of the plants studied. Of 24 combinations involving product, container type and size, tests on nine of them

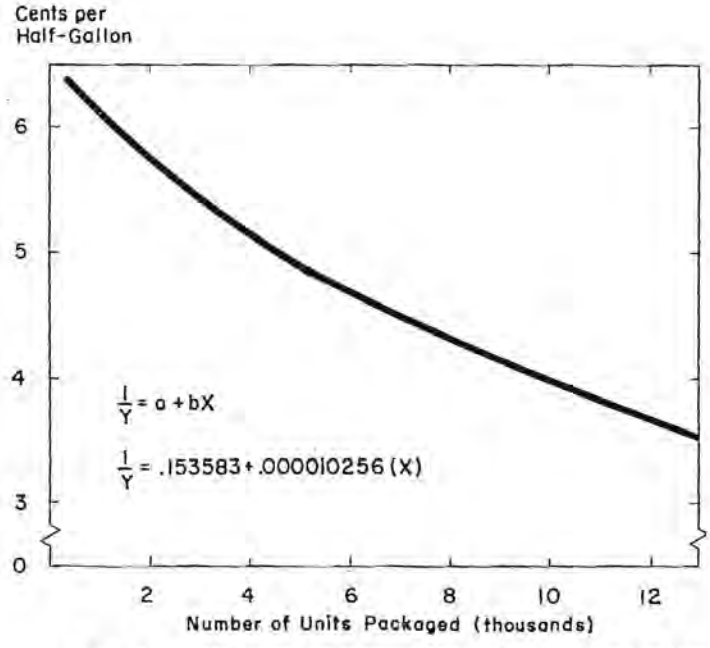


Fig. 4. Total cost-volume relationship in packaging homogenized milk in paper half-gallons in eight plants.

indicated rather significantly that as volume increased unit costs generally decreased. Similarly, tests on six additional combinations indicated this same relationship between volume and unit costs but to a somewhat lesser degree.[7]

Table 14 shows the weighted average of the total unit costs for each product-container size combination packaged in glass and in paper. Of all the combinations for which comparisons could be made between glass and paper, the weighted unit costs were less for those products packaged in glass than for those packaged in paper, with the exception of four combinations.

Using the weighted average unit costs for homogenized Vitamin D milk packaged in glass and in paper in all of the container sizes used (see Table 14), a conversion was made of unit costs from that pertaining to their respective size of container to that of a quart equivalent basis. That is, the unit cost for half-gallons was halved, for pints was doubled, for 10-ounce was tripled, etc. This procedure shows the cost of packaging a given volume (1 quart) of product in the various sizes of containers.

[7] Op. cit., see footnote 6 page 25.

TABLE 14—Total unit packaging costs incurred (weighted average of all plants studied) for selected container sizes and for quart equivalent in packaging homogenized vitamin D milk

Unit	Glass		Paper	
	Weighted average	Quart equivalent	Weighted average	Quart equivalent
	(cents)	(cents)	(cents)	(cents)
Half-gallon	3.02	1.51	4.40	2.20
Quart	1.75	1.75	2.96	2.96
Pint	3.37	6.74	3.41	6.82
Third-quart	2.06	6.18	2.91	8.73
Half-pint	1.55	6.20	2.02	8.08

The unit costs for glass pints, 10-ounce and half-pints were over four times as great as the unit costs for half-gallons. For paper, the unit costs for these container sizes were from 3 to 4 times as great as the unit costs for half-gallons. The quart equivalent cost difference between glass and paper for half-gallons was 0.69 cents, for quarts was 1.21 cents and for half-pints was 1.88 cents. These differences show that the smaller the container being considered, the greater was the cost spread between glass and paper.

OTHER FACTORS AFFECTING EFFICIENCY OF PACKAGING OPERATIONS

Previous discussion has indicated that two factors greatly affected the technological efficiency of packaging operations. These were the volume of output packaged and the type of container used.

There were other factors, however, that played a rather dominant role in this respect. These will now be examined.

Equipment Charges

One of these items was equipment charges, the least significant, percentagewise, of the three items.

In this study, equipment charges, a fixed cost item, included depreciation on the equipment only for packaging and on the proportionate share of the equipment used for steam, refrigeration, heating and general plant operation required for the packaging operation.

Also included were equipment repairs, rent for leased equipment, and minimum production rentals on the large, automatic paper fillers.

If a plant is going to package fluid milk products at all, it is necessary for it to have at least a certain minimum amount of equipment. Also, once equipment has been purchased, it is often quite some time before it is replaced. Equipment is not easily changed to coincide with changes in volume or to take advantage of new technology. Consequently, equipment is a costly, relatively long-time investment for a plant.

The primary opportunity for reducing equipment costs per unit of product packaged in the plants studied appeared to be in increasing the volume of product which the equipment handled. With equipment being a fixed cost item, the volume which the equipment handled had a very marked effect on the equipment cost per unit of product. The significance of this is indicated in Table 15 which shows the average daily volume of products packaged by each filler. Also shown are the daily equipment charges and the cost per quart equivalent of each filler and associated major pieces of packaging equipment in the 12 plants studied.

The data show that for those pieces of equipment which handled a relatively low daily volume of milk, the unit costs were relatively high as compared with the equipment that handled a higher volume of milk. This was particularly evident, for example, for the large automatic half-gallon size paper fillers in plants H, J and K. The daily equipment costs were about the same but the unit costs varied due to the different volumes being handled.

The volume handled by each filler was related to whether the plant had a combined glass-paper operation, rather than an all-glass or an all-paper operation, and whether more than one filler was being used to package products in the same type of package.

Five of the 12 plants studied had either an all-glass or an all-paper operation, thereby allowing them to have fewer fillers than plants having combined glass-paper operations. The three all-glass plants had only one filler each, certainly a contributing factor to plants I and E having the lowest average total unit packaging costs of all 12 plants. The two all-paper operations, on the other hand, had more than one filler per plant. Plant L had two fillers and plant H had three.

Six of the nine plants packaging products in paper had at least two fillers each. In contrast to the paper packaging operations, each

TABLE 15—Average daily volume of products packaged by each filer and the daily cost and the cost per quart of each filler and associated major pieces of packaging equipment in the 12 plants

Plant	Glass			Paper					
	Equipment for packaging units of all sizes			Equipment for packaging quarts or smaller units			Equipment for packaging half-gallons or smaller units		
	Volume packaged	Equipment cost	Equipment cost per quart	Volume packaged	Equipment cost	Equipment cost per quart	Volume packaged	Equipment cost	Equipment cost per quart
	(quarts)	(dollars)	(cents)	(quarts)	(dollars)	(cents)	(quarts)	(dollars)	(cents)
A	420	5.27	1.26	...	....	....	2,040	2.52	0.12
B	2,608	4.91	0.19	...	....	....	.....	.....	....
C	2,889	4.22	0.15	238	2.55	1.07	1,453	1.68	0.12
D	4,519	3.95	0.09	...	....	....	1,683	1.68	0.10
E	8,985	6.60	0.07	...	....	....	.....	.....	....
F	893	4.24	0.48	3,008	12.27	0.41	9,006	20.26	0.22
G	11,738	9.26	0.08	1,936	8.49	0.44	.....	.....	....
H (No. 1)	.....	....	....	7,246	18.99	0.26	10,850	26.65	0.25
H (No. 2)(*a*)	.....	....	....	118	8.17	6.92	.....	.....	....
I	20,314	13.32	0.07	...	....	....	.....	.....	....
J	12,543	17.03	0.14	4,140	15.58	0.38	8,169	26.64	0.38
K (No. 1)	4,794	9.82	0.20	7,802	19.28	0.25	13,968	26.03	0.19
K (No. 2)(*b*)	4,845	8.29	0.18	.....	.....	....	.....	.....	....
L	.....	....	....	7,039	22.56	0.32	28,558	33.62	0.12

(*a*) This filler was used on only one day of the four days that the plant was observed. Due to a major equipment breakdown, the data for this filler are not representative of normal operations.

(*b*) Plant K had two glass lines—quart and half-gallon.

plant except one that packaged products in glass had only one filler, the exception being plant K which had two.

Packaging Materials

The second major cost item was packaging materials. These were important cost items in that for the paper operations it was a larger percentage of the total packaging cost than any other cost item and for the glass operations it ranked second. For the paper operations, the daily cost of packaging materials ranged from 40.0 to 65.2 percent of the total daily packaging costs. For the glass operations, the range was from 20.0 percent to 44.4 percent.

Some of the plants were having difficulty reducing to any substantial degree the total daily cost of packaging materials. An increase in the volume of product packaged may have a small effect in this respect. Larger volumes of containers can usually be purchased at varying discounts, particularly in the case of paper. Only plant L could take advantage of volume discounts to any appreciable extent.

One advantage of glass operations over paper operations is that the same glass bottles can be used for the packaging of any number of different products. This means a larger volume packaged in a smaller variety of bottles. In contrast, every different product packaged in paper must be packaged in its respective carton due to the pre-printed labels on the cartons. Consequently, small volumes of several varieties of cartons must be purchased for the packaging of products of minor importance. This results in a higher packaging materials cost for these types of products than would result when packaging them in glass.

Both past studies and data from this study, as presented in Table 16, indicate that there is a considerable cost difference in favor of packaging materials for glass operations. This situation, however, is not usually looked upon by a plant as a way to reduce the cost of packaging materials. The decision to use paper containers, for instance, is often based on other factors considered important by the plant management. These may very well carry a greater weight in determining what type of container to use. Nevertheless, it is worthwhile to be cognizant of the differences that may exist between packaging materials for glass and paper. (Table 13).

Since the cost of packaging materials was a somewhat large and unchanging cost item, it obscured to some degree the actual operating

TABLE 16—Average total packaging materials cost per unit of homogenized milk packaged by the 12 plants studied (All columns in cents)

Plant	Cost of packaging materials									
	Half-gallon		Quart		Pint		Third-quart		Half-pint	
	Glass	Paper	Glass	Paper	Glass	Paper	Glass	Paper	Glass	Paper
A.....	....	3.86	0.59	1.44	....	....	....	....	0.75	....
B.....	0.90	....	0.51	....	....	....	....	....	0.62	....
C.....	....	4.66	0.60	2.12	....	....	....	....	0.52	1.23
D.....	0.86	2.41	0.67	1.49	....	....	....	1.29	0.68	....
E.....	....	....	0.58	....	....	....	....	....	0.65	....
F.....	....	2.87	0.52	1.59	....	....	....	1.19	0.67	0.96
G.....	0.70	....	0.61	1.60	0.64	1.37	....	1.08	0.71	0.94
H.....	....	2.82	....	1.50	....	1.13	....	....	....	0.90
I.....	0.74	....	0.52	....	0.63	....	0.66	....	0.58	....
J.....	0.75	2.75	0.54	1.57	....	....	0.71	1.13	0.59	0.94
K.....	0.88	2.79	0.53	1.47	....	1.12	....	1.15	0.61	0.92
L.....	....	2.82	....	1.55	....	1.25	....	1.12	0...	0.92
Average	0.80	3.12	0.57	1.59	0.64	1.22	0.68	1.16	0.64	0.97

efficiency of the packaging operations. When the cost of packaging materials are not included, a comparison of the weighted average of unit costs for homogenized vitamin D milk (Table 17) shows that the packaging costs are very nearly the same. In the case of half-gallon and pint containers, costs were less for the paper than glass operations.

TABLE 17—Average total packaging cost, excluding the cost of packaging materials, per unit of homogenized vitamin D milk packaged by the 12 plants

Plant	Homogenized vitamin D milk				
	Half-gallon	Quart	Pint	Third-quart	Half-pint
	(cents)	(cents)	(cents)	(cents)	(cents)
GLASS					
A	....	2.52	....	....	1.96
B	2.36	1.08	....	....	0.87
C	....	1.39	....	....	0.75
D	1.34	0.77	....	....	0.69
E	....	0.90	....	....	0.97
F	....	2.96	....	....	1.92
G	2.12	1.09	4.50	....	1.10
I	2.08	0.75	2.19	0.83	0.73
J	2.25	1.22	....	2.14	0.97
K	2.89	1.59	....	....	0.89
Weighted average	2.22	1.10	2.74	1.38	0.94
PAPER					
A	3.10	3.98	....	....	....
C	2.41	2.83	....	....	2.74
D	4.31	3.18	....	4.61	....
F	1.53	1.35	....	1.23	1.35
G	....	2.38	2.22	1.79	1.92
H	1.98	1.30	3.64	....	1.41
J	1.84	1.30	....	1.41	1.59
K	1.35	0.97	0.91	14.10	0.86
L	1.05	1.20	2.28	2.48	0.78
Weighted average	1.53	1.42	2.27	1.78	1.09

Payroll Expenses

The third of the three major cost items was payroll expenses. These expenses include the cost of all labor that worked specifically with

the packaging equipment, designated herein as direct labor, and the proportionate cost of the labor required for general maintenance, general plant operation, general supervision, miscellaneous and clerical work and administrative duties, designated herein as indirect labor. This cost item was, as in the cost of packaging materials, highly important to both glass and paper operations, though considerably more so for glass than for paper on a percentage basis. For the glass operations, payroll expenses ranged from 33.0 to 47.1 percent of the total daily packaging costs. For the paper operations, payroll expenses ranged from 18.8 to 34.9 percent of the total daily packaging costs.

Payroll expenses in the packaging cost center comprised almost one-half of the payroll expenses of the total fluid milk operations (Table 2) for all of the 12 plants. Measures taken to reduce labor requirements in these cost centers would have a relatively large influence in reducing costs for the total operations.

A considerable portion of the payroll expenses for these plants consisted of indirect labor costs. Indirect labor, particularly the administrative costs, remain somewhat fixed over a period of time and are not changed easily. The percentage of the payroll expenses for indirect labor ranged from 21.2 to 67.2 for all plants. The average was 42.6 percent as shown in Table 18. Four of the plants, F, G, H and J, had higher indirect labor costs than direct labor costs, a situation which may have had some bearing on the fact that all of these plants had relatively high unit packaging costs.

The main opportunity for reducing payroll expenses appears to be in the area of the direct labor requirements for the packaging operations. An analysis of the requirements in the 12 plants indicates that the amount of labor required in relation to the volume packaged varied with the different characteristics of the packaging operations. The average daily amount of direct labor time required by the glass and paper packaging operations in each plant is shown in Tables 19 and 20, respectively.

These tables also show the number of quarts packaged per minute of labor time, thereby placing all of the plants on a common basis for comparative purposes.

Table 19 indicates that the average total labor time required daily by the operations ranged from 168 minutes to 2,596 minutes, or, in terms of number of men needed (based on a man's normal working day, or 480 minutes), from about one-third of a man to almost 5.5 men. The quarts of product packaged per minute of labor ranged

TABLE 18—Average daily cost of direct and indirect labor incurred by the packaging operations and the percentage that each is of the total costs in the 12 plants

Plant	Cost of labor				Total cost of labor
	Direct labor		Indirect labor		
	Amount	Percentage of total	Amount	Percentage of total	
	(dollars)	(percent)	(dollars)	(percent)	(dollars)
A	24.75	78.8	6.70	21.2	31.45
B	14.75	54.3	12.43	45.7	27.18
C	33.05	64.0	18.55	36.0	51.60
D	37.58	70.2	15.96	29.8	53.54
E	44.84	57.7	32.94	42.3	77.78
F	41.96	49.6	42.60	50.4	84.56
G	73.13	47.3	81.42	52.7	154.55
H	55.66	32.8	114.21	67.2	169.87
I	91.06	64.4	50.33	35.6	141.39
J	112.51	45.0	137.74	55.0	250.25
K	133.85	66.5	67.31	33.5	201.16
L	108.62	58.3	77.79	41.7	186.41

from 2.5 to 8.6 or an average of 5.7 quarts for all of the glass operations. The glass operations that were above this average were generally those handling a greater volume of product.

For the glass operations, there appeared to be a definite relationship between the total volume and the number of quarts packaged per minute of labor required for the operation of the packaging equipment. As the total volume increased, the quarts packaged per minute of labor generally increased. This could be attributed in part to the fillers in the larger plants having a greater capacity per minute. Also, a larger number of units of one product-container size combination is generally packaged at one time in the larger plants, thus necessitating fewer changeovers in relation to the volume being handled.

On the other hand, this volume-quarts per minute relationship did not prevail to any degree with respect to the labor required for the set-up and clean-up of the glass packaging equipment. Whereas one would expect the quarts per minute to increase with increases in volume, due to the relatively constant amount of time necessary for these jobs, this was not the case. It would be expected that the set-

TABLE 19—Average daily amount of direct labor time required by the glass packaging operations and the quarts of product packaged per minute of labor time in the 12 plants studied

Plant	Labor requirements for equipment used for packaging units of all sizes					
	Operation of equipment		Set-up and clean-up of equipment		Total time	
	Minutes required	Quarts per minute	Minutes required	Quarts per minute	Minutes required	Quarts per minute
A	119	3.5	49	8.6	168	2.5
B	355	7.3	125	20.9	480	5.4
C	385	7.5	275	10.5	660	4.4
D	517	8.7	267	16.9	784	5.8
E	813	11.1	236	38.1	1,049	8.6
F	136	6.6	94	9.5	230	3.9
G	692	17.0	766	15.3	1,458	8.1
I	1,144	17.6	1,452	14.0	2,596	7.8
J	989	12.7	839	14.9	1,829	6.9
K (No. 1)(*a*)	445	10.8	713	6.7	1,158	4.1
K (No. 2)	265	17.5	555	8.4	820	5.7

(*a*) Plant K had two glass lines—one quart and one half-gallon.

up and clean-up time for basically the same type of equipment, granting allowances for the range in sizes, would be about the same. The data indicate that there was a rather wide range in the time required for these jobs. This points out that those plants having above average labor requirements for set-up and clean-up should be concerned with this aspect of their operation.

Table 20 shows the labor requirements for the two principal sizes of paper fillers. These sizes refer to the filler that packages quarts or smaller units and to the filler that can package only half-gallons. Some paper fillers requiring pre-formed cartons were capable of filling quarts or smaller units. They were, however, primarily for the packaging of half-gallons and have been classified under that category.

The data indicate that the total labor time required for the packaging of quarts or smaller units in paper ranged from 120 minutes to 1,488 minutes, or from one-fourth of a man to about 3 men. The quarts of product packaged per minute of labor ranged from 2.0 quarts

TABLE 20—Average daily amount of direct labor time required by the paper packaging operations and the quarts of product packaged per minute of labor time in the 12 plants

Plant	Labor requirements for equipment used for packaging quarts or smaller units						Labor requirements for equipment used for packaging half-gallons					
	Operation of equipment		Set-up and clean-up of equipment		Total time		Operation of equipment		Set-up and clean-up of equipment		Total time	
	Number of minutes	Quarts per minute	Number of minutes	Quarts per minute	Number of minutes	Quarts per minute	Number of minutes	Quarts per minute	Number of minutes	Quarts per minute	Number of minutes	Quarts per minute
A.....	...	...	...	....	...	...	239	8.5	72	28.3	311	6.6
C.....	78	3.1	42	5.7	120	2.0	128	11.4	92	15.8	220	6.6
D.....	...	...	...	....	...	...	243	6.9	64	26.3	307	5.5
F.....	399	7.5	166	18.1	565	5.3	282	31.9	176	51.2	458	19.7
G.....	260	7.4	168	11.5	427	4.5	...	....	...	....	...	....
H (No. 1) ..	744	9.7	405	17.9	1,149	6.3	331	32.8	305	35.6	636	17.1
H (No. 2)(*a*)	31	3.8	305	0.4	336	0.4	...	....	...	....	...	....
J.....	408	10.1	169	24.5	576	7.2	306	26.7	164	49.8	470	17.4
K.....	809	9.6	352	22.2	1,160	6.7	465	30.0	382	36.6	847	16.5
L.....	843	8.3	646	10.9	1,488	4.7	687	41.6	950	30.1	1,637	17.4

(*a*) This filler was used on only one day of the four days that the plant was observed. Due to a major equipment breakdown, the data for this filler are not representative of normal operations.

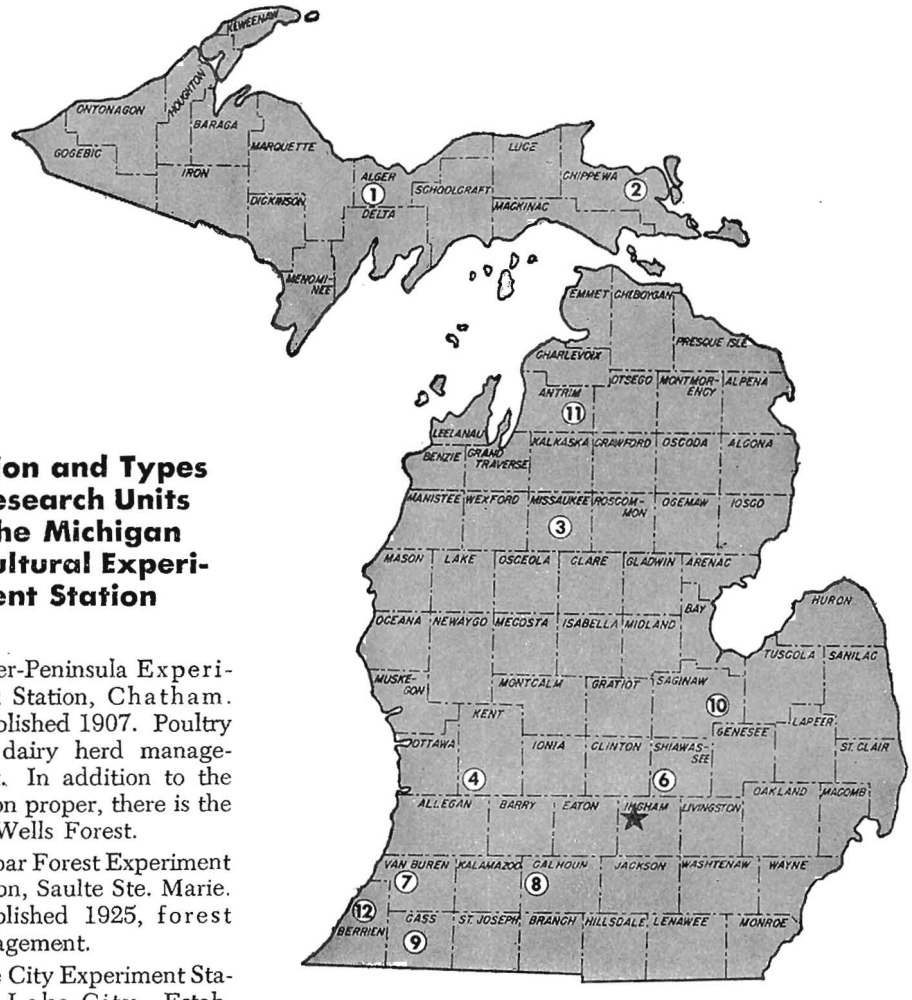
to 7.2 quarts or an average of 5.2 quarts for all operations concerned, excluding the data pertaining to the No. 2 filler in plant H which did not represent normal operation of the filler. As was the case for the glass operations, those paper operations above this average tended to be those operations handling a greater volume of product.

The same situation prevailed with respect to labor required for set-up and clean-up of the quart paper packaging equipment as did with the glass operations. The amount of the time varied considerably for almost identical equipment, excluding the paper filler requiring pre-formed cartons in plant C which is quite small and simple as compared to the larger and more complex automatic paper fillers.

For the packaging of half-gallons, the data in Table 20 indicate that the total labor time ranged from 220 minutes to 1,637 minutes or from almost one-half a man to about 3.5 men. The quarts of product packaged per minute of direct labor ranged from 5.5 quarts to 19.7 quarts, or a weighted average of 13.4 quarts for all operations concerned when the three paper fillers requiring pre-formed cartons in plants A, C and D are included. When only the large, automatic paper fillers are considered, the average is 17.6 quarts per minute of labor. The three small paper fillers averaged only 6.2 quarts per minute, indicating the competitive disadvantage that the smaller plants have since their labor costs must be prorated to a smaller number of units of product.

Again the situation is found to have prevailed where the labor required for set-up and clean-up of the half-gallon packaging equipment varied considerably for almost identical equipment, excluding the paper fillers requiring pre-formed cartons. Plant L was particularly out of line in this respect, as was the case for this plant with respect to the quart filler.

Whereas the average number of quarts of product packaged per minute of direct labor time was about the same for the glass operations and for the portion of the paper operations pertaining to the equipment used to package quarts or smaller units, the average for the large, automatic half-gallon paper fillers was about 12 quarts per minute greater. The large fillers apparently have a very definite labor advantage in relation to the volume of product packaged as compared to other types of fillers.



Location and Types of Research Units of the Michigan Agricultural Experiment Station

(1) Upper-Peninsula Experiment Station, Chatham. Established 1907. Poultry and dairy herd management. In addition to the station proper, there is the Jim Wells Forest.

(2) Dunbar Forest Experiment Station, Saulte Ste. Marie. Established 1925, forest management.

(3) Lake City Experiment Station, Lake City. Established 1928. Potatoes, breeding of beef cattle, soil and crop management.

(4) Graham Horticultural Experiment Station, Grand Rapids. Established 1919. Varieties, orchard soil management, spray methods.

(★) Michigan Agricultural Experiment Station, Headquarters, 101 Agricultural Hall, MSU, East Lansing. Established 1888. Research work in all phases of Michigan agriculture and related fields.

(6) Muck Experimental Farm, Laingsburg. Plots established 1941, crop production practices on organic soils.

(7) South Haven Experiment Station, South Haven. Established 1890. Breeding peaches, blueberries, apricots. Small fruit management.

(8) W. K. Kellogg Farm and Bird Sanctuary, Hickory Corners, and W. K. Kellogg Forest, Augusta. Established 1928. Forest management, mink, dairy and poultry nutrition.

(9) Fred Russ Forest, Cassopolis. Established 1942. Hardwood forest management.

(10) Ferden Farm, Chesaning. Plots established 1928. Soil management. (Land Leased)

(11) Streiffert Farm, Elmira. Plots established 1949. Cropping systems with special emphasis on potatoes. (Land Leased)

(12) Sodus Horticultural Experiment Station, Sodus. Established 1954. Production of small fruit and vegetable crops. (Land Leased)