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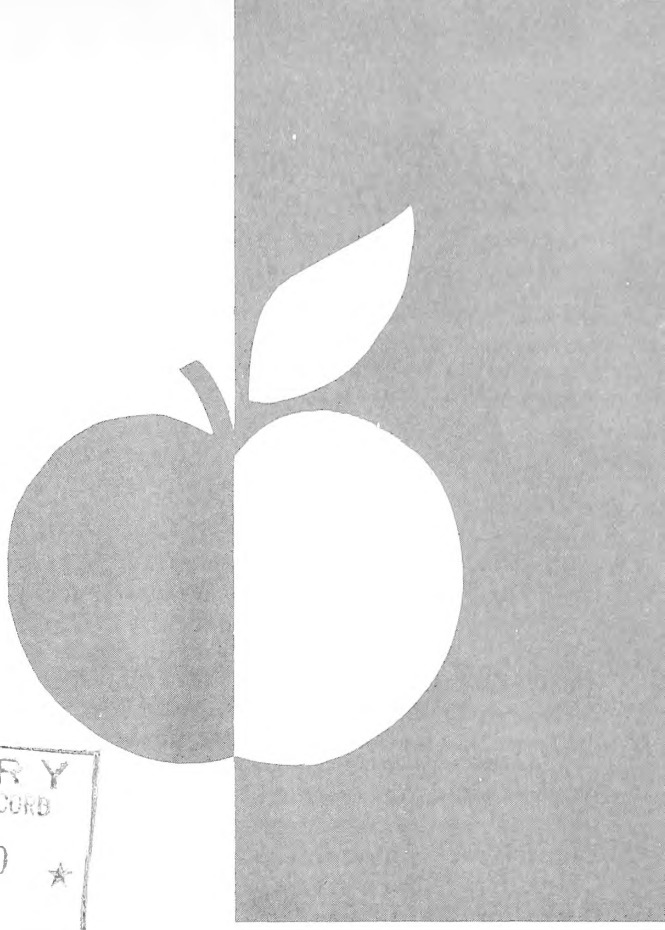

Appalachian Apples

PACKING COSTS and EFFICIENCY

U.S. DEPARTMENT OF AGRICULTURE
Agricultural Marketing Service
Marketing Economics Research Division

PREFACE

This report is part of the Northeast regional project NEM-19, "Handling Methods and Costs in Storing and Packing Apples." In this particular phase of the regional project, the Agricultural Marketing Service cooperated with West Virginia University in planning the study and conducting the fieldwork. This study is part of a continuing research program designed to improve efficiency and reduce costs in the marketing of farm products.

This is the fourth in a series of reports on economic-engineering studies of Appalachian apple packinghouses. Earlier reports are:

"Costs and Mechanical Injury in Handling and Packing Apples" by Homer C. Evans and Ray S. Marsh, West Virginia Agricultural Experiment Station Bulletin 416, June 1958.

"Possibilities for Reducing Apple Packinghouse Costs" by Homer C. Evans and Ray S. Marsh, West Virginia Agricultural Experiment Station Bulletin 436, November 1959.

"Cost of Marketing Appalachian Apples" by Jules V. Powell and John K. Hanes. U. S. Dept. Agr. Marketing Research Report 300, February 1959.

Grower-packers in the Appalachian area cooperated wholeheartedly in permitting work-sampling observations and time studies to be made in their plants during the packing seasons and provided detailed information on overhead and operating costs. Equipment replacement costs were supplied by Mr. C. E. Sheetz, Food Machinery and Chemical Corporation, and Mr. Kurt Story, Trescott Company. The pictures were taken by David Creel of the West Virginia Agricultural Experiment Station.

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SUMMARY

Labor and machinery costs are of major importance in determining the efficiency and costs of packing apples in the Appalachian area. This report analyzes these factors as they affect the costs of performing one of the most important packinghouse jobs--placing apples in containers for shipment to the fresh market.

Labor costs in packing apples are affected by (1) type of equipment, (2) type of containers, and (3) method of paying the packing workers. Machinery costs are affected by (1) types and quantities of equipment and (2) length of packing season. Packinghouse operators are interested in finding least-cost combinations of labor and equipment.

Workers can pack more quickly from return-flow belt systems than from rotating tubs. The rotating tubs have two disadvantages: (1) They have low capacity per square foot of floor space and (2) they are not adapted to the use of semiautomatic packing aids. Workers could pack 18 cartons per hour from rotating tubs and slightly over 26 cartons per hour from return-flow belts. If semiautomatic tray-packing machines were included in the return-flow belt system the packing rate could be increased to 47 cartons per hour.

The type of container affects packing efficiency. Tray-pack cartons can be filled more quickly than Northwest boxes. From rotating tubs, packers could attain a rate of 18 tray-pack cartons per hour or 17 Northwest boxes. (Northwest boxes were not packed from return-flow belts in any of the plants studied.)

Master cartons of nine 5-pound and twelve 4-pound bags were packed from return-flow belts. The average production rate for cartons of twelve 4-pound bags was 5.8 cartons per hour when homemade bagging contrivances were used and 8.15 cartons per hour when commercial bagging machines were used. For master cartons of nine 5-pound bags the production rate was 8.7 cartons per hour with homemade bagging contrivances and 11.2 cartons per hour with commercial machines.

Methods of paying the packing workers had no discernible effect on the performance rates of bag packers but did have considerable effect on that of tray packers. Packers who were paid a piece rate of 10 cents per tray-pack carton, could pack 18 cartons of size 100 apples per hour. Those who were paid an average hourly wage of 75 cents packed 14.5 tray-pack cartons per hour.

When labor costs based on the foregoing labor requirements were combined with equipment costs, for certain lengths of season and volumes of output, the data indicate that increased mechanization of the packing operation pays. In smaller plants with short packing seasons of 200 hours and season output of 50,000 tray-pack equivalent units, packing costs for labor and machinery could be reduced from 21 cents to 15 cents per tray-pack carton by using semiautomatic tray-packing machines.

In larger plants that operate 1,400 hours a season and have an output of 250,000 tray-pack equivalent units, labor and machinery costs could be reduced from 19 cents to 12 cents per carton of tray packs by using the semiautomatic equipment. Similarly, labor and machinery costs for each carton of twelve 4-pound bags could be reduced from 26 to 23 cents each, while costs for cartons of nine 5-pound bags would drop from 21 to 19 cents each if semiautomatic bagging machines were used instead of manual methods.

APPALACHIAN APPLES--PACKING COSTS AND EFFICIENCY

by
Jules V. Powell, agricultural economist
Marketing Economics Research Division

INTRODUCTION

Packing-cost studies in Appalachian apple packinghouses have indicated wide variations between plants in the cost of packing apples for fresh market. 1/ There are also variations in costs from day to day, or week to week, in any particular plant. These variations are due to many factors which affect packinghouse efficiency and labor costs.

Appalachian apple growers and packers are placing increased emphasis on sales to the fresh market. In order to meet the competition from other apple producing areas, packinghouse operators are interested in finding ways to reduce their production and marketing costs. This report is concerned with one of the major cost components in marketing apples--the labor and machinery used in placing apples in containers for shipment to market. The major factors affecting the efficiency and cost of packing labor are analyzed: (1) Types of packing equipment, (2) type of containers, (3) method of paying workers, and (4) length of packing season.

METHOD OF STUDY

This study is based upon data obtained from eight packinghouses in the Appalachian area. The packinghouses were selected so as to permit comparison of costs and efficiency for different types of equipment and different methods of packing apples for the fresh market. A further requirement was that each plant should pack a minimum of 50,000 bushels per season. The sample consisted of one packinghouse in Pennsylvania, two in Maryland, two in Virginia, and three in West Virginia. These plants were representative of the more efficient methods of packing and marketing apples in the Appalachian area.

Work sampling and time studies were made in each of the plants during the 1956-57, 1957-58, and 1959-60 seasons. Detailed records of season packout, sales, operating expenses, and overhead costs were obtained from each plant in the spring of 1958 through personal interviews.

1/ Evans, Homer C., and Marsh, Ray S. Costs and Mechanical Injury in Handling and Packing Apples. W. Va. Agr. Expt. Sta. Bul. 416, 26 pp., illus. June 1958.
Powell, Jules V., and Hanes, John K. Costs of Marketing Appalachian Apples. U. S. Dept. Agr. Mktg. Res. Rpt. 300, 24 pp., illus. 1959.

The costs presented in this report do not necessarily represent actual costs incurred in any of the plants studied. To facilitate comparisons of efficiency of different methods the following standardizations and adjustments were made: The labor requirements are the observed net time spent in packing plus an allowance of 15 percent of the total worktime for personal delays, rest periods, and minor work stoppages. The resulting labor requirements are not averages of the actual performance rates attained in the eight plants, but are rates that can be attained by competent packers fully supplied with fruit. Rates of output equal to or greater than the requirements used in this report were found in 20 percent of the observations.

Labor costs were obtained by applying an hourly wage rate of $1 or a piece rate of 10 cents to the labor requirements obtained. Container costs were standardized to represent the most popular sizes and types used throughout the area during the 1958-59 season. The net weight of apples in each type of container was obtained from samples taken during the observations in each of the plants. Average net weights per container used throughout the computations are shown in table 1.

Table 1.--Average weight and cost of various types of containers used in 8 Appalachian apple packinghouses, 1957-58 season

Container	Gross weight	Net weight	Cost per container
	Pounds	Pounds	Cents
Field crate	51	41	10
Tray pack carton	48	44	63
Northwest box	50	44	70
Master carton:			
9 5-pound bags	49	46	48
12 4-pound bags	52	49	55
15 3-pound bags	49	46	62
Bushel basket	52	47	57
Graded-out fruit: 1/			
Cartons (jumble filled)	48	44	---
Crates (jumble filled)	51	41	---
Eliminated small apples	59	49	---

1/ Graded-out fruit consists of apples to be sent to processors or sold in bulk to itinerant truckers. These apples are placed in used cartons and boxes.

Annual overhead and operating charges for use of packing equipment were computed by applying certain percentages to the replacement cost of the equipment. These percentages--averages of those used by the plants in the sample--were: Depreciation, 10 percent; taxes, 0.2 percent; insurance, 0.3 percent; repairs, 0.5 percent; and power, 1.3 percent. A charge of 3 percent was added to cover interest on the invested capital. While, on the face of it, this seems to be a small interest charge, when 3 percent of the replacement cost is used for annual interest charge, it averages (over the lifetime of the equipment) slightly over 5 percent on the undepreciated balance.

PACKER LABOR REQUIREMENTS

Labor requirements for packing are influenced by the type of container, the type of equipment being used, the method of paying packers (that is, hourly or piece rate), and the size of apples to be packed. The labor requirements observed in packing tray-pack cartons and Northwest boxes are shown in table 2.

Effect of Apple Size

Apples packed in Northwest boxes and tray-pack cartons are sold by sizes which indicate the number of apples in the container. Thus size 64 apples are much larger than size 150. Large apples can be packed more rapidly than an equal weight of small apples regardless of the type of container or the equipment used. For example, it took 3.07 man-minutes to pack size 64 apples in a Northwest box and 3.69 man-minutes for size 150 apples when packers were paid a piece rate. Comparable labor requirements for packing tray-pack cartons ranged from 2.55 man-minutes for size 64 apples to 4.29 man-minutes for size 150 apples. When packers were paid an hourly wage, labor requirements for packing tray-pack cartons ranged from 3.22 man-minutes for size 64 apples to 5.18 man-minutes for size 150 apples.

Effect of Type of Container

Most competent packers believe they can individually wrap and pack apples in the wooden Northwest boxes as rapidly as they can place apples on the indented trays used in tray-pack cartons. The data support this belief for the smaller sizes (table 3). Workers paid a piece rate could pack 16.3 Northwest boxes of size 150 apples per hour; for tray packs they averaged 14 cartons per hour when paid piece rates and 11.6 when paid an hourly wage. There were too few observations of hourly-rate workers packing Northwest boxes for reliable estimates of packer performance rates. However, it is believed that the performance rate would be below that of packers paid a piece rate, but the relationship between labor requirements for Northwest boxes and tray-pack cartons would remain the same.

A major reason for the lower labor requirements in packing small size apples in Northwest boxes rather than tray-pack cartons is the amount of time required to place the individual trays in the cartons. As the size of apples decreases the number of trays to be placed increases, thus increasing the total worktime required. For example, packers paid a piece rate required 0.47 man-minute to place the trays in a carton. In Northwest boxes this element is eliminated.

However, the use of Northwest boxes in the Appalachian area has been declining in recent years. Actually, most of the larger packers in the Appalachian area had abandoned use of Northwest boxes during the 1959-60 season, except for a few shipments to the armed services or to foreign countries that particularly specified wooden boxes.

Effect of Packer Payment Plans

The number of cartons packed per hour in any given plant is influenced considerably by the method of paying workers. In the Appalachian area packers were usually paid a piece rate of 10 or 11 cents for each tray-pack carton or Northwest box they packed. In plants that paid an hourly wage, rates ranged from 55 cents to $1 an hour, depending upon the location of the packinghouse and the competition for labor in the

Table 2.--Labor requirements for packing apples from rotating tubs, by size of apples, type of container, and method of paying workers, Appalachian area, 1957-58 season

(Man-minutes per container)

Container, wage payment method, and job element	Size of apples								
	64	72	80	88	100	113	125	138	150
Tray-pack cartons, hourly rate of pay:									
Get and place carton	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
Get and place trays	.45	.45	.45	.45	.54	.54	.54	.54	.54
Place fruit	1.68	1.84	2.00	2.15	2.38	2.62	2.83	3.05	3.25
Stamp carton	.13	.13	.13	.13	.13	.13	.13	.13	.13
Aside full carton	.16	.16	.16	.16	.16	.16	.16	.16	.16
Get materials	.07	.07	.07	.07	.07	.07	.07	.07	.07
Change station	.10	.10	.10	.10	.10	.10	.10	.10	.10
Total net worktime	2.74	2.90	3.06	3.21	3.53	3.77	3.98	4.20	4.40
Delay allowance	.48	.54	.54	.57	.62	.67	.70	.74	.78
Total worktime	3.22	3.41	3.60	3.78	4.15	4.44	4.68	4.94	5.18
Tray-pack cartons, piece rates:									
Get and place carton	.15	.15	.15	.15	.15	.15	.15	.15	.15
Get and place trays	.39	.39	.39	.39	.47	.47	.47	.47	.47
Place fruit	1.21	1.30	1.38	1.50	1.78	2.00	2.18	2.43	2.61
Stamp carton	.13	.13	.13	.13	.13	.13	.13	.13	.13
Aside full carton	.16	.16	.16	.16	.16	.16	.16	.16	.16
Get materials	.07	.07	.07	.07	.07	.07	.07	.07	.07
Change station	.06	.06	.06	.06	.06	.06	.06	.06	.06
Total net worktime	2.17	2.26	2.34	2.46	2.82	3.04	3.22	3.47	3.65
Delay allowance	.38	.40	.41	.43	.50	.54	.57	.61	.64
Total worktime	2.55	2.66	2.75	2.89	3.32	3.58	3.79	4.08	4.29
Northwest boxes, piece rates:									
Get and place box	.09	.09	.09	.09	.09	.09	.09	.09	.09
Place and adjust liner	.12	.12	.12	.12	.12	.12	.12	.12	.12
Wrap and place fruit	1.97	2.07	2.15	2.24	2.34	2.37	2.42	2.46	2.50
Stamp box	.12	.12	.12	.12	.12	.12	.12	.12	.12
Aside full box	.17	.17	.17	.17	.17	.17	.17	.17	.17
Get materials	.06	.06	.06	.06	.06	.06	.06	.06	.06
Change station	.08	.08	.08	.08	.08	.08	.08	.08	.08
Total net worktime	2.61	2.71	2.79	2.88	2.98	3.01	3.06	3.10	3.14
Delay allowance	.46	.48	.49	.51	.53	.53	.54	.55	.55
Total worktime	3.07	3.19	3.28	3.39	3.51	3.54	3.60	3.65	3.69

Table 3.--Number of containers packed per hour from rotating tubs, by size of apples, type of container, and method of paying workers, Appalachian area, 1957-58 season

Container and wage payment method	Size of apples								
	64	72	80	88	100	113	125	138	150
Tray-pack cartons, hourly rate of pay	18.6	17.6	16.7	15.9	14.5	13.5	12.8	12.1	11.6
Tray-pack cartons, piece rates	23.5	22.6	21.8	20.8	18.1	16.8	15.8	14.7	14.0
Northwest boxes, piece rates	19.5	18.8	18.3	17.7	17.1	16.9	16.6	16.4	16.3

area. Obviously, a packer who can pack 17 or 18 tray-pack cartons an hour has more incentive to work at an optimum rate when paid 10 or 11 cents for each carton than when paid a dollar or less for the same work. In plants paying a piece rate, packers averaged 23.5 cartons per hour for tray-packing size 64 apples. Approximately 14.0 cartons per hour of size 150 apples could be packed in these same plants. Workers packed 18.6 cartons of size 64 apples and 11.6 cartons of size 150 apples in plants paying an average wage rate of 75 cents per hour.

Methods of paying packer wages were determined largely by the location of the packinghouse, the competition for labor in the area, and the emphasis on speed and quality in the particular packinghouse. In areas where packing labor was plentiful, packinghouse operators preferred to pay an hourly wage, not only because of the lower labor costs of packing but also because they believe packers would do more sorting of fruit and thus maintain a higher quality pack. In areas where packinghouses needed to pay a piece rate in order to attract a sufficient number of competent packers, the overall pace of the packinghouse was faster, the volume of packed fruit per hour or day was greater, and the quality of the pack less meticulously guarded.

However, it was observed that the caliber of packinghouse supervision had a greater effect on the overall quality of the packinghouse output than the method of packer payment. High-quality packs of fruit were put out by packinghouses that paid a piece rate as well as ones that paid an hourly wage. Close supervision of packers, either by a hired inspector who is continually on duty or by a packing supervisor, can insure careful packing of fruit, regardless of the method of packer payment.

Effect of Semiautomatic Tray-Packing Machines

With the introduction of semiautomatic tray-packing machines, however, packers should be paid an hourly rate. One packer plus a machine can pack three times as many tray-pack cartons of apples as a packer using manual methods (table 4). If packers were paid a piece rate, labor and machinery costs per unit would be prohibitive or piece rates would have to be set so low that packers would not be attracted to the job.

Table 4.--Labor requirements in tray-packing apples with semiautomatic tray-packing machines, Appalachian area, 1957-58 season

Item	Sizes 64-88	Sizes 100-150
	Man-minutes	Man-minutes
Per carton:		
Net worktime	0.88	1.07
15 percent delay allowance	.16	.19
Total worktime	1.04	1.26
	Cartons	Cartons
Per hour	57.7	47.6

PACKER LABOR REQUIREMENTS FOR PACKING APPLES IN BAGS

The type of bagging equipment used was a major factor affecting labor requirements for packing master cartons of 4- and 5-pound bags. Methods of packer payment or type of crew organization had little effect on packer performance rates (table 5).

Labor requirements were lowest for 4-pound bags in packinghouses A and G. In packinghouse A, one girl filled the bags, another closed them, and still another placed the bags in cartons. The packers in packinghouse G filled and closed the bags and placed them in cartons. Both packinghouses A and G had commercial bagging equipment which consisted of two bagging heads per machine and automatic weighing devices which cut off the flow of apples when the bags were filled. Packinghouses C and D had simple bagging equipment which consisted of bagging heads (or bag holders) and separate scales.

Labor requirements for packing 5-pound bags were lowest in packinghouses B, F, and G. All of these plants had commercial bagging machines, but different crew arrangements. In packinghouses B and F, one girl filled bags, another closed them, and still another placed them in cartons. In packinghouse G, as explained above, the bag packer also closed the bags and placed them in cartons. Packinghouse E was the only one observed packing both polyethylene and mesh bags. A carton of mesh bags could be packed more quickly than one of polyethylene bags. However, polyethylene bags are much more widely used for apples than mesh bags, largely because of their lower costs.

PACKING LABOR COSTS

When packers are paid a piece rate of, say, 10 cents per carton, that is the packing labor cost per unit of output regardless of the volume of output for any given unit of time or for the season. When packers are paid an hourly wage, however, the labor cost for each unit of output varies inversely with the number of units packed in a given period of time. For example, the packing labor cost for a carton of size 64 apples when packers are paid an hourly wage of 55 cents would average slightly less than 3 cents per carton, with an output per packer of 18.6 cartons per hour. For size 150 apples, labor costs per carton would average less than 5 cents per carton. With an hourly wage rate of $1 per hour, packing labor costs would be 5.4 cents per carton for size 64 apples and 8.6 cents for size 150.

Table 5.--Labor requirements for bagging apples and packing master cartons, by type of bagging machinery when workers were paid hourly rates, Appalachian area, 1957-58 season

Job element	Twelve 4-pound bags				Nine 5-pound bags				
	Commercial machines		Homemade machines		Commercial machines			Homemade machines	
	Plant A	Plant G	Plant C	Plant D	Plant B	Plant F	Plant G	Plant E	Plant E (mesh bags)
	Man-minutes	Man-minutes	Man-minutes	Man-minutes	Man-minutes	Man-minutes	Man-minutes	Man-minutes	Man-minutes
Per bag:									
Fill bag	0.08	0.10	0.26	0.07	0.06	0.08	0.10	0.12	0.09
Other elements 1/	.19	.22	.21	.35	.19	.21	.19	.30	.26
Close bag	.10	.10	.13	.12	.08	.14	.11	.13	.10
Place in carton	.09	.06	.08	.09	.07	.06	.04	.09	.08
Net time per bag	.46	.48	.68	.63	.40	.49	.44	.64	.53
Per carton:									
Bagging apples and filling carton	5.52	5.76	8.16	7.56	3.60	4.41	3.96	5.76	4.77
Close carton	.26	.12	.52	.34	.60	.20	1.12	.28	.28
Net time per carton	5.78	5.88	8.68	7.90	4.20	4.61	5.08	6.04	5.05
Delay allowance	1.46	1.48	2.15	1.99	1.05	1.13	1.04	1.52	1.27
Total time per carton	7.24	7.36	10.83	9.89	5.25	5.74	6.12	7.56	6.32
	Cartons	Cartons	Cartons	Cartons	Cartons	Cartons	Cartons	Cartons	Cartons
Per hour	8.2	8.1	5.6	6.0	11.4	10.7	11.6	7.9	9.5

1/ Other elements consist primarily of attaching and detaching the bag, twisting the bag, adjusting weight of bag, and other minor motions necessary. These varied between sheds, depending on the type of bag closures used and the arrangement of packer stations.

EQUIPMENT REQUIREMENTS AND COSTS

The amount and cost of packing equipment required for any particular level of output can vary widely depending upon the preferences of plant operators as to size, flexibility, and expectations for future levels of output. The equipment specifications in the following analyses are based on observed types and combinations of equipment currently used in the Appalachian area. In order to isolate the packing cost element, only the equipment used directly by the packers is included. Or, putting it another way, the dumper, sorting tables, and transportation belts or trucks are not included in equipment costs for packing.

Equipment costs for the rotating-tub system are based on 40 tubs (two rows of 20 tubs each) with a canvas-cup weight sizer running the length of the tubs (fig. 1). This equipment is no longer manufactured because it does not lend itself to the use of semiautomatic packing aids and has the further disadvantage of low output rate per square foot of floor space. However, much of this equipment is being used in the Appalachian area, and at 1960 equipment price levels the 40-tub unit would cost $9,875 installed.

Equipment costs for the return-flow belt system are based on two 16-inch belts 80 feet long (fig. 2). If nine packers are stationed along the belt, this allows almost 9 feet of space per packer. Twelve feet would be preferable and some manufacturers recommend 18 feet per packer, especially if operators expect to introduce the semiautomatic tray packers into the system. For this analysis, however, 9 feet of space per packer was allowed. The total cost of this return-flow belt system would be $13,450.

Semiautomatic tray packers may be used with return-flow belts (fig. 3). These require a minimum of 7 feet per packer, although 12 to 18 feet is preferred to allow adequate space for the accumulation of fruit. The semiautomatic tray-packing machines observed were installed at a definite spot along the return-flow belt, but it would be a simple matter to make them mobile so that they could be moved to take care of heavy runs of fruit to one or two sizes. Under these conditions, five semiautomatic tray packers would be sufficient for the volumes considered here. At 1960 price levels, the cost of these machines installed was $738.50 each, or $3,692.50 for the complete installation.

Bagging machines are currently being built by several manufacturers in a wide range of prices. The ones incorporated into the following analysis were medium-priced ones costing $401 installed. The number of bagging machines has been varied in order to attain the levels of output considered.

CONTAINER COSTS

Container costs varied considerably even for the same type of container, particularly in tray-pack and other fiberboard cartons.

Differences in container costs were due to differences in quality of the fiberboard and the amount of printing and artwork on the carton. For example, cartons of heavy fiberboard were used for apples that were to be placed in storage. Apples packed for immediate shipment to market were placed in thinner cartons, which may have had more advertising material printed on them.

Costs of materials for tray-packing apples, including the carton, trays, and pad, averaged 63.3 cents and ranged from 60.5 to 67.2 cents each. Costs for master cartons, twelve 4-pound bags, and bag closures ranged from 52.6 cents to 60.4 cents and averaged 55.2 cents per completed carton. Master cartons, bags, and closures for nine 5-pound bags of apples averaged 47.6 cents. Total costs for Northwest boxes, including lid, pads, and wraps for 100 apples, averaged 70 cents.

Figure 1.--A typical packing line using rotating tubs.

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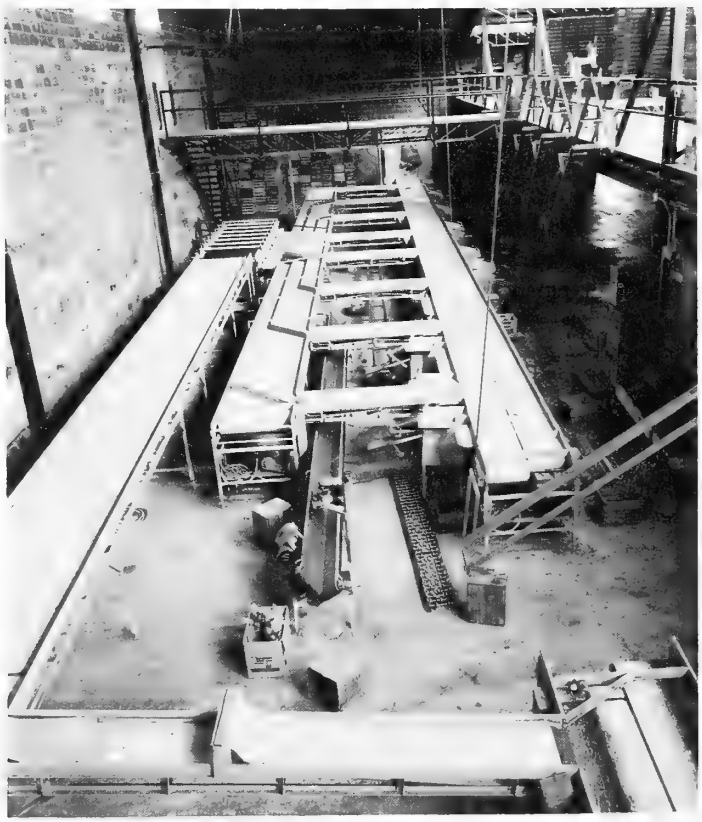

Figure 2.--A modern plant layout using return-flow belts and dimension sizer.

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Figure 3.--A semiautomatic tray-packing machine.

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TOTAL SEASON COSTS

This section compares costs of packing various types of containers using types of equipment described previously for certain quantities of output, methods of paying workers, and varying lengths of season. Before this analysis is undertaken, however, it might be well to describe how packinghouses in the area actually operate.

The length of packing season for the eight plants studied varied widely. Total hours of operation ranged from slightly less than 400 to over 1,400 hours. The total season hours of operation for the individual packinghouses seemed to depend primarily upon the amount of storage capacity of the plant. There seemed to be little relationship--at the levels of output considered here--between the volume of fruit to be packed and the length of packing season. The largest plant studied packed apples less than 400 hours, the smallest plant packed approximately 500 hours, while three of the medium-size plants had packing seasons ranging from 1,200 to 1,400 hours.

The packinghouses having the longer seasons of operation were those that packed only out of storage. Fruit from the orchard was received into storage and was packed on order. These plants also emphasized high quality, bruise-free fruit. Packing was largely a hand operation and the pace was slow. Mechanical means of filling cartons or bags were not employed. While actual costs of packing apples in these plants were higher than they might have been, returns to the plant were also higher because of the premium prices paid for apples from these firms.

Those plants with short packing seasons had limited storage facilities and packed apples as they were brought from the orchard. Overflow fruit in excess of the capacity of the packing line was placed in storage until it could be packed. The flow of fruit through these packinghouses was rapid. It was in these plants that most of the observations of newer types of packinghouse equipment were obtained.

Most of the plants with long packing seasons had only one dumper and packed only one variety of apples at any particular time. The plants with short packing seasons, however, usually had two or more dumpers and could pack two or more varieties of apples concurrently. For example, these packinghouses might pack Extra Fancy Red Delicious in tray-pack cartons, Fancy Red Delicious in Northwest boxes, and U. S. No. 1 Jonathans in master cartons of twelve 4-pound bags or nine 5-pound bags. Following are some simplified examples of the effect of packing equipment and hours of operation on costs.

A Tray-Pack Plant

Assume first, a packinghouse that packed only tray-pack cartons and Northwest boxes. Labor and machinery costs per carton for various hours of operation would be as shown in table 6. Labor and equipment costs were computed from the labor and equipment requirements presented earlier.

Labor and machinery costs are higher for rotating-tub plants than for return-flow belt plants for all types of containers, whether packers are paid a piece rate or an hourly wage. This illustrates the comparative inefficiency of the rotating tubs.

For plants that have rotating tubs, however, and are not in a position to change types of equipment in the near future, labor costs can be minimized by paying packers an hourly wage. Even for a short season of 200 hours, labor and machinery costs for each tray-pack carton produced would approximate 11.2 cents if packers were paid $1 per hour (a high wage rate for the area) and 13.5 cents if packers were paid 10 cents per carton.

Labor and machinery costs are lower for return-flow belt plants than for rotating tub plants because of the higher rates of output packers are able to attain from this equipment. The higher machinery costs are more than compensated for by lower labor costs. Savings that are possible with return-flow belt equipment are further augmented by the addition of semiautomatic tray-packing equipment. Labor and machinery costs would approximate 2.6 cents per tray-pack carton over a 1,600-hour season in return-flow belt plants with semiautomatic tray-packing machines, 4.3 cents with return-flow belts, and 7.4 cents with rotating tubs--assuming all packers were paid a wage of $1 per hour.

A Bag Plant

If a packinghouse specialized in producing consumer packs of 4- or 5-pound bags, labor and equipment costs might be as shown in table 7. Although bags can be filled manually from rotating tubs, this type of operation was not observed. In this example, the same length of return-flow belt is used but the types of bagging machines are different. In the first case, the bagging is done from return-flow belts using homemade or inexpensive bag holders and separate scales. The bagging crew consists of nine packers and two extra employees who place the bags in cartons. This setup is similar to one observed in the area. In the second example, packers use commercial, semiautomatic bagging machines. These packers fill and close the bags and place them in cartons.

It costs less to pack master cartons of nine 5-pound bags than to pack cartons of twelve 4-pound bags because a 5-pound bag can be filled as quickly as a 4-pound bag, and there are three less bags to be filled. For any given type of equipment or wage payment, it is cheaper to pack the 5-pound bags. The cheapest way to pack cartons of

Table 6.--Estimated labor and equipment cost per container for packing Appalachian apples in tray packs and Northwest boxes by various methods, for seasons of 200 to 1,600 hours

Item	Rotating tubs 1/			Return-flow belts 2/	
	Tray packs, hourly wage $1	Tray packs, piece rate 10¢	Northwest boxes, piece rate 10¢	Tray packs, hourly wage $1	Plus 5 semi-automatic tray-pack machines, hourly wage $1
Workers . . . . . (number)	12	12	12	3/ 9	5
Output per line per hour . . . . . (containers)	174	217	205	238	263
Replacement cost of equipment 4/ . (dollars)	9,875	9,875	9,875	13,450	17,150
Season cost of equipment 5/ . (dollars)	1,511	1,511	1,511	2,058	2,998
	Cents	Cents	Cents	Cents	Cents
Labor and equipment cost per container during season of:					
200 hours	11.2	13.5	13.7	8.1	7.6
400 hours	9.1	11.7	11.8	6.0	4.8
600 hours	8.3	11.2	11.2	5.2	3.8
800 hours	8.0	10.9	10.9	4.9	3.3
1,000 hours	7.8	10.7	10.7	4.7	3.0
1,200 hours	7.6	10.6	10.6	4.5	2.8
1,400 hours	7.5	10.5	10.5	4.4	2.7
1,600 hours	7.4	10.4	10.5	4.3	2.6

1/ Two sections of rotating tubs, 40 tubs in all. Most packinghouses in the Appalachian area allowed 3 packers for each 10 tubs.

2/ 2 16-inch belts, 80 feet long.

3/ One worker for each size of fruit commonly packed with allowance for shifting of packers as fruit size varied.

4/ These replacement costs are not strictly comparable. The rotating tubs and canvas-cupped weight sizes observed are no longer being manufactured.

5/ Annual season costs computed as follows: Depreciation, 10 percent; taxes, 0.2 percent; interest, 3 percent; insurance, 0.3 percent; repairs, 0.5 percent; and power, 1.3 percent. Semiautomatic tray packers depreciated 20 percent annually.

Table 7.--Estimated labor and equipment cost per carton for packing Appalachian apples, by 2 methods of bagging, for seasons of 200 to 1,600 hours

Item	Return-flow belt 60 feet long used with--	
	Homemade bagging machines	Commercial bagging machines
Workers . . . . . (number)	1/ 11	6
Labor capacity for:		
12 4-pound bags 2/ . . . . . (cartons per crew hour)	52.2	48.9
9 5-pound bags 3/ . . . . . (cartons per crew hour)	78.3	67.2
Replacement cost of belts . . (dollars)	2,227	2,227
Replacement cost of bagging machines . . . . . (dollars)	4/ 900	2,406
Total replacement cost of bagging machinery . . . . . (dollars)	3,127	4,633
Annual cost of machinery 5/. (dollars)	478	709

	Labor and machinery cost per carton when wage rates were--			
	$1 per hour	12 cents per carton	$1 per hour	12 cents per carton
	Cents	Cents	Cents	Cents
12 4-pound bags per carton in a season of--				
200 hours	23.9	16.6	19.5	19.2
400 hours	21.6	14.3	15.9	15.6
600 hours	20.8	13.5	14.7	14.4
800 hours	20.4	13.1	14.1	13.8
1,000 hours	20.2	12.9	13.7	13.4
9 5-pound bags per carton in a season of--				
200 hours	16.0	15.1	14.2	17.3
400 hours	14.4	13.5	11.5	14.3
600 hours	13.9	13.0	10.7	13.8
800 hours	13.7	12.8	10.2	13.3
1,000 hours	13.5	12.6	10.0	13.1

1/ 9 packers filling and closing bags paid $1.00 per hour; 2 placing bags in cartons paid $0.55 per hour. Packers using patented machines fill and close bags and place them in cartons.

2/ Cartons per hour per worker--homemade machines 6, patented machines 8.

3/ Cartons per hour per worker--homemade machines 8, patented machines 11.5.

4/ Cost of scales and bagging head. Could range from $25 to $150. Arbitrarily set at $100.

5/ Belts and patented bagging machines depreciated 15 percent. Scales and bag heads not depreciated.

5-pound bags would be to use commercial bagging machines and an hourly wage rate for the packers. For a short season of 200 hours, total labor and machinery costs would amount to 14.2 cents per carton. If the season were extended to 1,600 hours, costs would decline to 10 cents per carton.

To meet the demands of the trade, however, packinghouses also must pack 4-pound bags. This is not a great inconvenience, however, because it merely entails the added inventory in bags. The data presented in table 7 indicate that it is slightly cheaper to pack master cartons of twelve 4-pound bags using homemade bagging machines and paying packers a piece rate of 12 cents per carton. The next cheapest method would be to use commercial bagging machines and pay packers a wage of $1 per hour. Since this method was cheapest for 5-pound bags, and since the packinghouse would have to pack both sizes, the least-cost method would be to use commercial bagging machines and pay the packers an hourly wage rate. The cost advantage of the commercial machine and hourly wage method would vary with the wage paid.

A Multicontainer Plant

Throughout any particular season a packinghouse has orders for tray-pack cartons, Northwest boxes, master cartons of bags, and other types of containers. The savings on cost of labor and machinery possible with the semiautomatic tray-packing and bagging machines would be made only on that portion of the total plant output that was packed in tray packs and bags. There were no observations of improved methods of packing the Northwest box or other types of containers.

A typical season output by type of container--disregarding varieties of apples--might consist of 45 percent tray packs, 20 percent Northwest boxes, 15 percent cartons of twelve 4-pound bags, 10 percent cartons of nine 5-pound bags, and 10 percent miscellaneous containers, such as bushel baskets, wirebound crates, cell cartons, and jumble-filled cartons and boxes. This was the 1957-58 pattern of output for the eight plants studied. Individual plants tended to specialize in packing two or three particular containers.

For various expected levels of output, there would be combinations of packing labor and equipment that would be more efficient than others, even for the packing job alone. To explore this possibility, the typical season outputs of types of containers were used to arrive at an expected level of total output. All containers are expressed on a tray-pack equivalent basis.

The effect of types of containers and methods of packing on costs under given volumes and total hours of operation during the season are illustrated in tables 8 and 9. Plant equipment costs are held constant, but packer hours and number of packers required are varied to allow the predetermined volume of apples to be packed.

Under these conditions, plants that pack only 22,500 tray-pack cartons during a short season of 200 hours could expect to save approximately 5 cents per carton by using the semiautomatic machine rather than manual methods. However, at corresponding levels for packing bags, savings accruing from the use of the commercial bagging machines would be small. Savings of 1.1 cents could be made on each carton of twelve 4-pound bags, for a total of $87.50. However, a loss of 1.3 cents would result from packing each carton of 5-pound bags. Net savings from using the commercial bagging machines rather than homemade methods in this instance would be $22.50 per season.

Table 8.--Estimated cost of packing 50,000 equivalent tray packs of apples in several types of packs in a 200-hour season, by manual and machine methods

Method and type of pack	Volume 1/	Packer hours 2/	Cost of labor and equipment			Cost per equivalent tray packs		
			Labor 3/	Equipment 4/	Total	Labor and equipment	Container 5/	Total
	Equivalent tray packs	Hours	Dollars	Dollars	Dollars	Cents	Cents	Cents
Manual methods:								
Tray pack	22,500	1,243	2,250	2,410	4,660	20.7	63	83.7
Northwest box	10,000	585	1,000	1,071	2,071	20.7	70	90.7
12 4-pound bags	7,500	1,293	1,293	803	2,096	27.9	56	83.9
9 5-pound bags	5,000	575	575	535	1,110	22.2	48	70.2
Miscellaneous	5,000	345	345	535	880	17.6	57	74.6
Total	50,000	4,041	5,463	5,354	10,817	---	---	---
Semiautomatic methods:								
Tray pack	22,500	473	473	2,976	3,449	15.3	63	78.3
Northwest box	10,000	585	1,000	1,071	2,071	20.7	70	90.7
12 4-pound bags	7,500	920	920	1,092	2,012	26.8	56	82.8
9 5-pound bags	5,000	446	446	727	1,173	23.5	48	71.5
Miscellaneous	5,000	345	345	535	880	17.6	57	74.6
Total	50,000	2,769	3,184	6,401	9,585	---	---	---

1/ Total season volume 50,000. Tray packs, 45 percent; Northwest boxes, 20 percent; 4-pound bags, 15 percent; 5-pound bags and miscellaneous, 10 percent each.

2/ Manual method: Packer hours for tray packs and Northwest boxes computed using labor requirements for size 100 apples packed from rotating tubs when packers were paid a piece rate; for bags, average labor requirement for plants using homemade bagging contrivances; miscellaneous container hours computed with labor requirement for tray-pack cartons when packers were paid an hourly wage.

Semiautomatic method: Packer hours using semiautomatic equipment calculated from labor requirements for semiautomatic tray packing of size 100 apples; for bags, calculated from average labor requirements of those plants having semiautomatic bagging machines.

3/ Labor cost computed at $1 per hour except for piece rate of 10 cents per unit for manual tray packs and for Northwest boxes in both methods.

4/ Equipment costs computed for this level of output from data supplied by equipment manufacturers. Substantiated by equipment costs of new plant in area. Fork trucks, lighting fixtures, and wiring not included in costs. Charges are included for semiautomatic tray-packing and bagging machines.

5/ Average costs for containers of comparable quality. Master cartons include costs of bags and bag closures. Miscellaneous containers figured at 1959 cost of bushel baskets.

Table 9.--Estimated cost of packing 250,000 equivalent tray packs of apples in several types of packs in a 1,400-hour season, by manual and machine methods

Method and type of pack	Volume 1/	Packer hours 2/	Cost of labor and equipment			Cost per equivalent tray packs		
			Labor 3/	Equipment 4/	Total	Labor and equipment	Container 5/	Total
	Equivalent tray packs	Hours	Dollars	Dollars	Dollars	Cents	Cents	Cents
Manual methods:								
Tray pack	112,500	6,215	11,250	10,328	21,578	19.2	63	82.2
Northwest box	50,000	2,924	5,000	4,590	9,590	19.2	70	89.2
12 4-pound bags	37,500	6,466	6,466	3,442	9,908	26.4	56	82.4
9 5-pound bags	25,000	2,874	2,874	2,295	5,169	20.7	48	68.7
Miscellaneous	25,000	1,724	1,724	2,295	4,019	16.1	57	73.1
Total	250,000	20,203	27,314	22,950	50,264	---	---	---
Semiautomatic methods:								
Tray pack	112,500	2,363	2,363	11,232	13,595	12.1	63	75.1
Northwest box	50,000	2,924	5,000	4,590	9,590	19.2	70	89.2
12 4-pound bags	37,500	4,601	4,601	3,884	8,485	22.6	56	78.6
9 5-pound bags	25,000	2,232	2,232	2,589	4,821	19.3	48	67.3
Miscellaneous	25,000	1,724	1,724	2,295	4,019	16.1	57	73.1
Total	250,000	13,844	15,920	24,590	40,510	---	---	---

1/ Computed as in table 8.

2/ Manual method: Packer hours for tray packs and Northwest boxes computed using labor requirements for size 100 apples packed from rotating tubs when packers were paid a piece rate; for bags, average labor requirement for plants using homemade bagging contrivances; miscellaneous container hours computed with labor requirement for tray-pack cartons when packers were paid an hourly wage.

Semiautomatic method: Packer hours using semiautomatic equipment calculated from labor requirements for semiautomatic tray packing of size 100 apples; for bags, calculated from average labor requirements of those plants having semiautomatic bagging machines.

3/ Labor cost computed at $1 per hour except for piece rate of 10 cents per unit for manual tray packs and for Northwest boxes in both methods.

4/ Equipment costs for plant of this capacity, computed from data supplied by equipment manufacturers. Does not include costs of transportation equipment, lights, or wiring. Semiautomatic system includes annual charges for semiautomatic tray packing and bagging machines.

5/ Average costs for containers of comparable quality. Master cartons include costs of bags and bag closures. Miscellaneous containers figured at 1959 cost of bushel baskets.

Assuming a 1,400-hour season and a total season packout of 250,000 tray-pack equivalent units, savings using the semiautomatic machines are greater, and the use of commercial bagging machines becomes more feasible. Labor and machinery costs for tray packing with a semiautomatic machine would be almost 7 cents per carton less than with manual methods. Savings of almost 4 cents could be realized by using commercial bagging machines rather than homemade contrivances for packing apples in 4-pound bags. Under the same conditions, savings for 5-pound bags would be almost 1.5 cents per carton. On the packing operation alone, savings could be realized at all levels of output by using semiautomatic tray-packing machines rather than manual methods. Under the conditions set forth in tables 8 and 9, increased automation of the bagging operation becomes feasible when a total of 12,500 cartons of bags is packed during a packing season of 200 or more hours.

IMPLICATIONS

This report has analyzed the major factors affecting packer efficiency in Appalachian apple packinghouses: (1) type of packing equipment, (2) method of paying packers, (3) type of container, and (4) length of packing season.

Tray-pack cartons are the most popular containers currently being packed in the Appalachian area--accounting for approximately 45 percent of the total output of the plants studied. Labor and machinery packing costs are lowest when semiautomatic tray-packing machines are used in conjunction with return-flow belts and packers are paid an hourly wage rate.

The Northwest box has been declining in favor as a shipping container for apples, and during the 1959-60 season none was observed in any of the plants visited. The wrap-and-place method of packing was slow and costly, and did not lend itself to the use of mechanical aids. High cost of containers and excessive bruising augmented the decline of the Northwest box.

Sales of apples in 4- and 5-pound bags are continuing to increase. Labor and machinery costs for packing master cartons of bags are lowest when commercial bagging machines are used in conjunction with return-flow belts and packers are paid an hourly wage.

Miscellaneous containers will always have a place in apple packinghouses to meet the vagaries of trade and consumer demand. And it might be that one of the present miscellaneous containers will become the most popular one in the years ahead. However, to be profitable it will have to lend itself to automatic or semiautomatic methods of filling. Automation has come to the apple industry, and most packers who are slow to accept it will find it increasingly difficult to compete in today's markets.

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